Were the developments in 19th century small arms due to new concepts by the inventors and innovators in the fields, or were they in fact existing concepts made possible by the advances of the industrial revolution?

by

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Chapter 1 - New advances and New norms; The adoption of new developments

To understand how firearms developed across the nineteenth century, it is first necessary to understand how and why new developments in firearms are accepted into general use. A typical, and in fairness logical, assumption would most likely consist of an invention driven view which asserts that the main driving force is the invention and practical application of new ideas in regards to firearms. This would mean that progress would advance in line with new developments, and these new developments would be able to supersede their predecessors with their enhanced capabilities. The end result would be seen as technology advancing at a steady pace, in line with new developments and concepts. Certainly, the improving developments of the nineteenth century appear to support this view, with the rapid rate of change and obsolescent technology seemingly phased out by new developments. But on a closer examination there are clearly flaws in this approach, such as numerous discrepancies between dates of invention and adoption. As a result this thesis argues that there must be more to the story that isn't immediately apparent from such a viewpoint. The purpose of this chapter is to show how the development of firearms in the nineteenth century does not follow this straight path, but rather it runs in fits and starts and owes far more to the demands of industry, economy, and the effects of conflict and society which in turn make the firearm into an acceptable and viable industrial product. The effect of invention, while important is not a driving force in itself. In fact, invention is often called upon to meet an existing need, as opposed to creating a new demand. While there are many examples of this being the case, this chapter will briefly outline three of them, namely the development of the military rifle in the second half of the nineteenth century and the development of self-contained cartridge ammunition as well as the development of the expanding conical bullet. These particular examples are chosen as they show the influence of all of these factors, and while there are many more examples that could be given, they will be touched on in greater depth in later chapters.

An example of the way firearms technology develops in the nineteenth century is the development of the military rifle. It would seem that the military rifle takes a very invention driven path, making use of new ideas and developments as they came about to remain up to date and effective. However, the American Civil War ushered in the era of a new type of weapon, the repeating rifle. The combat

performance of this type of weapon, whether issued to infantrymen or cavalrymen far outstrips anything that can be offered by a muzzle loading or single shot breech-loading weapon in terms of practical firepower, and various examples were combat proven by rifles such as the Spencer and the Henry in various engagements across the course of the war.[1] New advances in manufacturing technology allowed the repeating rifle, which has existed in some form as far back as experimental designs in the 1650's, to become a practical option for mass production, and as a result, military service. Developments in ammunition were also key, with new and practical Rimfire cartridges like the .44 Henry being equally necessary. These in turn needed new manufacturing techniques to produce. At the end of the Civil War, the muzzle-loader was clearly shown to be approaching obsolescence, and as such most militaries began to accept that new weapons would be needed in the near future. However despite having a new weapon proven in front of their very eyes, the ordnance boards of both Europe and America decide to adopt single shot breechloaders as their primary service arm, instead of a repeating rifle. It would not be until the development of the magazine fed bolt action rifle that a British, American, French or German infantryman would be issued with a weapon capable of discharging more than one round of ammunition before requiring reloading. So despite all their advantages over previous designs and their effectiveness in the field, weapons like the Chassepot Rifle, the Martini-Henry and other contempories were, in a sense, developmental dead ends. While they did have their advantages, particularly the ability to use more powerfully loaded cartridges, the future of small arms would be found in rapid firing weaponry, not single shot arms. Of course, this begs the question of why this new type of firearm was overlooked. Perhaps the most pertinent reason was simple economics. For example, during the American Civil War, the price of a muzzle loading rifle was approximately $10-20, whereas a single shot breechloader cost from $20-30, while a repeater could cost from $37-65.[2] Clearly, given the fiscally conservative tendencies that some governments tend to exhibit towards their ordnance boards the adoption of a cheaper rifle must have been an alluring prospect, particularly if there was no guarantee of weapons ever seeing such intense use as in the Civil War. In the case of the European armies, there is evidence to suggest that the experiences of the American Civil War were written off as irrelevant to the European military situation. However, the experience of the Prussian army driving the Danes in 1864 and Austrians in 1866 from the field with their needle rifles, gave ample evidence of the weaknesses of the muzzle-loader much

[1] Paddy Griffith, *Battle Tactics of the American Civil War* (Ramsbury, 2001), p.75.
[2] Griffith, *Battle Tactics*), p.81.

closer to home, and helped contribute towards a move to breech-loading weapons across the continent.[3] Indeed, the Prussian general Von Moltke was allegedly quoted dismissing the Civil War as "two armed mobs chasing each other around the country, from which nothing could be learned".[4] This view would continue until the reverses suffered by the Russian Army at the Siege of Plevna in 1877, where Turkish troops armed with Winchester rifles, as well as their single shot breechloaders, held a numerically superior force at bay for six months, showing again the value of rapid firing weaponry.[5] On the other side of the Atlantic, the Battle of Little Bighorn resulted in a resounding defeat for Custer's US cavalrymen, armed with single shot Springfield carbines, with a mere 50 rounds of ammunition per man.[6] Their opponents however, arrived bearing a variety of arms that included modern repeating rifles, of which many were Civil War surplus Henry rifles sold off by the US government after the war was over.[7] The catastrophic defeat shows a definite shortcoming in the firepower offered by the single shot rifle. Another factor given is the sum total of reliability, ruggedness, utility and simplicity, best summed up under the term of 'soldier proof'. This in itself presents and interesting question, as while this is a perfectly sensible notion, there is the issue of how much of this is a genuine desire for effective arms, and if there is possibly an unwillingness to issue mere soldiers with what would equate to very cutting edge technology. While today we see little reluctance to equipping soldiers with advanced and complicated equipment, the nineteenth century soldier occupied a very different role in both society and the eyes of their superiors, hinting at the effects of society on arms development. Wellington's famous line that "We have in service the scum of the earth as common soldiers" was hardly unusual for the period.[8] While some European forces, particularly the French following the revolution, developed a feel of 'citizen soldiering' in some regiments, the Officers of the time tended to look to their men as their inferiors rather than their peers. As such, lavish provisioning of advanced arms to the rank and file may well have been frowned upon. In addition the threat of mutiny was also present, particularly in the case of the British, who following the Indian Mutiny of 1857 issued inferior weapons to colonial troops, even going as far drilling out the rifling on Pattern 1853 rifles for Indian use, and creating the Pattern 1858 and 1859 muskets for colonial service. There may also be further evidence found in the compatibility of the breechloader

[3] Roger Pauly, *Firearms, The life story of a technology* (Baltimore, 2008), p.96
[4] Griffith, *Battle Tactics*, p.21.
[5] Pauly, *Firearms,* p.110.
[6] Dean K. Boorman, *The History of Colt Firearms,* (New York, 2001), p.23.
[7] Pauly, *Firearms,* p.110.
[8] Richard Holmes, *Redcoat: The British Soldier in the Age of Horse and Musket*(London, 2002), pp.148-150.

with existing military drill. A weapon with the capability to fire multiple times before reloading would make existing drills inefficient, requiring each infantryman to be able to recognise, range, aim and engage their own targets to make the most of their weaponry. In addition, drill was used as the cornerstone of military discipline, used both to keep order and also to mitigate the psychological effects of battle through close control and mutual reinforcement. The changes that would be brought on by such new weapons would have seemed to be a severe shock to established military wisdom, and given that military thought of the time tended to be conservative and patriarchal, this may have had an effect on the adoption of arms. It is interesting to note that even when Bolt-Action rifles were adopted by the British Army, the Lee-Metford and Pre-First Wold War Lee-Enfield rifles came with a stopper plate, designed to slide over the magazine feed, effectively converting the weapons to single shot breechloaders.[9] The reason given was to prevent the soldiers from wasting their ammunition, and that doctrine instructed that long range firing was to be conducted with the magazine cut-off, which allowed the weapon to be loaded one round at a time, to keep the magazine feed available in reserve for closer ranges. While this appears to be a sensible choice on the surface, this also hints that the British Army may not have trusted its own soldiers to fire in a responsible manner without superior direction.

Another example of development is that of ammunition. Across this period there are several examples of new advances in ammunition being ignored or sidelined, only to find their way into mainstream use accepted later in time as situations changed. Starting in 1812, we have the Pauly System, which appears to be the first example of a self-contained centrefire cartridge developed.[10] Clearly an advance like this should be of massive importance, as compared to using a flintlock to ignite powder charge, this method offered massive advantages in reliability, speed and firepower, and one surviving example in the Royal Armouries at Leeds, a breech-loading pistol built off the Pauly system, shows how much of a boon this would be to men on horseback as well as on foot.[11] However, despite a demonstration to Napoleon and the enthusiasm of several officers in the French Army, the cartridge was never a success, and Pauly and his design fell into obscurity.[12] In this instance the design failed

[9] Martin Pegler, *The Lee-Enfield Rifle,* (Osprey, 2012), p.11.
[10] Jaroslav Lugs, *Firearms Past and Present: A complete review of firearm systems and their histories, Vol.1 ,* (London, 1973),pp.76-7.
[11]Centrefire Breech Loading Pistol. French, 1820, Pauly's patent, possibly made by H. Roux. Royal Armouries Leeds Collection (XII.3890).
[12] Lugs, *Firearms Past and Present,* p.77.

not because of its practical performance, but rather because of industrial reasons; the cartridges were of precision hand manufacture and fitted to each gun, with the owner expected to reload the spent cartridges. This meant the ammunition casing was not disposable, which would be a rather impractical solution for soldiers, not to mention the quartermasters responsible for supply. In comparison, shot could easily be cast from lead bars and powder was similarly easy to store in barrels, flasks and paper cartridges. To add to this, the system was developed at the height of the Napoleonic wars, clearly not the best time to introduce new equipment into an already burdened supply chain. However, elements of Pauly's work would later be seized on by some of his associates such as Casimir Lefeaucheux and Johann Nikolaus von Dreyse would go on to adapt his work into their own and far more famous designs (the Lefeaucheux shotgun shell and the Dreyse Needle Rifle, respectively) showing the influence of past ideas on new developments, rather than the pure imagination of the inventor. It is also important to note that Pauly's development of a centrefire cartridge was around half a century ahead of its eventual refinement in the 1860's, with the development of both new primers for centrefire cartridges, and the industrial technology to make precise ammunition casings.

A further advance is that of the conical expanding bullet, that is a round which expands to fit the barrel by expanding under the pressures of the powder charge. While the design found its popularity with the bullet devised by Captain Claude Etienne Minié, similar examples had previously been submitted to the British ordnance board by William Greener in 1836. Similar to the design later submitted by Minié, this was an oval ball which utilised an expansion plug in the base to allow the edges of the bullet to grip the rifling when fired, despite the ball being of a smaller diameter than the barrel. However, his design was rejected following ordnance trials describing the bullet as "Useless and Chimerical".[13] This left the British army using round ball for musketry, supplemented by the problematic belted ball for the Brunswick rifle until the adoption of the pattern 1851 Minié Rifle and Pattern 1853 Enfield Rifle utilizing the Minié style bullet that works on the same principle. Here we can see that the superior solution squashed by the opinions of those in positions of authority, showing more evidence that it is not new invention alone that drives arms development.

[13] Howard Blackmore, *British Military Firearms 1650-1850,* (Huntingdon, 1994), p.229.

Although just a mere snapshot, these examples show that the development of arms was not a simple straightforward path, but could be better compared to a plant in a dense forest, growing in the ways that present either the easiest outcome, or through the path of least resistance. Old branches of development could flourish again as conditions change, and prominent ideas fallout of favour as both new ideas develop and old ones develop sufficiently to replace them. From these examples, we can also see that invention is not the sole driving force behind arms development, but rather Industry, Economy, Conflict and Society have a far more profound effect on the development of arms in the nineteenth century. As such, it can be argued that the development of the firearm comes from its growth into an industrial product that is mechanically refined, socially acceptable and economically viable. The following chapters will explore the development of the nineteenth century firearm and examine how this explanation can be seen to have driven development.

Chapter 2 - The Pattern 1853 Enfield Rifle

As a starting point, The Pattern 1853 Enfield rifle sits on the crossing point between the firearms of old, in terms of both their capability and their production, and what can be considered the beginning modern firearms and especially modern firearms production. Before its introduction most firearms still operated on principles that were similar to designs hundreds of years old, and the methods that were used to make them were similarly backwards. Its arrival heralded a move towards accurate, reliable and precise firearms, which were in turn manufactured with new machinery and methods of using them to allow production on both a mass scale, and at a level of precision so far unheard of on such a scale. This was essentially the turning point from the production of the firearm as an art form, to the firearm as a product of science and industry and a viable mass product. As such, it is fair to say that the impact of this weapon, be it on the battlefield or factory floor was one of absolute importance.

To understand this it is first necessary to assess the state of firearms and their production in the world at the time. Most firearms were relatively simple in terms of capability, mechanism and construction. By the 1840's most major militaries had adopted, often after much deliberation, the percussion cap system of ignition for the vast majority of their firearms. This system, first invented by Rev. Alexander Forsyth in 1807, used a detonating compound, gold fulminate, to ignite the main charge of powder in place of a flintlock. The spark then travels down a short tube to ignite the main powder charge in the barrel (Fig 1.). Forsyth’s design used what is known as a scent bottle lock, which was a somewhat complicated system due to the need for accurately fitted parts (as the lock doubled as a magazine for the fulminate itself and if badly made could be prone to accidental detonation), and as such it was further developed by many gunsmiths on both sides of the Atlantic during the 1820's and 30’s. This ultimately resulted in the familiar brass or copper cap containing the fulminate powder the formed the basis of the majority of percussion locks (Fig 2.). The design is usually credited to the Englishman Joshua Shaw, on the grounds of his 1822 American patent for such a design, as well as the $20,000 reward from Congress for his design, although there is still debate over who invented, as opposed to patented the idea first. As an ignition system it was a major improvement over the temperamental flintlock that preceded it, but other than this new method of ignition, the weapons themselves

remained as ineffective as those which had preceded them.[14] An excellent example of this would be the British Pattern 1842 musket, the predecessor of the Enfield in general service.[15] This was little more than the venerable Brown Bess, a design past its hundredth birthday, fitted with a new percussion lock. Other than this the unrifled barrel and ammunition of lead ball and black powder was exactly the same. Some Brown Bess muskets were even converted to this standard, known as Pattern 1839's although most Pattern 1842's were factory fresh, as a fire in the tower armouries destroyed many of the conversion pieces.[16] The arms were virtually identical with the only differences being a slightly different lock plate and the addition of fixed sights on the Pattern 1842. Similar firearms were adopted by most other militaries, for example the French Army undertook a conversion to percussion for most of its long arms in 1840.[17] The majority of privately manufactured arms for self defence and hunting followed this pattern, showing this to be a global situation. While these percussion smoothbores had the advantage of being cheap, simple to produce and reliable, their effectiveness at ranges over 100 yards was frankly quite dubious.

In addition, there were some examples of firearms far more advanced, in both private hands such as sportsmen and hunters, and some in military use. The effectiveness of the rifle had been proven to European militaries in the Napoleonic Wars, such as the British experimental rifle corps in 1800 which eventually became the 95th Rifle Regiment, and Britain had experience of them even earlier in the American revolutionary war where they were used extensively by the Americans and also by Patrick Ferguson's band of riflemen using the breech-loading rifle he designed.[18] As a result, regular rifle units began to be raised by many militaries to act as scouts and skirmishers.[19] New advances in machine rifling was beginning to make rifle production easier and less expensive and as such, weapons such as the British Brunswick rifle were reaching service in specialist units. However, these rifles were not without flaws and perhaps the most glaring of all, aside from their cost, came from the need for effective ammunition for use in rifles. Most rifles needed to have ball wrapped in a greased paper or fabric patch and have balls hammered home with a mallet to allow them to grip the rifling,

[14]Lugs, *Firearms Past and Present Vol.1,* p.58. ; There was a slight increase in rate of fire due to a faster lock loading process, and in muzzle energy due to the lack of gas escaping from the touch hole. However, this was mostly marginal.
[15] Pattern 1842 musket. British, Enfield, 1842. Royal Armouries Leeds Collection (PR.5097).
[16] Pattern 1839 Musket (Converted). British, Enfield, c.1839.Royal Armouries Leeds Collection (PR.5081).
[17]James E. Hicks, *French Military Weapons 1717-1938,* (New Milford, 1964), pp.22-3.
[18] Ferguson Breech loading military Rifle. English, 1776, by Durs Egg and Presented to Patrick Ferguson. Royal Armouries Leeds Collection (XII.11209).
[19] Holmes, *Redcoat,* p.43.

making them cumbersome weapons and able to fire maybe once a minute.[20] Various solutions were trialled, such as the belted ball issued with British Brunswick rifles which was designed so that the belt was aligned with the rifle grooves (Fig 3.).[21] The French solution offered by Thouvenin used a steel pillar known as a tige to act as a anvil to expand the ball when rammed home, while two more significant solution were the early expanding balls as proposed by John Norton and William Greener which operated on a similar principle as the later Minié ball.[22] While all these ideas were trialled, and the belted ball and tige system adopted by the British and French respectively, these were imperfect solutions. It was not until the development of a new type of expanding ball by Captain Claude Etienne Minié that a workable solution was found, and even then his original was somewhat flawed due to its shape and saw improvements across its service life to correct this.

Perhaps the most advanced firearms available were breech-loading rifles, which after centuries of failed testing and experimentation (Examples of repeating breech-loading rifles can be found as far back as an example belonging to King Henry VIII) became a somewhat practical proposition, thanks to new manufacturing techniques. [23] An early example of this was the M1819 Hall Rifle, developed by John Hancock Hall and manufactured at Harper's Ferry armoury and by Simeon North in his Connecticut plant.[24] Hall decided on a breech-loading design as a means of keeping the American rifleman competitive with his counterpart in Europe, but without the need for drills and formations that he saw the Europeans as experts in.[25] The initial design used a hinged breechblock that would swing forwards for loading with ball and powder and saw several changes over its lifespan, including conversion to percussion ignition in 1833 and other smaller changes throughout its lifespan. In addition, its manufacturing process was based on concepts that were to become the "American System of Manufacture", pioneering new and better methods of construction. However the design suffered from the gas leakage that plagued early breech-loading rifles after very little use and the

[20] Pauly, *Firearms,* p.68.
[21] Brunswick Rifle, first model. British, dated 1841, Royal Armouries Leeds collection (XII.2444).
[22] Blackmore, *British Military Firearms,* pp.228-9. ; Pauly, *Firearms,* pp.72-3
[23] Breech-loading Wheelock gun of King Henry VIII. Probably English, dated 1537, probably made by William Hunt. Royal Armouries Leeds collection (XII.1).

[24] Model 1818 Hall Rifle. US, Connecticut, manufactured 1837 by Simeon North. Royal Armouries Leeds Collection (XII.11126).
[25] Pauly, *Firearms* p.90.

weapon never saw general issue, although in the early years of the American Civil War some venerable examples saw service when serviceable arms were in short supply.[26]

A more successful weapon used in this timeframe was the Prussian Dreyse Needle Gun and its related variants, developed by Johann Nikolaus von Dreyse from 1827 onwards, resulting in the Model 1841 Needle Rifle issued to the Prussian army as their standard arm. A former workman of Samuel Johannes Pauly, Dreyse saw the value in a system that used self-contained ammunition and developed a rifle around his needle fire system. Unlike the hinged breech of the Hall, the Dreyse used a bolt action system to chamber its ammunition, a paper cartridge containing ball, powder and percussion ignition, which was ignited by a needle which pierced the cartridge to ignite the cap within.[27] The Model 1841 saw several variations such as carbine and wall pieces, but the general principles remained the same. Despite its advantages such as a rate of fire as high as seven rounds per minute and the ability to be operated from a prone position, it suffered from gas leakage due to imprecise manufacture just like the Hall, and in addition the reluctance of the Prussian military to embrace new tactics meant that the advantages conferred by shooting prone were mostly ignored.[28] As can be seen, while these weapons were all far more effective than a smoothbore percussion musket, they were also plagued by faults, often relating to gas leakage from imprecise manufacture. There were also early revolvers such as Elisha Collier's flintlock revolver and Samuel Colt's early Paterson models, but these also had their flaws, and will be covered in depth in the next chapter.

On the manufacturing side, the situation was equally primitive. The Royal Small Arms Factory at Enfield had been set up by the British government following the Napoleonic Wars and the critical flaws in British arms procurement that were exposed by the demands of war, which saw the seizure of arms set for the East India Company for Army service. While the factory was set up successfully, production methods were no more advanced than the Birmingham gunsmiths or those in Liege, who the government were often forced to turn to in times of crisis. Parts would often be subcontracted out and the delivered separate, for construction at Enfield, known as the ordnance system of manufacture. The methods of manufacture still placed great emphasis on the skill of the individual craftsmen, and drawings of gun barrels being manufactured at Birmingham in 1851 show work being

[26]Pauly, *Firearms* p.91. ; Griffith, *Battle Tactics,* pp.75-7
[27]Lugs, *Firearms Past and Present Vol.1,* pp.70-1.
[28]Pauly, *Firearms* p.96. ; Lugs, *Firearms Past and Present Vol.1,* pp.74-6.

conducted by methods ranging from hand to steam hammers and grinding wheels.[29] Overseas the situation was brighter in places, for example military arms production in France was centred around government arsenals and manufactories, such as the factories at Saint-Etienne, Tulle, Mauberge, Versailles and Mutzig.[30] This was backed up by a strict system of proofing and quality control, resulting in a higher standard of arm being produced. Other nations, such as Britain, still had systems of proof and inspection, but not to the level of sophistication of the French system. America also established the state arsenals at Springfield and Harpers Ferry in 1798 to ensure a domestic supply of government arms, and these factories would soon find themselves involved in the next great manufacturing advance of the nineteenth century.[31]

The idea of interchangeable parts was not exactly new in the field of firearms, being commonly credited to Honore Blanc in France around the late 1770's.[32] Following the attempts by General Gribeauval to standardise the French artillery, Blanc attempted to make interchangeable muskets. While he did partially succeed in this goal, developing some gunsmithing machinery, the influential Parisian artisans saw this as a threat and curtailed it's development. Their act of self defence (or self interest) meant that the only way to produce these arms was to use skilled craftsmen to make the arms by hand, resulting in a method far too expensive and time consuming for mass production. His designs, such as the French 1777 Musket still went into production, but not using the machines he developed for them. In the US, such ideas were trialled first by Eli Whitney, followed by Simeon North and John Hall, inventor of the aforementioned M1819 rifle. Fittingly enough, one of North's products was the US Model 1799 pistol, the American version of the French Model 1777 pistol, designed by none other than Honore Blanc, showing considerations for mass machine production when designing his arms.[33] The US also accepted into service the Model 1777 Musket, this being the weapon that kick started the whole American system after Thomas Jefferson saw an example of a Model 1777 with an interchangeable lock in Paris. This would eventually result in what came to be known as the American system of manufacture, where workmen would use machine tools and only work on one type of part each, also referred to as the armoury system as it was quickly used in state arsenals such

[29] *The Illustrated London News*. Vol. 18 (1st February 1851), pp. 84-5.
[30] Lugs, *Firearms Past and Present Vol.1,* pp.457-8.
[31] Boorman, *Colt Firearms,* p.62.
[32] Lugs, *Firearms Past and Present Vol.1,* p.473.
[33] Lugs, *Firearms Past and Present Vol.1,* p.37.

as Harper's Ferry under John Hall, and also to differentiate it from the British ordnance system.[34] However, despite machine production and claims of interchangeable parts, the reality did not always match the claims. When contracted to produce interchangeable muskets for the US army, Eli Whitney found himself struggling to make production meet demands, and as will be see in the case of Colt's early revolvers, these supposedly advanced techniques left a lot to be desired.[35] As can be seen, the state of small arms worldwide prior to the 1850's was both uneven and not particularly advanced. While there were some signs of innovative ideas reaching the fore, a lack of industrial sophistication, will to pay for them and resistance to change tended to hold them back. But by the late 1840's and early 1850's these disparate ideas would eventually come together under the influence of new technology and of historical events into the Pattern 1853 and change both the state of firearms and their manufacture.

By the late 1840's it was becoming apparent that the British infantryman's arm, the Pattern 1842, was heavy, cumbersome, backward and inaccurate. New advances in machine production had made the previously complicated rifles a viable mass production option, and the new ammunition developed by Minié could be used to give a rifle the same effective rate of fire as a musket, without the drawback of extremely limited range. In 1846 the Inspector General of Fortifications conducted a series of tests in which regulation pattern 1842 muskets were fired across the River Medway. The muskets were fired from static rests at a target 11 feet 6 inches high by 6 feet wide, with the result being that at 150 yards only half the shots hit the target and at 250 yards every shot missed.[36] Despite being performed under ideal conditions, these tests showed the weaknesses of musketry at ranges longer than the 100 yards or less that combat was usually conducted at, and resulted in a call for a new service arm. As a result, a call was put out for new designs, and one of the first ideas to be tested was the breechloader. Specimens of the American Jenks Rifle were acquired and given limited issue to four cavalry regiments, but those soldiers reported that the weapons suffered from difficulty in cleaning and loading and larger scale testing was dropped.[37] In 1850 an inquiry committee of Officers set up to inspect and evaluate the proposed arms. Of particular interest to the committee were arms based of the Prussian breech-loading needle fire pattern, of which two were ordered to be made at the Enfield

[34]Lugs, *Firearms Past and Present Vol.1,* pp.475-6.
[35]Lugs, *Firearms Past and Present Vol.1,* p.475.
[36] Blackmore, *British Military Firearms,* p.226.
[37] Blackmore, *British Military Firearms,* p.226.

factory.[38] The breechloaders did impress with their rate of fire, but it was found that the mechanisms were liable to seize up under the heat and grime of sustained firing.[39] However by now the main source of interest was in the new French Minié rifle, and as a result in May 1851 the Regulation Pattern Minié Rifle was adopted by the British Army. This new weapon was rifled with a percussion lock and used Minié ball for ammunition, but resembled the old Pattern 1842 in terms of appearance with its pinned as opposed to banded barrel.[40]

As the rifle went into issue, there were several problems that arose. First, was the matter of weight. Despite one of the aims of adopting a new arm being to reduce combat weight, the new weapon and 60 rounds of ammunition weighed 17 pounds and 9 ounces, more than both the Pattern 1842 and the Brunswick rifle it replaced.[41] The reason for this lay in the other major problem with the weapon, namely its ammunition which had two flaws. First, the large bore of .702 meant that more material would be required to construct the barrel, adding significantly to the weight of the weapon. Second was that the Minié type was of a totally conoidal form, and as a result lacked any cylindrical section, or in simple terms, it lacked straight sides. This meant that it was easy for the bullet to become misaligned when rammed home, resulting in the bullet exiting the barrel off axis and as a result, accuracy was reduced, particularly at the longer ranges it was hoped the rifle would be engaging at (Fig 4.).[42]As a result, some of Britain's best gunmakers were invited to submit rifles to compete with the Brunswick, the regulation Minié and an improved version submitted by George Lovell of the Board of Ordnance to see if a better solution could be found. Of the rifles to be submitted the entrants by Westley Richards failed to arrive on time and Greener withdrew his design leaving rifles by Lancaster, Purdey and Wilkinson to be pitted against the government designs in the hope of finding a clear winner.[43] The end result was that while the Brunswick and the regulation rifle were shown to be lacking, none of the other entrants could be classed as totally acceptable either. What came of this was a recommendation for a theoretical rifle with a list of features taken from across the range of entrants, but of these the most important are a 3ft 3in barrel held by three bands with three grove

[38] Trial Needle Fire rifle, Copy of Model 1841 Dreyse Needle Rifle. Britain, Enfield, 1850, Serial No. 1. Royal Armouries Leeds Collection (PR.9837) ; Blackmore, *British Military Firearms,* p.224.
[39] Blackmore, *British Military Firearms,* p.227.
[40] 1851 Pattern Rifle Musket, Minié Rifle. British, Enfield, dated 1852. Royal Armouries Leeds Collection (XII.1907).
[41] Blackmore, *British Military Firearms,* p.231.
[42] Smithurst, *The Pattern 1853 Enfield Rifle,* pp. 11-12.
[43] Blackmore, *British Military Firearms,* p.232.

rifling.[44] It would chamber a .577 calibre improved Minié bullet designed by Pritchett (Fig 5.). A sample carbine was made in 1852 with these features, apart from the full length barrel, and became the basis of the new pattern of weapon.[45] From this came a new design of firearm which was to become the Pattern 1853 Enfield Rifle.[46]

Upon its introduction, the Pattern 1853 was the first British rifle to be standard issue and as a result the combat effectiveness of the British army rose dramatically. Compared to the old smoothbore weapons which had a n effective range of perhaps 150 yards under good conditions and still subject to variations in accuracy, the new Enfields were sighted out to 1000 yards and tests showed they could hit artillery piece and crew sized targets as far out as 800 yards with accuracy, which allowed infantry for the first time in history to outrange and outshoot artillery pieces.[47] Even though the infantry would still fight in line, the range at which volleys could be fired would be increased, along with their effectiveness, and specialist marksmen in the light infantry and rifle regiments could get even more out of the weapon. The rifles were so accurate that it was possible to hit a man sized target beyond the range that the human eye could even acquire man sized targets as was seen in the Crimean War. To solve this, riflemen would work in pairs, one with a telescope and one with an Enfield rifle trained on a Russian gun embrasure. When the gunner exposed himself, the spotter would tell the rifleman to fire, resulting in many Russian gunners being killed inside their fortifications.[48] This was likely one of the first, if not the first, examples of a sniper/spotter system in military history.

For all of its advantages and its massive leap forward in firepower, however, it would be inaccurate to call the Pattern 1853 state of the art, and it was not without its rivals on a global scale. In terms of rate of fire, the aforementioned Prussian Dreyse and Norwegian Kammerlader were far more effective due to their breech-loading design and easier to use ammunition which allowed a soldier to put more bullets downrange than his opponent armed with a muzzleloader. Although maybe not as accurate as the Pattern 1853 at long range, tactics had yet to catch up with the new ranges these weapons allowed and in linear warfare these arms were perfectly serviceable, although the massive expenditure of ammunition in its initial military use hinted at a weapon notably less accurate than the

[44] Blackmore, *British Military Firearms,* p.232.
[45] Prototype Pattern 1853 Artillery Carbine. British, Enfield, 1852. Royal Armouries Leeds Collection (PR.5173).
[46] Pattern 1853 Enfield Rifle Musket. British, Enfield, Dated 1855, Serial No. V K2 14. Private Collection B.
[47] Pauly, *Firearms,* p.75.
[48] Pegler, *Sniper Rifles,* p.18.

rifle-musket.[49] In accuracy too, the Enfield had a home-grown competitor in the Whitworth rifle. The Whitworth used a barrel cut with a hexagonal section barrel as opposed a cylinder with rifling grooves cut into it, and in addition to regular expanding ball, it could fire hexagonal section bullets which didn't need to expand to grab the barrel like normal rounds and as such could be made of harder alloys or steel.[50] On the range the rifle was capable of exceptional feats of accuracy, making it a popular rifle for target shooters.[51]The Whitworth was not simply a target rifle though, with examples used in the American Civil War taking a toll on Union Generals, and being prized by Confederate marksmen showing that its $600 minimum price tag (compared to the Pattern 1853 at a cost of $50 to run through the Union blockades) was seen as a worthwhile price to pay.[52] Additionally, Colt produced a line of revolving rifles in large calibres like .64 for military use and these offered all the advantages of the revolver in terms of rate of fire.[53] However, for all their strengths, they also had equal or greater weaknesses, for instance the breech on the Dreyse was liable to leak hot gasses when fired and prone to fouling, and the needle could break, rendering the weapon useless until it was replaced. Despite the success of the Colt revolver as a handgun, the system was cumbersome to use on a rifle, and the shooters forearms was vulnerable to sparks from the chamber or actual bullets should a chain fire occur. Likewise, the Whitworth worked in theory, but specialist ammunition made it an unattractive prospect to generals due to supply chains and although it could be used with Minié type bullets its tight barrel would also get hopelessly fouled after only a few shots had been fired (Figs 6&7). Production would also require re-tooling for the hexagonal barrel, and the design was difficult to produce in large numbers, as Whitworth would later discover. But perhaps where the Pattern 1853 really gained its advantages came from its means of production, where it made as much of an impact on the factory floor as on the battlefield.

When the rifle was first put into production at Enfield, it was intended to be built under the old Ordnance system, with components being subcontracted out to various manufacturers, and the final assembly, fitting and marking being done at the Enfield factory. However, the Crimean war of 1853 caused a panic in the British government, as it was realised that existing stocks were too small to fully

[49]Lugs, *Firearms Past and Present Vol.1,* p.74.
[50] Enfield-Whitworth Rifle. British, dated 1860. Royal Armouries Leeds Collection (XII.2446)
[51] Lugs, *Firearms Past and Present, Vol.1,* p.104.
[52] Pegler, *Sniper Rifles,* p.25.
[53] Colt Revolving Rifle, Military Model. USA, Hartford, Serial No.88. Royal Armouries Leeds Collection (PR.6608).

equip the field army being raised, and existing methods would not allow the factory to produce the desperately needed rifle in time. In the past, ordnance would have sent out agents to purchase or contact new arms from independent gunsmiths, such as those in Birmingham or Liege, and solved the problem that way. But the entire reason for the existence of the Enfield factory was to ensure the government would have their own means of producing the arms they require, so to contract elsewhere would turn the whole Enfield factory into both a national embarrassment as it would still leave Britain vulnerable to being held hostage by manufacturers both at home and abroad and political fiasco for those involved. As a result, Parliament called a Select Committee to look into modernizing it methods of arms production, and to do this they turned to the talents of two Americans, Samuel Colt and Richard Lawrence. Both of these men had exhibited their work at the great exhibition at Crystal Palace and were asked by the government to help bring the factory at Enfield up to speed.[54] At the time, Colt's revolver factory in London was unique in the country, as it was seemingly the only place where entire firearms, from the stock to the muzzle, were manufactured under one roof and by relatively unskilled labourers using mostly machine tools, as opposed to the British Ordnance system of subcontractors. The Colt factory had caused much consternation among the British gunsmiths regarding its methods and working practices, resulting in Colt being slandered as a liar and an impostor, but it would now become apparent to Ordnance that this system of manufacture would be the key to solve their problems.[55]

Lawrence hailed from the Robbins & Lawrence arms factory in Vermont, who exhibited at the Great Exhibition, showing rifles that were completely identical and interchangeable. In addition to being responsible for the construction and use of machinery in producing their own arms, the company specialised in making precision machinery for others.[56] Given their eminent expertise, Robbins & Lawrence were contracted to provide the machinery for the Enfield factory to modernise. When the methods of Colt were combined with the new machinery of Robbins & Lawrence, the end result was an arm that was more precise, constructed faster and potentially interchangeable, or at least to the point of being easily repaired with spare parts made in the same manner. In addition, after the initial capital outlay for the machinery, it was a very cost effective model, which was no doubt of interest to the treasury. In addition to vastly speeding up production, mechanised manufacture opened the door

[54] Joseph G. Rosa, *Colt Revolvers,* (London, 1988),p.30.
[55] Lugs, *Firearms Past and Present Vol.1,* p.477. ; Boorman, *Colt Firearms,* pp.64-5
[56] Lugs, *Firearms Past and Present Vol.1,* p.476.

to another key innovation in the Pattern 1853, which was the manufacture of wholly interchangeable parts. With the use of precise measurements in addition to a set a gauges made to check the fit of parts, the weapons could be made with fully interchangeable components. This would greatly simplify the process of repairing damaged arms and breaking broken parts, and allowed certain precisely made but easily damaged components, such as percussion nipples or lock components to be issued en-mass as spares. In addition, this greatly reduced the workload of the regimental armourer when it came to fixing breakages. By 1857 the new machinery was fully functional and the use of these precise gauges resulted in every rifle made in Enfield from then on to be completely interchangeable. As the new machines and new methods were used, production rose dramatically, eventually peaking at 26,739 rifles in the year ending March 1858.[57]

One of the key reasons for the success of the Pattern 1853 was its widespread distribution. In addition to the production out of the Enfield factory, the Pattern 1853 was produced in massive numbers by private arms manufacturers elsewhere in London and particularly in Birmingham. During the American Civil war around a million rifles were exported, split roughly between the Union and the Confederacy.[58] Unlike the Enfield arms, they were of less advanced construction, made of a combination of machined parts, handmade parts and pieces rejected by government inspectors from the Enfield plant and bought up by the private trade, the only common factor being that these arms were supplied by the private trade, not the Government, irrespective of the origin of their parts. The end result was a weapon of rougher construction that might bear a wide array of proofs and stamps and would usually not be interchangeable, but would still have similar performance to a Pattern 1853 fresh from the government factory.[59] The significance of the Enfield in the American Civil War can be seen in the decision by the confederacy to adopt its .577 cartridge as it's standard calibre, as opposed to the .58 of the American made Springfield Model 1855.[60] Over its lifetime, the Pattern 1853 would see many variations, such as carbines for cavalry, artillerymen and sappers, the latter of which was bored with Lancaster's oval bore rifling as opposed to the grooved rifling of the other models.[61] The further development of the arm would see it take two very different paths, first with the Pattern1858/9 smoothbore models being introduced following the Indian Mutiny. The Pattern 1858 Musket was

[57] Smithurst, *The Pattern 1853 Enfield Rifle,* p.57.
[58] Smithurst, *The Pattern 1853 Enfield Rifle,* p.41.
[59] Smithurst, *The Pattern 1853 Enfield Rifle,* pp.48-9.
[60] Smithurst, *The Pattern 1853 Enfield Rifle,* p.47.
[61] 1856 Pattern Sappers and Miners Carbine with Lancaster's oval bore rifling. British, c.1856

simply an existing Pattern 1853 with the rifling drilled out. The side effect of doing so, apart from the loss of accuracy, was an alarming tendency to explode upon firing due to the thinner barrel walls from the drilling process. Obviously, this was an undesirable trait, especially when issued to troops who had just had come out of the trying times of the Mutiny and the Pattern 1859 was brought into production. the Pattern 1859 was like a Pattern 1853 but being built from the start as a smoothbore, giving it a barrel of necessary thickness.[62] Apart from the smooth barrel and fixed as opposed to adjustable sights, the Pattern 1859 was built in the Enfield factory to the same interchangeable standards as the Pattern 1853 rifles. The second development would be the Snider-Enfield, which saw the weapon converted into a centrefire breechloader, with a conversion mechanism designed by Jacob Snider, which will be expanded on in a later chapter.

As can be seen, the effect of the Pattern 1853 on firearms development, both on the battlefield and on the factory floor, can hardly be understated in its significance. But in terms of ideas, rather than being the work of one mind, the concepts behind the Pattern 1853 and the changes it brought into the production of arms were not entirely new ideas, nor were they the work of one mind. Rifling, percussion and expanding ammunition had all existed, just not yet brought together into one specimen. Even the design itself had rivals that could shoot faster or further, showing that although the Pattern 1853 was an effective weapon, it was hardly top of its class in every respect. The reason these separate concepts came together owes far more to the advanced state of industry allowing the combination of these factors to be practical proposition, rather than the inventive mind of any particular individual. In fact rather than being a case of individual invention, this firearms landmark was effectively designed by committee based of the ideas of others. The real reason for the success of this arm came from its full exploitation of new industrial technologies to produce an arm that was both advanced, ubiquitous, economically viable and made available in massive numbers around the world.

[62] Pattern 1859 Enfield Musket. British, Enfield, Lock Dated 1859, Serial No. 7 E 308. Butt plate stamped 1866 GA (Almost certainly standing for Gwalior Arsenal). Private collection B.

Chapter 3 - Colt 1851 Navy

Alongside the Pattern 1853 Enfield, Samuel Colt's Model 1851 Navy can be seen as another key turning point in firearms production and in the development of the firearms as a mass product. Whereas previous designs of Colt revolver had seen some military use, the 1851 Navy was one of the first revolver designs to see mass military service as well as civilian success, and was the one of the first generation of colt designs which saw the full advantages of manufacturing quality and precision that could be achieved at the Hartford factory. The 1851 Navy was accurate, reliable, affordable, sufficiently powerful and most importantly of all, it was far in advance of the single shot (and usually smoothbore) percussion pistols that were the standard for personal defence and military use at the time. Despite the mystique and legend built around the man, the concept of the revolver was not unique to Colt or indeed new to the nineteenth century. With early designs dating as far back as at least the mid seventeenth century, it was rather a case of an existing idea made practical by the new methods of the time. Also, just as important as the design of the weapon is the machinery it was made on, with the Hartford factory being an evolution of Colt's previous experience making arms at the Paterson plant, and his designs licensed to Whitney. Despite having its rivals, the 1851 Navy secured a solid position as one of the most popular revolvers of the day thanks to its ubiquity as both a weapon and as a product and showed that the future of pistols, for the time at least was with the revolver.

First, it is important to discuss the origins of the revolver. The revolver was not a new concept, but rather one that had been in existence for a very long time, Examples of Wheelock revolvers can be found from as far back as 1610, such as in a manually rotated six-shot cylinder weapon firing from a single barrel from Germany.[63] Additionally, snaphance revolvers with rotating cylinders firing through a single barrel can be found as far back as the 1670's and 1680's.[64] The existence of these weapons show quite clearly that the concept of a handgun that uses a rotating cylinder to fire multiple shots was a well established concept for centuries before Colt's birth. If these weapons existed around two centuries before then why did these designs never catch on? To answer this question we must look at

[63] Rosa, *Colt Revolvers,* p.8. ; Wheelock six shot revolver, about 1600. German, by Paul Dubler. Royal Armouries Leeds Collection (XII.1078)
[64] Howard Blackmore, *Firearms,* (New York, 1964) p.118.

the arms themselves, and while on a first glance they appear to have the capacity to function as advertised, it is clear that the level of industrial sophistication in both action and finish is relatively low. One of the main problems comes from the means of ignition, as both Wheelock and Snaphance revolvers would have required either re-priming between each shot, reducing the rate of fire which was the main advantage of these pistols over simpler single shot designs, or a more complicated system of pan covers or multiple locks.[65] Work around solutions were attempted, such as a Flintlock revolver by Annely from the 1680's which has a system of retracting powder pans on each chamber of the cylinder and a similar attempt by John Dafte, but this did little to reduce the mechanical complexity of an already complex weapon.[66] Chain fire was also a problem, where the sparks from one shot set off other chambers, usually damaging the weapon with the potential to injure or even kill the operator.[67] Additionally, reloading was still a slow and cumbersome affair, meaning that after the shots had been discharged the weapon took longer to reload than a single barrelled arm, thus resulting in a poor sustained rate of fire. On the other end of the spectrum, there was the problem of the ignition method failing to ignite the gunpowder, a serious issue in flintlock firearms in general. In terms of construction, these arms were made by hand with non-interchangeable parts and without even standardised measurements. As a result, it would be difficult to make strong gas seals, these arms took a long time to build and could be very difficult to repair when their delicate mechanisms went wrong. Even by 1818, Elisha Collier's flintlock revolvers, which may well have been seen by Colt, suffered from the sheer complication of the design and an antiquated form of ignition.[68] The combination of low reliability and high unit cost resulted in a lack of patronage from military and civil organizations in need of firearms, dooming the production of revolvers to a fate of being commercially unviable. Various gunsmiths had tried to create practical revolvers but all found themselves defeated by the above problems.

The nineteenth century saw the arrival of the practical revolver due to two key factors. The first was the percussion cap. This new means of ignition was vastly more reliable than the flintlock, as is shown in the previous chapter, but equally important was the size of the new system. Whereas a flintlock

[65] Rosa, *Colt Revolvers,* p.8.
[66] Flintlock Revolver. Annely, c.1680. Royal Armouries Leeds collection.
[67] Rosa, *Colt Revolvers,* p.8.
[68] R.L. Wilson, *Colt, An American Legend,* (New York, 1985) p.10. ; Lugs, *Firearms Vol.1,* pp.208-9; 'Flintlock Revolver by Elisha Collier (Britain), dated 1818. Victoria & Albert Museum Collection (M.680-1927).

weapon required a relatively large lock and powder pan or even in some designs an individual lock for each cylinder, a percussion weapon simply needed a hammer mechanism with sufficient force to ignite the fulminate in the cap, allowing pistols to be made far smaller than before. By replacing the powder ignition with a cap which would still operate upside down or when exposed to damp, it was now possible to position this on each end of the cylinder, removing the need to prime the weapon with powder before each shot. Complicated systems such as the automatic priming powder magazine found on Collier's Revolvers could be consigned to the dustbin.

The next key invention was the development of modern mechanised means of production, as used in the American system of manufacture. Revolvers will always be more mechanically complicated than a single shot muzzle loading arm, and as such require precisely made components to make their mechanisms operate reliably. As a result, previous revolvers suffered from having hand built parts which required both large amounts of time and the use of skilled craftsmen. The American system of manufacture, with its use of machine tools and gauges to allow for interchangeable components enabled these fine parts to be made cheaply, quickly and in large quantities. As a result, for the first time in history it became feasible to make complicated mechanisms in large quantities, making the revolver a viable concept.

These two inventions heralded a revolution in firearms design and production, and it was onto this background that Samuel Colt began his career as a gunsmith. Having claimed to have drawn inspiration for a revolving gun from the wheel of a sailing ship, Colt set out to design a practical revolving pistol, taking advantage of these new technologies.[69] Following the production of some prototypes beginning in 1832, Colt applied for European patents which were granted in 1935 and followed in 1936 by US patents and set out produce his own revolving firearms.[70] Opening a factory in Paterson, New Jersey, Colt began in 1836 to produce his first pistols, known as the Paterson revolvers, which came in several variations, as well as rifles which operated using a similar mechanism.[71] Compared to the standard single shot pistols of the day, the Paterson pistols were a great advance, incorporating features such as 5 shot single action operation, percussion ignition,

[69]Boorman, *Colt Firearms,*pp.34-5.; The inspiration may just as likely have come from an example of a matchlock revolver he saw in the gun shops of Calcutta. Colt was nothing if not a promoter!
[70] Rick Sapp, *Standard catalog of Colt Firearms,* (Iola, 2007) p.31.
[71] Charles T. Haven and Frank A. Belden, *A History of The Colt Revolver and the Other Arms Made by Colt's Patent Fire Arms Manufacturing Company from 1836 to 1940,* (New York, 1978) p.20.

mostly metal construction built with machinery, a folding trigger that deployed when the weapon was cocked and chambered in a much smaller calibre such as .28, .31 or .36.[72] In contrast, the standard US military pistol, issued in 1837 was a smoothbore flintlock bored for .54 calibre ball, which despite being manufactured in relatively advanced American arsenals, would not have been unfamiliar to a soldier of 1737.[73] Clearly this was a great leap forwards, and it would be fair to call this weapon the world's first practical and modern revolver, as once loaded, it would operate in a similar manner as a modern single action revolver would today.[74] Rifle variants were also produced using a similar system with the intent of arming soldiers for military service, although revolving rifles would never be as popular as revolving pistols in either attitudes or numbers produced.[75]

The Paterson however, was not without flaws, and although it saw civilian purchase, a large-scale military order to financially underpin the factory proved elusive. One particular bone of contention was the mechanical complexity of the weapon itself, which did little to endear it to naturally conservative and cautious US Ordnance officials and as a result saw no major orders. A report from the US Navy on the suitability of Colt's weapons for shipboard use stated (seemingly without evidence) that the greater risk of mechanical failure outweighed the firepower offered for use in boarding actions, and therefore could not recommend a purchase order.[76] Mechanical issues were to cause even more serious problems for Colt when one of his revolving rifles chain-fired at an 1837 Ordnance Board test, costing him another contract and sealing the fate of the Paterson arms in the eyes of the US Ordnance.[77] While some small private orders were made to supply soldiers in the 2nd US Dragoons, Colt was unable to secure any significant US military or government contracts and the Paterson plant and the company went bankrupt in 1842.

With his factory gone and no government orders to rely upon, it would appear that the story of Colt's revolvers would be the same as countless others, a good design defeated by mechanical flaws and lack of orders. However, Colt would go on to be saved by another key factor in the Colt story, the events of the world around him. Some of the Paterson weapons, both pistols and rifles came into the

[72] Sapp, *Standard catalog,* pp.32-4.
[73] Haven & Belden, *A history of the Colt Revolver,* p.43.
[74] Single action refers to a weapon that must be cocked before the trigger is pulled; pulling the trigger alone will not fire the weapon.
[75] Boorman, *Colt Firearms*, p.43.
[76] Report from the Secretary of the Navy in compliance with a resolution of the Senate, in relation to the improved boarding-pistols and rifles invented by Samuel Colt, May 6th 1840, p.4.
[77] Haven & Belden, *A History of the Colt Revolver,* pp.32-4.

hands of several individuals who found themselves on the front lines of America's battlefields. First was the use of Colt weapons in the 2nd Dragoons, engaged in the later Seminole wars in Florida, where the utility of the Paterson pistols and rifles in the Everglade swamps against native Seminole Indians was praised, gaining notice of those in the military establishment looking for new ways to arm American troops.[78] Lieutenant Colonel Harney of the 2nd Dragoons and many of his officers and men would go on to write letters of support and approval for Colt when he would later approach the Government to sell his improved arms.

Secondly, and perhaps more importantly, were the Patersons that were purchased by Texas (then an Independent Republic) and used by the Texas Rangers. The weapons found themselves used on many occasions against Comanche Indians, and in one skirmish which came to be known as 'Hays' Big Fight' a small group of 15 rangers armed with Paterson revolvers held off and defeated a numerically superior force of around 80 Comanche warriors, leaving 33 of the attackers dead.[79] Following the Annexation of Texas into the US as the 28th state, General Zachary Taylor, another Seminole veteran and Colt supporter, lead an army of three to four thousand into Texas over fears of conflict with Mexico, and among the equipment requested were 150 Colt pistols and carbines.[80] Following the integration of the Rangers into the US army, demands for effective revolvers were renewed, and while back in Washington on a recruiting drive, Captain Samuel Walker of the Texas Rangers organised the signing of a contract for Colt to produce 1,000 'Heavy Revolvers' on behalf of the US Ordnance Department.[81] The new design would come to be known as the Whitneyville Walker Colt, or more simply as the Colt Walker.

The provenance of the Walker design is a cause for debate, with the traditional story being that it was a collaborative effort between Colt and Walker, based off the experiences of the Texas Rangers with the Paterson model and the changes that Walker would like to have seen. However, Haven and Belden argue that it was actually the culmination of various tweaks and fixes added to production Patersons and experimental models by Colt, with minimal to no input from Walker, as all of the new features can be seen in Paterson era production variants.[82] Regardless of its designer or designers,

[78] Haven & Belden, *A History of the Colt Revolver,* p.33.
[79] Boorman, *Colt Firearms,* p.44.
[80] Haven & Belden, *A History of the Colt Revolver,* p.46.
[81] Boorman, *Colt Firearms,* p.45.
[82] Haven & Belden, *A History of the Colt Revolver,* pp.25-32.

the Walker was far simpler, more rugged than the Paterson and far larger too. The Walker model came with a nine inch .44 calibre barrel fed from a 6 shot cylinder. Single action was retained but the mechanism was greatly simplified, deleting the folding trigger for a normal fixed trigger in a large brass trigger guard and reducing the total number of moving parts in the mechanism.[83] A loading lever was added as standard and the complete weapon weighed 4 lb., 9 oz. In addition to its physical characteristics, the weapon was made for Colt by Eli Whitney Jr., in his Whitneyville plant using machinery and techniques far more advanced and well organised than Colt was able to use at his Paterson factory. The contract also stipulated that Colt would reclaim his patents, which went defunct along with the Paterson company, and that we would become the eventual owner of the special machinery used to produce the Walker guns, which would go on to become the nucleus of his later Hartford plant.[84] The Mexican-American War, and the publicity the revolvers gained during the fighting, would signal the reversal of Colt's fortunes and the success of the Walker models gave Colt the necessary capital to set up a new factory in Hartford in 1848. This new plant would produce his new designs, the Holster revolver, now known as the Dragoon, a large .44 calibre weapon which was essentially a refinement of the Walker design and the smaller Model 1849 Pocket Revolver line designed as personal protection weapons.[85] In addition to the Whitneyville machinery and his improved designs, Colt had another major advantage in his Employment of Elisha Root as his factory superintendent. An old friend of Colt, Root had years of experience in operating and organizing factories for efficient production, and with the production and administrative side of matters under control Colt could focus on arguably his greatest talent, his skill as a showman and entrepreneur. To give an idea of the precision of the plant machinery, of an order for another thousand Walker Revolvers to the US government placed in 1848, only 1% of the order was condemned by inspectors, as opposed to the 12% of the original batch.[86] Almost immediately after the Hartford plant began production the Californian Gold Rush of 1849 saw a massive demand for personal protection firearms coming from prospectors heading east. The pocket filled this demand perfectly, with its reliable firepower and handy size and as a result the Hartford factory found itself flooded with orders. On the

[83] Mike Cumpston & Johnny Bates, *Percussion Revolvers, A Guide to their History, Performance and Use,* (New York, 2007), p.43.
[84] Haven & Belden, *A History of the Colt Revolver,* p.49.
[85] Model 1849 Colt Pocket. US, Hartford, Dated 1860, Serial No.179119. Private Collection B. ; Model 1848 Colt Dragoon. US, Hartford, about 1851, retailed in London. Royal Armouries Leeds Collection (XII.1431).
[86] Petition of Samuel Colt, Praying a Contract for Supplying the Government with an additional number of his repeating fire-arms, December 12, 1848, pp.1-2.

military front interest had been piqued by the performance of the Walker and the Dragoon models being ordered by both national militaries and state militias.[87] In addition, an order of Dragoon revolvers was ordered by the British Board of Ordnance for testing.[88] This new surge of orders ensured that Colt was financially secure and it appeared that the revolver would finally escape from obscurity after two centuries of experimentation. It was against this background that Colt would design the Model 1851 Navy, which would be one of his greatest success stories. With more than 215,000 examples produced in Hartford and a further 42,000 in London, the 1851 Navy was a commercial and critical success story, and certainly one that deserves a closer look at why it became the success it did.[89]

The Colt range already had two perfectly practical revolvers in the 1849 Pocket and the Dragoon pistol, both single action revolvers like the 1851 Navy. Indeed, the Pocket was produced in greater numbers than the 1851 Navy, with around 325,000 made across its lifespan.[90] However these pistols occupied two extremes, with the Pocket being too small in calibre for military service and the Dragoon being rather large and heavy, despite chambering a powerful round. The 1851 Navy was designed, as may well be guessed, for Naval service where the qualities of the revolver, such as its capacity and near watertight design would be useful in shipboard use, particularly in boarding actions. A .36 calibre was chosen to give the necessary power to perform in close range, and to allow the design to be more compact than the large frame .44 Dragoons, and despite its smaller size, it was still accurate thanks to its rifled barrel.[91] It was light enough to wear comfortably on a belt holster and compact enough to conceal if necessary. This made it a highly desirable choice for militaries, police, other civil authorities, civilians and anyone else who wanted compact and reliable firepower. Ultimately the Navy was the 'jack of all trades' of the Colt line, making full advantage of nearly twenty years of experimentation and development

The production methods being used at the Hartford plant were also far in advance of previous Colt operations in terms of precision, speed and capacity. Whereas the Paterson plant suffered from the delay between opening and the production of the first guns, Hartford had both the staff and the

[87] Haven & Belden, *A History of the Colt Revolver,* p.57.
[88] Colt Dragoon 2nd Model. US, Hartford, Ordered for Board of Ordnance 1851 revolver trials, Serial number 92268K. Royal Armouries Leeds collection (XII.908)
[89] Sapp, *Standard catalog,* p.43.
[90] Sapp, *Standard catalog,* p.41.
[91] Colt Model 1851 Navy. US, Hartford, Dated 1957, Serial No. 77126. Private Collection B.

capacity to meet orders rapidly despite increased demand and even to allow for custom specifications. This precision also allowed interchangeablity, although even though it was advertised, truly interchangeable designs were only available by the late 1850's. As well as the technical advantages, machine manufacture and division of labour made the final product profitable once the initial start-up costs were covered. Due to the scale of production, Colt was able to produce quality weapons from quality materials, yet still reach a reasonable retail price due to the economies of scale and efficient production, allowing the weapon to be a successful mass product. Whereas many firearms were expensive to customise and required specialist craftsmen to produce, Colt revolvers could be ordered with customised decoration, calibre and barrel lengths from the factory, allowing a buyer to personalise their weapon, which in turn gave these custom weapons a reputation as a status symbol. Even a standard pistol came with cylinder engravings, made possible by advances in machine engraving such as the grammagraph invented by W.L. Ormsby of New York.[92] Combined with Colt's methods of achieving sales and prestige by giving custom presentation guns to people of note, particularly those who may have placed large orders for his weapons or who may be in place to influence such an order, this helped his revolvers attain a desirable level of status. The Prince Albert presentation pieces are an excellent example of the fine specimens produced for presentation by Colt. The fact that his patents ran until 1859 meant that Colt effectively had a captive market for most of the 1850's further cementing his success.

Of course, a good design alone does not guarantee success, and the combination of Colt's skill as a salesman together with international events would conspire to bring the Model 1851 Navy to worldwide acclaim. The Great Exhibition at Crystal Palace won him notice in Europe, along with a lecture to the Institution of Civil Engineers in November 1851 which helped pave the way for his London factory, thus giving Colt a factory on both sides of the Atlantic. The Crimean War of 1853 increased demand for firearms from militaries and saw the Model 1851 Navy tested in battle, a test which it passed perfectly well bringing yet more publicity and orders. The Indian Mutiny would also show the value of the revolver in close quarters, although by then other competitors had arrived on the scene. Meanwhile in the US, the experiences of troops armed with Colt firearms in Florida and Texas, as well as settlers and gold prospectors in the new west seemed to be enough to convince the conservative minds at the US ordnance that the revolver was indeed worth adopting. Of course the

[92] Boorman, *Colt Firearms,* p.46,

backing of Walker, Taylor and other Mexican war veterans in an 1849 report to the Senate must have helped lessen the resistance to change.[93] By the time Ordnance testing on the Model 1851 was undertaken, it was determined that the revolvers were more reliable than any design currently in government use.[94] Despite his intention that for design to be used at sea, it was actually the US Army that used the most Model 1851's sold to the US Government. It is fair to say that the Model 1851 helped sound the death knell of the single shot military pistol; the future was in the revolver.

Interestingly, like the Pattern 1853 Enfield, the 1851 Navy was a weapon that despite its successes was not without its rivals, and in some ways its rivals were in advance of it. Perhaps the fiercest rival of the 1851 Navy at least in terms of personal rivalry was the family of revolvers developed by Robert Adams, which included the Deane-Adams, Deane, Adams & Deane and the later Beaumont-Adams revolvers. These weapons linked the trigger to the hammer, making them double action weapons and as a result, capable of a greater rate of fire in close quarters.[95] This advantage allowed the Adams revolvers to be fired faster than the Colt designs by doing away with manipulating the hammer, increasing firepower at the cost of accuracy and in addition the weapon also had a closed frame, in which the frame covers the top of the cylinder, as opposed to the open frame of the Colt.[96] The advantage of this is that with an open frame revolver wear and tear, as well as gunpowder corrosion can cause gas leaks over time, whereas a closed frame holds the cylinder close enough to the barrel to minimise this risk. However, the Adams revolvers were not without drawbacks. The double action operation left it with a harder trigger pull, making the weapon harder to shoot with accuracy at range, as well as requiring more parts per weapon, an important reliability and maintenance concern. The later Beaumont-Adams design did mitigate this somewhat by adding a hammer spur for single action operation, but the pull would always be heavier than a single action weapon by design. The cylinder also only held around 12 to 15 grains of powder, as opposed to 30 in the 1851 Navy, equating to less muzzle velocity and a subsequent reduction in range and power.[97] Additionally, the Adams was handmade, meaning that the unit price was far higher and the parts were unlikely to be

[93] Report of the United States Senate on Colt's Arms, February 12, 1849, p.1.
[94] *Report of the United States Senate on Colt's Arms*, 30 January 1851, p.3.
[95] Rosa, *Colt Revolvers,* p.43.; Double action refers to a weapon which can be cocked by simply pulling the trigger, as opposed to having to cock the weapon first to prime it. The cost of this is an increase in the force needed to pull the trigger compared to a single action system.
[96] Deane, Adams & Deane Revolver. Britain, marked patent 6869, Retailed by LePage Moutier, Paris. Private Collection B. ;Beaumont Adams Revolver. English, around 1865. Royal Armouries Leeds Collection (XII.4727)
[97] Rosa, *Colt Revolvers,* p.45.

interchangeable. Another drawback was that the weapons were only supplied in cased sets, an unnecessary expense for military orders.[98] These last two drawbacks added up to a big loss in the eyes of practically minded military establishments. Ultimately, despite sales with the British Army and some commercial success, the Adams revolvers were never able to replicate the levels of success and utility of the Colt designs.[99] Other designs competing with the Colt were the various European revolvers using the pinfire system of Casimir Lefeaucheux, where the ammunition is self contained and fired by depressing a pin which protrudes from the casing (Figs. 8&9). These arms would come in various forms from sensible pocket pistols to double-barrelled 20 shot monstrosities, but all had the obvious advantage of self-contained ammunition.[100] The designs were popular in Europe, with the French government adopting the M1855 revolver, and types of pinfire revolver would go on to be highly popular in the American Civil War, with imported Lefeaucheux pistols being the most popular imported pistols.[101] However, pinfire ammunition is a risky proposition; accidentally pushing the firing pin will ignite the round even if not loaded into a weapon, making storage a difficulty. Once loaded, the weapon must also be kept with the hammer off the pin at either half or full cock and thus capable of being fired. This means that as long as the gun is loaded, a pinfire weapon is never truly safe, whereas the hammer of a Colt could rest on a percussion cap without discharging the weapon. In addition, the weapon would be forced to rely on factory made ammunition, whereas in the rugged new west of America or on Campaign, the Colt simply required lead to be cast into bullets, along with equally available powder and caps, making the simpler weapon a better choice for settlers, outdoorsmen and troops on patrol in hostile conditions.

It is clear that the 1851 Navy is a milestone in the development of the nineteenth century firearm, in terms of both the firearm as a weapon and in terms of its production as an industrial process. Despite the considerable persona built up around Samuel Colt it is clear that for all his talent, the key element that allowed his Model 1851 Navy Revolver to become the success it was is the level of industrial and technical sophistication afforded by the advances of nineteenth century industrial technology, which in turn allowed the revolver to become a viable arm both practically and economically. The earlier failure

[98] Adams Revolver, Model 1856 Army, cased with accessories. English, London, about 1856-6. Royal Armouries Leeds Collection (XII.1479).
[99] Rosa, *Colt Revolvers,* p.43.
[100] Dennis Adler, *Guns of the Civil War,* (Minneapolis, 2001) p.227. ; Pinfire Six Shot Lefeaucheux Revolver. Belgian, 1860. Royal Armouries Leeds Collection (PR.4687).
[101] James E. Hicks, *French Military Weapons,* p.82. ; Adler, *Guns of the Civil War,* p.223.

of his Paterson plant proves this point quite clearly. The 1851 Navy was produced in huge quantities across its production lifespan in one of the most advanced factories in the world, yet was still affordable enough for both government and private buyers. In addition to this the events of the 1850's which were clearly out of Colt's control allowed him to find markets for his weapons, allowing his designs to succeed financially, commercially and militarily where previous types of revolver had failed. While the design was not without its rivals, its utility and the ubiquitous nature of the Model 1851 allowed it to survive and thrive as the future of handguns in the 1850's. Ultimately, this gives further evidence that the nineteenth century revolution in firepower owes more to advances in industry and demand than to original design.

Chapter 4 - New ammunition and old weapons: The Cartridge Conversions

The availability of new industrial techniques had by the 1860's enabled a new generation of weapons to arise, based on very old ideas made feasible thanks to new advances in manufacturing. However, there was still room for improvements with regards to existing designs, and of these the most important would be the method of loading. It has long been known that a weapon which loaded from the breech would be far superior than on loading from the muzzle in term of speed and accuracy. Just like the revolver, breech-loading was a concept that had been tried with varying degrees of success for centuries. Indeed an early example can be seen in a Wheelock breech loader belonging to King Henry VIII, dating from 1537.[102] Later and more successful and practical designs such as the Fergusson Rifle and the aforementioned Hall Rifle, showing the breech-loading rifle was a proven concept that had been used by various gunsmiths over a period of centuries.[103] The revolution in firepower had its beginnings in three concepts, the need for firearms capable of accurate fire, the need to outrange the enemy and the need for rapid fire, as these are three key aspects by which firepower can be increased. In addition, reliability is also paramount, as a jam or any other mechanical failure will result in even the most advanced weapon being reduced to little more than a bayonet mounting or worse, an unwieldy and expensive club. The best way to accommodate these factors in the rifle would be to load from the breech. However, by this point it was becoming clear that as long as ammunition remained in the form of cap, ball and powder, the firearms would effectively plateau. For example, breech-loading weapons would be, in theory, faster to load and fire than their muzzle-loading counterparts, yet tests performed using the US Hall rifle showed a negligible difference in time to load and fire, due to the form of ammunition.[104] There was also the issue of gas leakage, as any breech-loading weapon had to be airtight against the explosive gasses of a powder charge. This requires a high degree of precision, and the corrosive nature of black powder made this even harder to achieve. Any new designs would need to first tackle the problem of creating practical self-contained ammunition. However, as Samuel Colt was to discover in his first forays into the world of gunsmithing,

[102] Breech loading Wheelock gun of King Henry VIII. Probably English, dated 1537, probably made by William Hunt. Royal Armouries Leeds collection (XII.1).
[103] Pauly, *Firearms,* pp.22-3.; Blackmore, *British Military Firearms,* pp.71-2.
[104] Report from the Secretary of the Navy in compliance with a resolution of the Senate, in relation to the improved boarding-pistols and rifles invented by Samuel Colt, May 6th 1840, p.4.

meeting these requirements does not guarantee success, particularly when it comes to convincing stubborn ordnance boards! In fact, there were many successful designs in use with civilians throughout the 1840's, 50's and 60's, and even in general service with two European militaries, but mass acceptance of the breech loader would not come easily. Just like the revolver, it would take war and its experiences to prove that the future of small arms lay in that direction. Interestingly, these conflicts would also give rise to a new weapon, the repeating rifle, which would face even greater trials for acceptance. Even then, rather than follow that path of purpose built arms, many governments chose to simply adapt their old weaponry to the new system, creating the breechloader conversions, such as the British Snider-Enfield and the various models of percussion revolver converted for cartridge use. This in turn shows that the advance in firearms technology is not a path simply determined by new developments.

The concept of the breech-loading weapon has many advantages, particularly for long arms. First, firing from the breech will ensure accuracy as the round doesn't need to be small enough to fit down the barrel, ensuring that windage becomes a non issue, as well as having the side effect of allowing all the energy of the round available to push the projectile, as opposed to leaking round the sides. Loading speed is increased, with the added advantage being that the user can reload while crouching, prone or taking cover without exposing themselves to fire, as well as disposing of the need for a ramrod, which can snap or be lost, rendering the arm useless. In addition, the passage of the round will clean the bore of any residue, aiding in cleaning and maintenance. Also, loading revolvers from the rear would make the reloading process easier and faster, removing the need for loading levers. However, as many gunsmiths who tried would come to find, making a breech-loading weapon is a far more complicated venture than a simple muzzle loader, and as such most designs were hindered by two factors: Manufacturing tolerances and suitable ammunition. Until the mid nineteenth century, it was very difficult to make the precise fit and mechanisms required for a practical breech-loading rifle. Early designs were dogged by either the cost of craftsman design or leaky gas seals or both. Even more recent designs like the Hall suffered from leaky seals.[105] However, the new machine construction techniques being pioneered on both sides of the Atlantic made it possible to construct arms to precise tolerances while remaining affordable.

[105] Lugs, *Firearms Past and present,* pp.46-7.

The second, and perhaps more important issue is ammunition. While loose ball and powder is perfectly fine for muzzle-loading, breech-loading weapons require a much more precise solution. The deficiencies of existing ammunition meant that even a breech-loading design was not much faster to load and fire in practical terms than a muzzle loader, so what was required would be a self-contained cartridge which would dispense with the delay altogether. Also, if a cartridge case could expand when fired then it would dispose of the need for a gas-tight seal in the arm itself, as the casing would provide this seal, in a similar manner to a Minié ball removing the need for a tight fit between bullet and bore by expanding itself. Work on self-contained ammunition can be traced to the Swiss gunsmith Samuel Johannes Pauly and his patent cartridge of 1812.[106] Whilst existing musket cartridges were simply paper tubes holding loose powder and ball, Pauly's cartridge was a self contained system incorporating ball, powder and a fulminate compound inside a shell casing. When the cartridge was struck by the weapons hammer, the fulminate would ignite the powder, the shell case would expand to fill the barrel and the ball would be fired.[107] Like many advanced inventions, Pauly did not benefit from being so far ahead of his time, and found little commercial success, dying effectively forgotten and destitute.[108] However, his ideas were to influence two of his associates, Casimir Lefeaucheux and Johann Nikolaus von Dreyse, who would go on to develop two differing but influential types of self contained ammunition. As mentioned in previous chapters, Lefeaucheux developed and patented the pinfire system, an effective if somewhat dangerous type of ammunition that saw popularity in Europe until something safer could be developed.[109] As well as revolvers, pinfire rifles, derringers and shotguns were produced and sold. Evidently, enough customers saw the advantage of practicality at the cost of safety a price worth paying, although the system didn't have a major impact on military long arms, only on revolvers. Dreyse would develop an alternative system of ammunition known as needle fire.[110] In this system, the cartridge consisted of a paper tube containing ball, powder and a percussion cap. Unlike Pauly's system, where the fulminate was located at the rear of the cartridge, the cap was placed behind the bullet and in front of the powder charge. The system used a needle to pierce the paper skin and ignite the cap, thus firing the round. Although this system seems overcomplicated at first glance, the advantage of placing the cap within the cartridge allows for a more

[106] Centrefire Breech Loading Pistol. French, 1820, Pauly's patent, possibly made by H. Roux. Royal Armouries Leeds Collection (XII.3890).
[107] Lugs, *Firearms Past and present,* pp.76-77.
[108] Pauly, *Firearms,* pp.94-5.
[109] Lugs, *Firearms Past and present,* p.78.
[110] Pauly, *Firearms,* pp.95-6.

even powder burn, making for a more efficient weapon. The archetypal needle fire weapon was the Needle Rifle developed by Dreyse himself which bears his name, a single shot bolt action weapon first designed in 1836 and which was adopted by the Prussian Army and first saw service in 1848.[111] While an advanced design, the Dreyse suffered mechanically from gas leaks due to the lack of fine tolerances used in its production combined with the fact that unlike the Pauly or Lefeaucheux systems the ammunition did not have a case. Needle breakages were also a problem for the weapons, as without the needle the weapon was useless. Regardless, the weapon saw continued service until the 1870's, with revisions to the original design in 1862 and 1865.[112]

Other approaches were tried, such as the innovative Norwegian Kammerlader rifle of 1842. Arguably the first successful military breechloader, the Kammerlader used a crank system to force a gas tight seal around the breech, eliminating the problem of leakage. The ammunition was simply a paper cartridge containing powder and a Minié ball, ignited by percussion cap, but the design worked as intended. Interestingly, the Norwegian military seemed to be decades ahead of conventional thought with regards to tactics and use, with the rifle being developed for a more fluid skirmishing style of infantry warfare, making use of the breechloaders ability to be fired prone or from cover, rather than the doctrine of massed ranks and rifle volleys in set piece battles. By contrast the Prussians view on the advantages conferred by the Dreyse range from happy accident to seeing firing prone as an affront to the martial spirit of the soldiers profession![113] Another approach was Samuel Colt's revolving rifles. Essentially using up scaled versions of his revolver actions, Colt produced rifles alongside his more popular pistols. However, these were still cap and ball based systems, and reloading was an arduous procedure, unless a replacement cylinder was on hand, and sparks given off by the action could burn the firer's forward hand, making it somewhat uncomfortable to use!

The next real advance would come in the form a Rimfire, a system still used today for certain target rounds. Rimfire rounds contain the primer needed to ignite the rounds charge around the rim of the base of the projectile, and are then struck by the weapons hammer. The first Rimfire round was the .22 BB Cap, developed by Louis Nicholas Flobert for indoor target shooting.[114] The round was little

[111] Pauly, *Firearms,* p.96.
[112] Dreyse Model 1862. German, 1862, Serial No.26. Royal armouries Leeds Collection (PR.11516) ; Needle Fire Bolt Action Military Rifle German, Hesse, about 1865. Royal Armouries Leeds Collection (XII.2506).
[113] Lugs, *Firearms Past and present,* pp.74-5.
[114] Lugs, *Firearms Past and present,* p.78.

more than a bullet fitted onto a percussion cap with a rim added to load it into the chamber a of a weapon, and the bullet was propelled by the primer. As a result, it had a very short range, and was completely useless for anything less than paper targets. In the US, attempts at self-contained ammunition were being attempted by Jennings and Hunt, resulting in the development of 'Rocket Ball' ammunition and the Hunt, Jennings and Volcanic repeaters.[115] The round was more akin to a musket ball in shape, giving it greater potential than the Flobert, but was still dogged by unreliability and lack of power. Rollin White, initially an employee of Samuel Colt developed a more effective system with potential to be used in self-defence applications, developing a series of .22 calibre Rimfire revolvers for Smith & Wesson.[116]Although .22 was a rather over optimistic cartridge for self-defence, the principle stuck and laid the ground for further advances. Additionally the work done by Benjamin Tyler Henry on the Jennings and Volcanic repeaters helped lay the groundwork for his own eponymous rifle and the cartridge he designed for it, and the significance of this design would soon be seen.

The cartridge would eventually see its worth in battle proven with the American Civil War. Although most troops would be issued with muzzle-loading rifles, the war also saw a smaller but not less significant issue of more advanced weapons, and one of the best known amongst these was the Sharps Breech-loading Rifle.[117] The Civil War era Sharps loaded a paper cartridge into the breech which was ignited by a percussion cap contained in a tape primer to increase its rate of fire.[118] Post-war models were produced in the centrefire .50-70 government round starting in 1866. Ballistic performance was comparable to a muzzle loading rifled musket, yet it was capable of much higher rates of fire, six to ten rounds per minute was possible compared to a maximum of three. Many other breech loaders were used such as the Burnside and Starr carbines, and these new types of rifle were generally well received.[119] The war also saw the advent of practical repeating rifles in military use, such as the Henry and Spencer repeating rifles. Just like the breech loader, the repeating rifle had been experimented with as far back as the mid seventeenth century, such as an example from 1690

[115] Harold F. Williamson, *Winchester, the gun that won the west,* (1952, New York),pp.9-10.
[116] Lugs, *Firearms Past and present,* p.78. ; Smith & Wesson Model 1 1/2. US, about 1859. Royal Armouries Leeds Collection (PR.2297).
[117] Alder, *Guns of the Civil War,* pp.174-6.
[118] Sharps Model 1855 Navy Rifle with Maynard Tape Primer. US, about 1856. Royal Armouries Leeds Collection (XII.3264).
[119] Breech Loading Starr Military Carbine. US, Manufactured by the Starr Arms Company, Yonkers, New York, about 1866. Royal Armouries Leeds Collection (XII.2415).

of a magazine fed rifle by John Cookson, but had never assumed any remotely practical form.[120] Also, while the initial Sharps designs used a single paper cartridge loaded into the breech and percussion tape primer, the Spencer and Henry Repeaters both used Rimfire rounds in much larger calibres than in the Rollin White revolvers, being chambered in both 55-56. Rimfire and 44. Henry respectively, which fed from tube magazines (Fig 10.).[121] These larger rounds made them powerful enough to see battlefield use, although the Henry in particular suffered from an arcing ballistic trajectory and low muzzle energy which limited to ranges of less than two hundred metres. Despite these weaknesses, they developed a fearsome reputation, particularly amongst units likely to find themselves in close fighting such as cavalrymen or infantry storming fixed positions. Here is evidence of weapons designed to make effective use of the new cartridge designs.

Nonetheless, it was becoming clear that while self-contained ammunition was the future; Rimfire was incapable of creating a powerful enough round for military use. In addition, the process of manufacturing the round was complicated, as it required the primer to be set inside the shell casing. The solution would come in the form of centrefire primers, a much simpler solution to produce and one capable of more powerful rounds. These primers were developed on both sides of the Atlantic by Berdan in America, patenting in March 1866 and Boxer in Britain, who patented his invention in October 1866. Although the designs shared slight differences, the mechanics behind them were the same in practice.[122] A primer, which is essentially a percussion cap, is placed at the base of the cartridge, with one side facing the gunpowder charge, and the other exposed in a recess at the base of the cartridge. The exposed side is then struck by the weapons firing pin, hammer or other device and the primer ignites the powder, thus firing the weapon. These types of primers also had the advantage of making the spent case reloadable, unlike Rimfire which was strictly a one shot proposition. The end result is a waterproof and drop proof self-contained round, and one which the casing can be recovered and reloaded if necessary by reloading primer and propellant. The Boxer and Berdan primers are still in use today, since no other system has yet been devised which works more effectively, and has superseded Rimfire in almost all applications (with the notable exception of

[120] Flintlock Magazine Rifle with Lorenzoni type action. England, c. 1690, by John Cookson. Victoria & Albert Museum Collection (77-1893).
[121] Alder, *Guns of the Civil War,* p.169. ; Spencer Repeating Carbine, Model 1865. US, around 1865, Royal Armouries Leeds Collection (XII.2451).
[122] Berdan primers use two channels for ignition into the propellant charge, whereas Boxer primers use one channel. Additionally, Boxer primers require slightly more complicated production process, but this is offset by the economies of scale in production and ease of use.

.22 calibre ammunition) due to effectiveness and costs. Manufacture was also easier and the centrefire design has the advantage of using standardised primers, making ammunition easier to produce and reload.

The American Civil War saw a massive variety of arm being tried, tested and used in battle by both the Union and the Confederacy, with possibly the most varied arsenal of small arms seen in any nineteenth century conflict. Domestic designs were used as well as imported European arms, and by the end of the conflict, it had become clear that certain types of arm showed much potential. While the revolver acquitted itself perfectly as a personal arm, removing any expectations of a return to single shot handguns, it had become clear that revolving rifles were not their equal in terms of long arms, due to a variety of reasons, chief of which were the difficulty of operation (sparks from the cylinder would discharge towards the firers hand, as would bullets in the event of a chain fire!) and more effective competing designs. Of these competitors, the arms can be grouped into two categories, single shot and repeating breech-loading rifles. Single shot rifles could only discharge one round at a time, but were still far faster than a muzzle loading design due to their self-contained ammunition. The superior accuracy of the design combined with the ability to load and fire from prone made it the standard issue among the 1st Union Sharpshooter regiment and prized in similar formations on both side of the war. The lack of moving parts allowed for a sturdier construction and therefore a more powerful round could be accommodated; many Civil war Sharps rifles were converted for Buffalo Hunting on the Great Plains.[123] Repeaters were capable of firing multiple rounds before reloading, allowing a single soldier to match ten times his number of muzzle loaders in terms of effective firepower. In tests the Spencer could fire seven rounds every ten seconds and under sustained fire the Henry could reach 120 rounds over five minutes.[124] Although usually chambering a relatively mild cartridge meaning a repeater would ultimately be less powerful than a single shot weapon, it could make up for this with rate of fire, particularly at close range. Many of these weapons also found their way in to the hands of cavalrymen given the ease of loading and the American tradition of relying on firearms for their cavalry over cold steel and the shock of the charge.[125] The Union Commander John Wilson stated that 'There is no doubt that the Spencer Carbine is the best fire-arm yet put into the hands of the soldier, both for economy of ammunition and maximum effect, physical and moral' and

[123] Alder, *Guns of the Civil War,* p.171.
[124] Griffith, *Battle Tactics,* p.75.
[125] Griffith, *Battle Tactics,* pp.181-3.

the effectiveness of the cavalrymen who crushed the Confederate left flank at the battle of Nashville certainly proved his words correct.[126]

If snobbish disdain towards the American way of war held sway in Europe, then the results of the Austro-Prussian war did plenty to convince even the conservative minds of the establishment otherwise. In a series of victories the Prussian Army, with their Dreyse rifles, swept the Austrian forces armed with muzzle-loading rifles from the field, despite often being outnumbered.[127] By attempting to rush the Prussian forces as opposed to engaging at long range, a tactic which worked well against the long range muzzle-loaders of other nations, the Austrian forces found themselves under a withering rapid fire barrage from the Prussian infantry, resulting in several surprise defeats. Despite many historians now arguing that the end result of the war was a combination Prussian tactics with Austrian incompetence, as opposed to their Needle Guns, ordnance boards across Europe rushed to find new breech-loading arms for their forces, resulting in a continent wide arms race to provide new rifles for their armed forces. The end result on both sides of the Atlantic was that the muzzle loading rifle was a thing of the past, and the future lay with some kind of weapon using self-contained ammunition.

One would expect to see this result in the production and adoption of new weapons; after all most small arms will have been made obsolete by new technology. However, despite this being the most desirable option, most major militaries did not adopt new weapons designed from scratch to take advantage of new technology, but rather decided to adapt their existing arms to this new pattern. Although somewhat perplexing, perhaps given what has been seen so far, this is to be expected, as economics play a pivotal role in the development of the firearm in this period. As a result, there exists an interim generation of converted small arms, all adapted to fire new self contained ammunition. An excellent example of this is the British Snider-Enfield rifles, which began life as a Pattern 1953 Rifle Musket fitted with the breech-loading conversion system devised by Jacob Snider.[128] This system added a hinged breech block into which the cartridge was placed and the percussion system converted to a firing pin for a centrefire round, known as the .577 Snider (Fig 11). Superficially it resembled a Pattern 1853, making it appealing to both traditionalists and more practical minds who recognised the value of muscle memory in its operators and not needing to buy new bayonets and

[126] Pauly, *Firearms,* p.101.
[127] Pauly, *Firearms,* p.96.
[128] Snider-Enfield Rifle. British, about 1867-9. Royal Armouries Leeds Collection (XII.6708); Snider-Enfield Mark II (**) Carbine. British, Enfield, Lock dated 1869, Serial No. SJR 445. Private Collection B.

other accessories. The Americans took a similar approach with their line of conversions known as Trapdoor Springfields due to their method of breech-loading through a trap door in the receiver, of which the M1866, M1868, M1869 and M1870 rifles belong.[129] Revolvers were also converted, such as the popular Colt Model 1851 and 1860/61's, some in the novel Thuer front-loading system to circumvent the Rollin White patent on cartridge revolvers, as well as more normal rear loading systems once the White patent had expired.[130]

A particularly interesting question posed by these decisions is why were the advances in repeating arms overlooked in favour of single shot arms? If weaponry does indeed advance following the most efficient advances then why was this advance overlooked? Certainly, the weapons were not unproven on the field of battle, with a long list of successes in the American Civil War. The arguments against repeating arms can be summed up into two categories, those surrounding the mechanical aspects of the weapon and those surrounding the implications of taking such a weapon into use. In terms of mechanical reliability, the major argument against repeaters is that construction will always be far more complicated, as the weapon has to not only accommodate and fire the round in the chamber, but remove the spent cartridge when fired and replace it with a fresh one. This necessitates more components and therefore more to go wrong in the field, which is a serious problem in a military weapon. But it is worth noting that more parts do not necessarily equate to lower reliability, for example the Colt 1851 revolvers were as reliable as or more reliable than the pistols they replaced despite being mechanically complicated. The Spencer and Henry never acquired a bad reputation for unreliability and American industry in particular was well suited to the production of complex arms as has been shown in preceding chapters. Perhaps a more pertinent factor is the nature of the rounds themselves. Single shot weapons can make a chamber that seals in such a manner that is essentially a solid block. This provides a far more solid construction and aids in the reduction of recoil via weight and allows for a tight gas seal, while allowing for powerful rounds to be chambered without ill effects. Repeating weapons have moving parts which are far more delicate and sensitive to recoil from powerful rounds, particularly in the case of lever-action weapons. The repeating arms of the mid to late 1860's were chambering rounds far inferior in power and range to their breech-loading

[129] Model 1866 Trapdoor Springfield Rifle in 55-70 Centrefire. US, Springfield Armoury, c.1866. Royal Armouries Leeds Collection (PR.10276)
[130] Colt 1849 Pocket Revolver, Converted to Thuer system. US, Hartford, C.1868, Serial No. 298951. with US manufacture and British proof stamps. Royal Armouries Leeds Collection (PR.11283) ; Sapp, *Standard Catalog,* pp.54-6.

counterparts, ensuring that they would play second fiddle at long range (after around 250 meters) against their single shot cousins, even if they could put more rounds downrange. The final consideration is of course price, with repeating rifles coming in at four to five times the cost of a breech-loader conversion, as well as being more costly to manufacture.

As well as the arguments surrounding the mechanics of the new weapons, there are other objections that were held up against the repeater, many of which were similar to those fielded against previous advances, namely that it represented a massive divergence from tradition and established doctrine. Adopting breech-loading rifles would mean only minor changes in the tactical operation of infantry units, linear combat would still be viable, albeit a far more deadly affair than it already was. To get the maximum use out of the repeating rifle it is necessary to delegate control of engagements and fires away from officers and down to the minor NCO's and even private soldiers. Fighting in large formations would be inefficient and utterly deadly, so units would operate in skirmish order, with the possible result of the dilution of force should a bayonet charge be necessary. The idea that a bayonet would be far less critical with repeating firearms was on hand seems to have been ignored. To move to these methods of warfare was seen as fundamentally undermining the foundations of military discipline. Loose formations were thought to reduce the effect of mutual reinforcement from comrades, and in an age before radio communications were a nightmare to control. Additionally, there was an unwillingness to spend excessive amounts of money on arming lowly infantrymen with expensive equipment, on top of the usual tight-fistedness displayed by ordnance boards across the world. As a result, converting existing designs was seen as far preferable to commissioning the production of new designs, despite the advantages such an action might confer. Overall, it can be seen that there is an inertia to change within the upper echelons of militaries that can require external events (such as say, a crushing defeat to superior arms as would be later seen at the Battle of Little Bighorn in America and to a lesser extent at Plevna in Europe) to bring about change.

Ultimately, the move from ball and powder to cartridge is significant for two reasons, which can actually be seen to be somewhat paradoxical. First, in the case of self-contained ammunition, it shows the willingness to adopt a new battle proven technology on a mass scale due to the advantages it conferred over existing methods. When presented with a new technology that would enhance the abilities of firearms considerably it was met with widespread acceptance. However this is contrasted

with the refusal to adopt new designs of firearms, in particular new types of repeating rifles which had finally become practical. This refusal can be put down to resistance to the changes this would bring, in addition to cost and differing capabilities. Although these two conclusions seem to conflict with each other, one other conclusion can be drawn from this, namely that advancement of the firearm is determined not by new ideas, but rather by its viability as a product, in terms of both manufacture and acceptance.

Chapter 5 - Dead ends and Realisations

With the advent of practical designs for breech-loading arms and ammunition and the accompanying conversion designs, it would only be a matter of time until purpose built designs would be required to replace the conversions. These designs were never meant to be much more than interim measures and as such a search was underway to find new replacements. By the 1870's new types of weapon were being brought into service, but in many cases were no more advanced than the ones they replaced in function. However, some nations and companies developed new designs and improved existing ones, resulting in advanced development continuing. After several encounters between the two weapons showed the weaknesses of the breech-loading designs, it was finally realised that the single shot weapon was past its prime, and some sort of repeating weapon would be the future of small arms. What was seen in the 1870's and early 1880's to be the pinnacle of firearms technology by much of the world was in fact a developmental dead end, and would see the early adopters of technology vindicated in their beliefs, while those who refused to embrace change found themselves cut off by the tide.

The conversion arms of the 1860's were always planned to be interim solutions, and as such governments around the world held trials and convened boards of inquiry to search for replacements. Most of the major nations settled on weapons that although new, were nearly identical in capability to the conversions they replaced. An excellent example of this is the British Martini-Henry rifle.[131] This was a single shot lever action breech-loading rifle, chambering a .450 centrefire black powder cartridge, superior to the .577 Snider due to its higher velocity and penetrating power.[132] This was due to the new round being essentially a .577 necked down to use a smaller bullet, yet retaining the same amount of powder, hence why it is often referred to as a .577/450 round. Interestingly, a Winchester rifle was submitted for consideration, but the official précis of development appears to write it off without consideration. This is most likely due to the Winchester submitted being chambered in ammunition equivalent to pistol rounds in power, as the more powerful Winchester designs were manufactured after the trials took place. In terms of capability it was very similar to its predecessor,

[131] Martini-Henry Rifle, Mark I converted to Mark II. British, Enfield, Lock dated 1875, stock marked 9. Private Collection B.
[132] Lugs, *Firearms,* p.104.

allowing a trained solider to fire perhaps fifteen to twenty rounds per minute rapid fire and able to hit targets out to several hundred yards away. Although a completely new design, as far as the target was concerned, it may as well have been a Snider firing rather than a Martini. Similarly, the French adopted the needle-fire Chassepot rifle (which would later be converted into the centrefire Gras rifle), Following the Franco-Prussian war the newly unified Germany rearmed with the Model 1871 Mauser and the Russians adopted the Berdan rifle, designed by the famous sharpshooter Colonel and primer inventor Hiram Berdan.[133] America, the birthplace of the modern repeater and the manufacturing techniques used to make it, adopted the Trapdoor Springfield rifles as their primary infantry arm.[134] These weapons were all perfectly suited for the style of warfare espoused and expected by their militaries; ordered set-piece battles based of the weight of fire for volleys to carry the day. These weapons were without exception single-shot rifles, chambered in a large (10+ mm) calibre round designed for a relatively flat trajectory and long range, suitable for engaging infantry and artillery. For close in work and cavalry defence, the Bayonet was still looked to, and the rifles themselves still being long enough to double as spears once the bayonet is mounted.

While most nations were adapting their rifle muskets into breechloaders, the Swiss government managed to put itself far ahead of the curve, having made the decision to adopt bolt-action rifles in 1866. The weapon chosen was the Vetterli rifle, which fed 10mm Rimfire rounds from a tubular magazine.[135] The design used elements from other designs, mainly the tubular magazine of the Henry and 1866 Winchester rifles, but combining it with a bolt action similar to the Dreyse rifles, resulting in a weapon capable of a much higher rate of fire than any other contemporaries. The use of a sturdy bolt action instead of the lever action of the Winchester allowed for a much more powerful round, thus removing one of the primary drawbacks of the repeating rifle. The result was a weapon capable of accurate long range fire and rapid rate of fire in close quarters or if enemy cavalry was closing to engage. Ironically, due to the Swiss foreign policy of neutrality, this weapon would never be used in anger by the Swiss, and as such never made its advanced design felt on the European battlefield. The Italian government did order a variant, but disposed of the magazine feed, seemingly copying the same short-sightedness of the major world powers of the time.

[133] Lugs, *Firearms,* p.72. ; Hicks, *French Military Weapons,* p.27. ; Chassepot Rifle. Serial No. 14578. Private Collection B.
[134] Pauly, *Firearms,* pp.109-10.
[135] Model 1969 Vetterli Rifle in 10.4mm Rimfire. Switzerland, 1869, Serial No. 21194. Royal Armouries Leeds Collection (PR.6506) ; Lugs, *Firearms,* p.147.

However it was not just the Swiss who adopted more advanced weapons. While they were not up to the same standards of effectiveness as the Vetterli rifles they were certainly capable weapons and Winchester's Model 1866 repeaters found plenty of customers in the form of the Ottoman Empire.[136] Being a relatively backward country with little heavy industry and military forces generally held to be inferior to those of the Europeans, the Ottomans were keen to import any weapons that would give them a technological edge over their neighbours. By 1871 orders had been placed for over 50,000 rifles for military use.[137] Winchester further strengthened their position through the release of their Model 1873 Rifle, capable of chambering much more powerful rounds than the 1866 model which were better suited to long ranged combat, and gaining acclaim as "The gun which won the West".[138] In America the end of the Civil War left the United States flooded with a massive surplus of weaponry. From a beginning where both sides struggled to find adequate arms, by cease-fire there were enough rifles available that Union troops were leaving them to rot and rust in open air depots or to corduroy roads in muddy areas. The post war decision to adopt the trapdoor left the US Government in possession of huge numbers of arms in various calibres and modes of operation, and desperate to make back their losses, they were sold off en-mass. Civil war repeaters like the Spencer and the Henry, passed over by the military, disappeared into the hands of civilians, pioneers and perhaps most fatefully, native American warriors and tribesmen, all for a fraction of their purchase price, with some Spencer rifles selling for as little as $7.00.[139] The US Government did retain small amounts of these advanced arms for specialist uses, such as cavalry units and on the new western frontier, but for the most part the single-shot trapdoor was used as the main service arm.

It was not just small arms technology that was advancing during this period, Artillery technology was also pushing forwards in opposition. Since the Crimean War, gunners had found themselves at the mercy of the rifleman, with modern machined rifles able to outrange and outshoot the cast iron smoothbore cannons of the various artillery corps around the world. However, new advances had made themselves felt in the intervening years. William Armstrong had begun developing rifled cannon from 1855 onwards, creating the type of breech-loading piece that carries his name. These Armstrong

[136] Winchester Model 1966 Repeater in .44 Henry. US, New Haven, Serial No. 146375, Around 1866. Royal Armouries Leeds Collection (PR.11076)
[137] Pauly, *Firearms,* p.110.
[138] Winchester Model 1873 Rifle in 44-40. Rimfire with factory section cutaway. USA, New Haven, c.1873. Royal Armouries Leeds Collection (XII.11119)
[139] Pauly, *Firearms,* p.110.

guns also dispensed with special ammunition, instead using rounds that resembled an upsized Minié ball, allowing for expansion in barrel. The American Civil War saw the advent of rifled cannons in large scale battle, although fears on both sides of 'hidden batteries' capable of wrecking advances turned out to be paranoid fictions for the most part, new rifled guns like the Armstrong gun and the American Parrot Rifles showed their worth in naval and siege actions across the conflict. Not only were the new weapons more accurate, they were both longer ranged (up to 3,000 yards as opposed to around a 1,000 with smoothbore for a typical field gun) and made in new methods from steel rather than iron, giving them greater power and longevity.[140] To further this advance of technology, the Krupp works in Germany began pioneering breech loaded cannons with new techniques and their own blends of steel. By the time of the Franco-Prussian War much of the German field artillery had been rearmed in this manner, and the effects would make themselves abundantly clear. The only military branch not making real progress in this period was the cavalry. Despite advances in pistols, carbines, tactics and even edged weapons by the end of the nineteenth century, the developments in small arms and artillery was making direct mounted action a risky proposition in the face of effective fire. Instead, cavalrymen found themselves moving towards a role of mounted rifleman and scout for the infantry and artillery, although the notion of the cold steel charge would take time to die out.

It is worth, for the sake of completeness, covering the pistol in this period as well. By this point in time, the cartridge revolver had established itself as the dominant handgun in military service and general purpose civilian use. Available in a wide range of sizes and calibres, and offering both single and double actions, a revolver to meet the needs of almost anyone could be found. While revolvers also saw a generation of weapons designed for the new metallic cartridges, the semi-automatic pistol which would eclipse the revolver was not developed until the 1890's, leaving the revolver with no competitor. It would take until the development of gas and recoil based actions intended for use in machine guns for the semi-automatic to begin to unseat the revolver. This period can perhaps be seen as the golden age of the revolvers, and resulted in such classics as the Colt Model 1873 Single Action Army, also known by the nickname of the equaliser or peacemaker.[141] Its rugged reliability and performance in the old west and military use as well as cult status by way of appearance in countless classic westerns turned it into a classic piece of Americana, and has seen the weapon remain in

[140] Griffith, *Battle Tactics,* p.167.
[141] Haven and Belden, *A History of the Colt Revolver,* p.145. ; Colt Single Action Army with 7.5" barrel in .45LC. US, Hartford, Serial No. 175032. Royal Armouries Leeds Collection (PR.12533)

constant production (Barring a short period during the second World War) from 1873 to the time of writing.[142] Other more complicated double action cartridge revolvers also saw popularity, showing the mechanical complexity was becoming less of a limiting factor in the minds of many. The modern revolver bears very little difference from these designs, showing exactly how effective these designs were and still are.

With the benefit of hindsight, it can be seen that many of the weapons in service with the world's foremost military powers were, despite being considered state of the art, about to be eclipsed and superseded by both new technology and the very weapons they deemed unfit for use. Yet despite all these advances, it had not yet become clear to the established minds that they were falling behind the curve, and rapidly so. While a reluctance to change may seem foolish to us in rapidly changing 21st century, it is worth remembering that the men in charge of the ordnance boards began their military careers using arms that would likely be familiar to their grandparents, seeing little change in decades. To deal with this inertia, it would take a series of events throughout the 1870's for the military establishment of the great powers to be relieved of the opinion that their arms were fit for task and spark the next generation of arms development. Although all of these events have other factors involved than the arms used, it is clear that the weapons used played a pivotal role in the outcome. While no one event can be said to completely tip the balance, the combined effect proved that the day of the single shot weapon, which had persisted since the advent of firearms, was finally over. Instead, it would be replaced with an arms race that would run all the way up to, and into, the First World War.

The first hint of things to come would be in the Franco-Prussian War of 1870-1, although it would not have an immediate effect on small arms, rather the major change would affect the artillery used. Up until this war, most artillery pieces were muzzle loading, sometimes even smoothbore guns mounted on carriages that were more suited to the Napoleonic Wars than the mid nineteenth century battlefield. However, new advances in breech-loading artillery by the Krupp company would bring the firepower advantage away from the infantryman, and back to the artilleryman. The Krupp guns were rifled steel muzzle loading weapons which stole the firepower advantage back to the gunners, who have kept it ever since. While batteries would still engage in direct fire work the new rate of fire made facing them down with infantry a far more risky proposition. As such, the need for a long ranged rifle is

[142] Boorman, *Colt Firearms,* pp.33-4.

now eroding compared to the need for a weapon better suited to closer fighting. A weapon suited for infantry fire fights and cavalry defence would still be needed however, with several successful Prussian cavalry charges being cited as proof that cavalry was still a viable shock weapon. The fact that these attacks came at huge cost in blood and under the cover fire of infantry was conveniently ignored.

The next event, as well as the first major blow to the single-shot weapon came in 1876, with the Battle of Little Bighorn in what is now the State of Montana. As a result of US troops having, in the eyes of the native population, broken agreements and moving into areas they were prohibited from, the two sides came to blows. The general state of affairs when US regular forces met native American warriors in battle was that the US troops would win the day by superior firepower from better small arms and better leadership. However in the battle, Col. Custer's 7th Cavalry forces were crushed by the natives, losing five companies totalling around nearly three hundred men including the Colonel himself. For this particular battle, most of the native troops were armed with modern repeating rifles, mostly Winchester Model 1866's and Ex-Civil War Henry rifles sold off as surplus. In comparison, the US cavalrymen were armed with Trapdoor Springfield carbines and Colt 1873 Single Action Army revolvers. Custer also had four Gatling guns at his disposal, but decided not to bring them, for fear of stifling his momentum on the field.[143] In the end, the result of the battle showed clearly that when faced with modern repeaters, the single-shot weapon was to be found wanting. While a later government investigation in 1879 showed that for the most part, Indian tribes were rarely as well armed as those at Bighorn, it also showed that some such as the Sioux and Cheyenne were in possession of advanced weapons such as the breech-loading Sharps, giving some cause for concern.[144] This devastating setback, in terms of both the supposed superiority of the US army and the doctrine of Manifest Destiny was to come to the notice of many in the US.

If any European snobbery to the American way of war as seen around the time of the Civil War still existed once the results of Little Bighorn filtered across the Atlantic, those holding them would not have to wait long to be disabused of these notions on soil closer to home. In the war of 1877 between Russia and the Ottoman Empire, the Russian Army laid siege to the town of Plevna. Seeing no

[143] Pauly, *Firearms,* p.120.
[144] Report of the Secretary of War; Bring part of the messages and documents communicated to the two house of congress at the beginning of the second session of the Forty-sixth congress, Vol. III. (Washington, 1879) pp.321-2.

opportunity for a breakout, the commander of the garrison, Osman Mui Pasha, decided to hold out until either defeated or relived and dug in, turning the town into a fortress of trenches and gun posts. Since they outnumbered the defenders and reckoned on having superior troops, some armed with the newest breech-loading Berdan Rifles, the Russians expected to capture the town from the Ottomans. Across four major battles the Ottoman garrison held back superior Russian forces, inflicting heavy casualties on the Russians before surrendering with most men still alive. It had taken about 40,000 Russian casualties to seize the town. The tenacity of this defence can be attributed to the arms in Turkish use. Each infantryman in the trenches was armed with a Peabody-Martini breechloader, but also with a Winchester Model 1866 repeater. As the Russian troops closed, the defenders switched weapons and were able to sweep the attackers away with their superior firepower. Whereas the attacking troops may have been able to brave the fire of the Peabody-Martini's, the Winchester forced them back, with one Russian commander, General E.J. Todtleben reporting that 'All our attempts to approach met with most stubborn resistance on the part of the Turks, who swiftly countered every attack with terrible, devastating rifle fire', noting that 'The enemy did not show the slightest signs of demoralisation'.[145] The Plevna 'delay' as it was euphemistically known showed the European militaries the weaknesses of the weapons that they had relied upon to be state of the art. The single-shot weapon was standing on thin ice, and there would be even worse to come.

Whereas the two previous battles involved both sides relying on firearms as their primary means of engagements, this next battle showed an army of a great colonial nation with state of the art technology utterly smashed and routed by a force of native warriors with spears and clubs. In 1879, following a series of confrontations over border disputes and cattle raids with Zulu tribes in what is now South Africa, an ultimatum was issued to the Zulu leader Cetchawayo. The ultimatum was little more than an excuse to give the British government a just cause for invasion, as it included a demand for the disbanding of the Zulu army, which was in reality a set of militias in which service was seen as integral to Zulu male culture. In terms of implausibility, it would be like demanding the British to stop drinking tea. The ultimatum was rejected and in 1879 British forces under Lord Chelmsford invaded Zululand, thus starting the Anglo-Zulu War. The British and Colonial regular forces were mainly armed with the Martini-Henry rifle, although some second line units still fielded the perfectly serviceable Snider-Enfield although some unlucky native contingents were left with even older arms. Cavalry

[145] Lugs, *Firearms,* pp.146-7.

units, artillery and rocket batteries formed part of the attack columns, and officers fielded service revolvers, rounding out the fire superiority. The Zulu forces depended mostly on the Assegai, a short spear designed for thrusting used in conjunction with a cow hide shield, and in terms of firearms had a mix of old muskets and rifles, stolen, scavenged or bought from opportunistic traders. Some even had sufficient ammunition and knew how to use them effectively. But despite the massive disparity in firepower, when the two sides met at the Battle of Isandlwana the result was perhaps the last thing that could be expected. Due to a combination of strategic and tactical ineptitude, superior Zulu numbers and ammunition problems, the British forces under Chelmsford were utterly routed in the battle. While the command failings are a key part of the defeat, the focus here will be on the arms and the role they played. The major issues with the Martini-Henry in the battle and indeed the campaign were the ammunition used, the extraction system and the inherently low rate of fire of a breech-loading design. The ammunition issued at the start of the campaign were known as rolled brass rounds, as the outer casing of the ammunition was made of a rolled brass foil. In the field these bullets could be damaged when stored loose, as they would be in a soldiers pouches and kit and as such were liable to jam when used. The hot climate further compounded this by causing the casings to deform from heat. This in turn lead to the next problem, the extractor system of the rifle. While the previous Snider design used gravity to remove the spent casings, the Martini-Henry used a mechanical extractor concealed inside the weapon casing. This turned out to be unreliable at removing spent rounds, and since it was a concealed mechanism, if the weapon jammed (as was likely with rolled brass rounds in hot weather) the weapon was very hard to clear in combat, allowing shell jams to render it inoperable. These two problems were corrected, but the final and most pressing problem was the rate of fire. Put simply, ten to twelve rounds per minute was insufficient to stop an enemy determined to close to melee combat, particularly if they had the advantage of numbers. For a colonial Empire who might expect to fight such foes on a regular basis, this was a serious issue. Clearly, a soldier armed with a weapon like a Winchester would not have this problem when presented with several close targets.

The result to these events, and others like them was the drive to investigate and adopt new types of firearm to improve on the weakness of single-shot weapons, namely their low rate of fire. Despite being up to three or four times faster to shoot than the weapons they replaced, these weapons were still too slow. The arms race saw added impetus in terms of the existence of private arms

manufacturers starting to assert themselves on the world stage. Where production of these cutting edge arms had been the domain of governments in factories like Enfield and Charleville, firms such as Mauser, Winchester and Colt were starting to offer advanced arms, and unlike governments they were relatively free to sell to who they want and when they want, indeed their existence as a company depended on it. The risk of another Bighorn or Plevna in the Colonies was a serious threat to the Empires and gave more drive to re-arm with new and better weapons. A good example of this would be the aforementioned Ottomans, who having a relatively weak and backward economy and industrial base, were keen to purchase arms from foreign firms, developing a particularly close relationship with Mauser, resulting in Paul Mauser giving personal demonstrations of his weapons to the Ottoman government.[146] The weapons that would come to replace them would use the new advances of smokeless powder, small calibre jacketed rounds and magazine fed bolt actions to place themselves far away from their predecessors. A generation of conversions, no matter how much accountants or Generals may have wanted one, would be impossible.

As a result of these events/factors, the last generation of single shot rifles can be seen to be something of a dead end. They cannot be practically converted into repeating actions, at least in any practical way due to their designs. Even their ammunition would become quickly obsolete, with big rounded lead bullets being surpassed by smaller but faster ones and chunky cases being unsuitable for the new magazine feeds. Some could be used with new smokeless rounds, seeing stop-gap types like the Martini-Enfield chambered in the new smokeless .303 calibre, but others would blow out their chambers under the new high pressures of the powders.[147] Even those that could take the pressure were difficult or impossible to convert to repeating actions. A new generation of weapons need to be developed to replace these weapons in a very short space of time. Perhaps the most important thing that can be seen here is that the resistance to change seen earlier in the century with rifles and revolvers did not disappear, but rather it resurfaced when a new changes rose to be made. It seems it is not the cutting edge that leads development and adaption, but rather the acceptance of a product or concept against the inertia of established thought that results in its adoption and such events as those showcased here simply speed the process. However, a few final pieces of the puzzle would need to be developed, such as smokeless powder and automatic actions, for the nineteenth century

[146] Lugs, *Firearms,* pp.176-7.
[147] Martini-Enfield Rifle. British, Enfield, Serial No. 1. Royal Armouries Leeds Collection (PR.5642).

firearm to reach its final development, and by extension, a plateau that firearms development has continued to this day.

Chapter 6 - Final developments and the plateau

The realisation that the era of the single shot weapon was finally over had finally dawned on both the arms designers, militaries and governments of the world. The future lay more than anything else in the magazine, as weapons with a feed of ammunition would surely triumph over those that did not. However, this last dash of development up to the first shots fired in anger of the First World War can be seen as the last great revolution in firepower. Barring the development of the submachine gun and assault rifle (and the roots of both of which can arguably be found in this period) firearms technology would effectively reach a plateau, and as of the present day the technology we use in modern firearms is in mechanical terms not too far removed from the technology which carved out the trenches of the Great War.

After the concept of the single-shot weapon was finally laid to rest, the question of what was best to replace it remained. Perhaps unsurprisingly given the amounts of time and money invested, not every nation was willing to abandon their single shot breechloaders. An example of this would be the Werndl 1878 conversion for the French Gras rifle, adding a ten round detachable magazine to the left hand of the receiver.[148] A less workable solution was the Fosberry conversion attempted for the British Martini-Henry developed in 1882.[149] Being unsuitable for both box and tube magazine feed from below, a system was developed in which rounds were stored in a magazine placed to left and above the breech. When the lever was dropped a flap on the magazine opens and a round drops into the breech by gravity. The fact that the prototype held in the Royal Armouries at Leeds often repeatedly fails to work when demonstrated shows exactly how impractical an idea this was. Another conversion system by Harston was more successful in the mechanical sense but was nowhere near durable enough for field use and failed to see success.[150] Neither conversion ever reached production. As it became clear that another generation of conversions was going to be impractical, the need for new designs became apparent. However some key changes to the way firearm ammunition was made were required first.

[148] Lugs, *Firearms,* pp.169-70.
[149] Lugs, *Firearms,* p.170.
[150] Martini Henry rifle with Harston conversion system. British, Around 1888, Serial No. 127. Royal Armouries Leeds Collection (PR.5811).

One of these key innovations was smokeless powder. What is regarded as the first smokeless powder was the Poudre B developed by the French chemist Paul Vielle. While not completely smokeless, the efficient deflagration process of the new powder made it so that firing a weapon would not give away the users position in a cloud of smoke.[151] More importantly, smokeless powder was a far more efficient propellant than black powder, allowing a bullet to be propelled to higher velocities for great energy and therefore damage to targets and range. This made all the large (>11mm) calibre black powder rounds obsolete overnight. Since they relied on their large mass to impart damage at relatively low speeds, a smaller round travelling at faster speeds could impart the same energy, while being of a smaller physical size due to the more efficient propellant. As such, new weapons would use a smaller bore, be they rifles or handguns. In addition the ammunition could be much lighter to carry and easier to store and carry.

Despite its advantages, this new powder had two main problems. First was the issue that the new high velocities meant that traditional bare lead rounds would become damaged or damage the barrel of the weapon they were fired from due the friction generated by high velocities. The solution to this as developed by Edouard Rubin of Switzerland was to jacket the bullets with a mixture of copper and nickel, thus preventing the lead from melting and damaging the barrel.[152] The end result is the jacketed round, which became standard for ammunition using the new powders. Tighter rifling twists were also used to compensate for the instability of faster moving projectiles that resulted from the new powder[153]. The second of these was the higher pressure generated by the firing of smokeless rounds rendered some older designs incapable of firing them without damage or destruction. While some were able to fire the new rounds, their designs were often unsuitable for conversion into repeating actions. As such, new weapons had to be developed to take advantage of this technology.

The combination of these led to arguably the first truly modern rifle, the French Lebel model 1888.[154] This design utilised powder in copper jacketed centrefire rounds and combined it with a bolt action and a magazine feed to produce the first of a new generation of infantry rifle (Figs 12&13.). The Lebel was far in advance of anything else available at the time thanks to the integration of these new

[151] Pauly, *Firearms,* pp. 111-2.
[152] Pauly, *Firearms,* p.111.
[153] Pauly, *Firearms,* p.112.
[154] Lebel Model 1888-93 Rifle. France, Guille, Serial No. 1564. Royal Armouries Collection Leeds (PR.6216) ; Lugs, *Firearms,* p.151.

technologies, and its short incubation period was aided by the rhetoric of those in French politics who wanted to avenge the loss of Alsace and Lorraine to the newly formed German nation.[155] Compared to the Gras that it replaced, it offered both superior ballistic performance and rate of fire. In addition, the smaller cartridges allowed for a greater supply of ammunition to be carried, allowing soldiers to remain combat effective for longer in battle.

However, the rifle design was not without flaws. The use of a tube magazine was adequate for the task, but had several disadvantages. These included being easy to damage, it could only be reloaded one round at a time and the receiver proved to be too weak. The French worked around this final problem by redesigning and modifying the rifle in 1897 to fix this error and accommodate the new Balle D cartridge, but the other issues remained.[156] The weapon had to be loaded one loose round at a time, and if the tube becomes damaged or jammed the function of the weapon was severely impaired. In contrast, box magazines, such as those made by James Lee were much tougher and able to feed rounds through the bolt to be stored vertically underneath, reducing the chance of a jam from impact on the magazine and even allowing the magazine to be effectively concealed into the rifle stock for protection. In conjunction with this came the charger clips developed by Ferdinand Mannlicher, which helped speed up reloading by affixing rounds to a thin metal or card frame at the base of the cartridge, thus allowing rounds to be loaded in multiples, but still be topped off with single rounds as needed.[157] As a result, most other nations adopted rifles with box magazines to store their rounds. Additionally, Lee's box magazines were designed to be removable, allowing spares to be kept on hand for reloading in the manner of a modern assault rifle, although the rifles using his system in British service were usually fed by clip with the magazine treated as a fixed component in combat.

The development of the Lebel led to yet another arms race amongst the world powers, resulting in yet another generation of nineteenth century rifles. However, unlike the previous generations of small arms, these would prove to be far longer lived, if not as long lived as the weapons in use at the start of the nineteenth century, lasting in active service through two World Wars. Examples of this generation include the British Lee-Metford, the German Mauser Gewehr 1888 (Known as the

[155] Lugs, *Firearms,* p.151.
[156] Hicks, *French Military Weapons,* p.34.
[157] Pauly, *Firearms,* pp.114-5.

Commission Rifle) and the Russian Mosin-Nagant.[158] These rifles were all repeating bolt-actions, fed from magazines of at least five rounds, using smokeless jacketed cartridges, just like the Lebel. Some further developments were made from these designs, such as the Lee-Enfield which was derived from the Lee-Metford, and the Mauser Gewehr 1898, both of which would see use in the First World War.[159] Additionally, the cartridges used began being manufacture with spitzer tips, starting with the French Balle D cartridge for the Lebel in 1898, which used a Spitzer tip and boat tail to greatly enhance the ballistics of the round, resulting in increased range, velocity and lethality (Figs 14&15.).[160] These features would become standard around the world for service rifle rounds in the next decade. Unlike the rifles they replaced, these arms and their derivatives would see service up to and even past 1945, and the rounds they fired would have even longer lifespan, such as the Russian 7.62x54R round developed for the Mosin-Nagant is still in use with PKM series medium machine guns and SVD precision rifles in Russian service today.[161]

No discussion of late nineteenth century firearms would be complete without mention of the machine gun, although the focus here will mostly be on how its development influenced small arms. While primitive automatic weapons had existed in the form of guns like the Gatling gun, which used a hand cranked system with rotating barrels to avoid overheating, the automatic machine gun action came about as a result first of the work of Hiram Maxim, and later of John Browning. Both inventors discovered a way of harnessing the otherwise wasted energy of a fired round and using it to cycle the action of a weapon. Maxim utilised the energy of recoil to move the barrel and breechblock to enable automatic action (Recoil Operation), while Browning used the energy of the gas generated by the round to feed his action (Gas Operated).[162] The Maxim used a water jacket around the barrel for cooling which allowed a high rate of fire of around 600 rounds per minute from a single barrel, while

[158] Mosin-Nagant Model 1891 Rifle. Russian, dated 1894., Royal Armouries Leeds Collection (XII.2663). ; Mauser Gewehr 1888. Germany, Amberg, 1890, Serial No. 8006K. Royal Armouries Leeds Collection (PR.6402). ; Lee-Metford Mk1 1st Pattern Rifle. British, Enfield, 1888, Serial No.21. Royal Armouries Leeds Collection (PR.5699).

[159] Mauser Rifle, Model 1898. Germany, Suhl, Amberg Arsenal, made 1916. Royal Armouries Leeds Collection (XII.9810). ; Lee-Enfield Mk1 Rifle. British, Enfield, 1893, Serial No. 1. Royal Armouries Leeds Collection (PR.5642)

[160] Hicks, *French Military Weapons,* p.60.

[161] SVD Dragunov Sniper Rifle in 7.62x54R. Russian, 1986. Royal Armouries Leeds Collection (XIIV.8853) ; PKM Medium Machine Gun in 7.62x54R. Romania, 1987, Serial No. T4983. Royal Armouries Leeds Collection (91019) ; Despite these examples being dated from the late 1980's these arms are still in use and production toady.

[162] Pauly, *Firearms,* p.121-5

Browning's design used an air cooled barrel firing at a lower rate of around 400 rounds per minute. Either way, these systems allowed for massive firepower in relatively compact platforms. While the machine gun has had a massive impact on history, these early machine guns were far from being individual weapons, requiring a crew of several men to operate and move, making them somewhat beyond the scope of this thesis. Surprisingly, the biggest effect these weapons had on small arms was at the other end of the size scale, on the pistol.

It was soon realised that the repeating actions of the machine gun could be scaled down to work with smaller cartridges and as such be used as handguns. By modifying a recoil or gas operated action to cycle once on each pull of the trigger as opposed to constantly for as long as the trigger was held down, it became possible to develop a handgun design to rival the revolver for personal protection and defence. Such a weapon could take advantage of a box magazine to hold more rounds than a revolver, and have the potential to be reloaded much faster. This new weapon would be known as the semi-automatic pistol. One of the earliest known such weapons was the Schonberger pistol patented in 1892 by Joseph Laumann. This used a system of operation called blowback, a kind of hybrid between gas and recoil operation, and better suited for lighter calibre pistol ammunition.[163] Although not particularly successful, a weapon developed the following year by Hugo Borchardt found greater success and its action opened the way for further developments like the famous Luger pistol as well as the Mauser C96.[164] Making these mechanisms on a much smaller scale would inevitably result in teething problems and early semi-automatics did suffer in terms of reliability and practicality. An excellent example of this is the Mars Pistol, which suffered from a fatal mixture of complex operation, poor ergonomics and ferocious recoil, which when combined with a top ejection system meant that the shooter would have the hot shell casing launched into their face.[165] The weapon proved a failure and only around 150 were ever made. Additionally, new rounds needed to be developed, as the cartridge rim required in revolver rounds could cause feeding issues in box magazines. However, by the eve of the First World War, these weapons were beginning to mature and challenge the dominance of the revolver. By this period there were even designs that would go on to become well known classics, such as the aforementioned C96 Broom-handle Mauser, the P08 Luger and M1911

[163] Pauly, *Firearms,* p.127-8.
[164] Borchardt Self-Loading pistol, Model 1893. German, Berlin, Around 1894, Manufacture by Ludwig Lowe and Company, Royal Armouries Leeds Collection (XII.3732).
[165] Mars Pistol with 12" barrel in .45L. UK, about 1900, Serial No.33. Royal Armouries Leeds Collection (PR.10766)

Colt, that latter of which still sees active military, police and private use today.[166] The fact that the M1911 was designed by John Browning himself shows the how the knowledge of firearms action gained in the development of machine guns passed over to handguns.[167]

An important factor to note is that within this relatively short period of time, new ideas manage to reach acceptance far faster than new ideas had in the past, which can be attributed to several factors. First, manufacturing to high precision and tolerance had now become relatively commonplace in firearms production. Both national arsenals and private firms were able to make mechanically complex weapons in large numbers with both ease and efficiency. The previous technical and financial boundaries to precise mass production had been brought down. Second, the worldwide arms market had begun to trigger an arms race in all branches of the military, which would go on to be a significant factor in the causes of the First World War. The scramble for new land in Africa backed by advances such as malaria medicine and machine guns, along with new developments in naval warfare lead to governments searching for the latest piece of equipment to give them an edge. New advances were no longer something to be afraid of, but rather useful legs up on rivals and competitors, with the initial outlay cost paying for itself elsewhere. In addition, cunning firms could effectively sell to rivals in potential flashpoints, creating a pendulum effect as rivals hoped to gain an advantage over each other. Finally, the performance of these new types of weapons was such a dramatic improvement and combined with events like Plevna and Little Bighorn, as discussed in the previous chapter, made it a very foolish move to ignore their potential, lest someone else acquire it instead. If they could acquire the money there may be little stopping those under colonial rule from purchasing arms if they felt independence would be more to their tastes. These factors helped greatly speed up the adoption of new firearm designs.

After a century of development and change, sometimes at a very rapid pace, by 1914 we have reached a point where firearms technology effectively plateaus in terms of mechanical principles and basic design. A modern rifle still uses these advances from the turn of the century and may well continue to do so for a great many years to come. In terms of small arms, even the developments of the twentieth century can be rooted to this period or just after it. For example, the submachine gun

[166] Mauser C96 Self Loading Pistol. German, About 1905, Royal Armouries Leeds Collection (XII.5785). ; Luger P08 pistol. Germany, Erfurt, 1911, Serial No. 1. Royal Armouries Leeds Collection (PR.4154)
[167] Colt M1911 pistol in .45ACP. US, Government service model, About 1911, Serial No. 9562. Royal Armouries Leeds Collection (PR.10429)

can be seen as rooted in the First World War, in the form of the Villar-Perosa and Bergman.[168] The former was an Italian double barrelled machine gun firing a pistol cartridge and was more suited for use on aircraft or fixed positions, while the latter was a more traditional weapon from Germany, resembling a small carbine again firing pistol calibre ammunition from a magazine. The assault rifle can be seen to originate from the Mondragon rifle of 1908. A particularly interesting weapon, this rifle was designed by the Mexican General Manuel Mondragon and was select fire capable, as well as chambered in an unusual looking 5.2x68mm cartridge resembling a heavily necked down rifle cartridge. Given that it both select fire and of an intermediate calibre (as in between a pistol and a rifle round) it can claim to be the first assault rifle. Another design originated during the War in Russia as the Avtomat Fedorov, a select fire weapon chambering the relatively weak 6.5mm Arisaka cartridge (at least compared to the Russian standard of 7.62x54!) and is classed as another contender for the title. It certainly has a good claim in terms of language, as Avtomat would go on to become the Russian word for automatic rifle, becoming best known as the 'A' in AK-47. Even rifle mounted grenade launchers can be seen as functional descendants of century old hand mortars and bomb guns. Mauser type bolt-actions, the Russian 7.62x54R cartridge and the Colt M1911 pistol still see use today, with the Russian cartridge holding the title of longest serving round in active military use at 120 years as of 2011. Interestingly, when new advances have been attempted, such as Gyrojet and Caseless ammunition, neither have managed to overcome the inertia as of yet.[169] All the technology of the twentieth and twenty-first centuries has yet to find something more effective than a jacketed bullet launched down a rifled barrel by a propellant change, or at least do so in a practical manner. Although some experimentation with caseless ammunition is currently underway it appears as if the developments of over a century ago will still hold sway for the time being.[170]

[168] Villar-Perosa submachine gun. Italy, c.1915. Royal Armouries Leeds Collection (246A/8); Bergman MP18 Submachine Gun. Swiss manufacture, SIG, c.1918-20. Royal Armouries Collection Leeds (PR.7394) ; Technically the first 'submachine gun' was a downscaled demonstration model made for Hiram Maxim around 1890 to allow him to demonstrate his invention without needing a large firing range to do so. It was never intended to be used as anything more than a demonstration device and it is currently in the Royal Armouries Leeds Collection (PR.7163)

[169] Gyrojet ammunition aimed to replace the bullet with a miniature rocket, while caseless ammunition removes the expanding casing of the round, instead making the round a block of propellant with a bullet and primer embedded inside. Gyrojet saw small scale field tests in the Vietnam war and Caseless was trialled in the West German G11 rifle prototypes but ultimately never adopted.

[170] The US Marine Corps is investigating the LSAT caseless light machine gun system as of writing, although the project service date is a few years off. Interestingly enough, the US Army has sided with the cased ammunition

variant of the same arm. The success of caseless ammunition could signal the biggest change in firearms technology in around a century

Chapter 7 - Conclusion

The development of the firearm in the nineteenth century was not determined simply by new ideas in a constant wave of progress. Its story is far more complicated. It can be seen that the development of the firearm is instead linked to its development as a product which is efficient in mechanical, practical and economic terms. As each new development reaches acceptance it does so because the development itself has reached the point where it's mass adoption has become a practical proposal. Until this point new developments face obstacles in the form of mechanical complexity in production and economic costs in manufacture. Only when these are overcome can the new development hope to reach acceptance, and even when these are overcome, there is often a inertia to overcome in terms of resistance to change, as can be seen with the adoption of repeating arms only coming after several costly military disasters.

This can first be seen in the development of the Pattern 1853 Enfield rifle and the Colt 1851 Navy revolver. Most arms prior to this were simplistic smoothbore weapons with either flintlocks or the new percussion locks due to the difficulties of making rifled weapons and revolvers on a mass scale. In addition, each part was unique can could not be interchanged, making maintenance and repair a difficult task. There were other advanced designs like the Hall and Dreyse rifles and early revolvers like the Collier or Colt's earlier Patersons, but these in turn suffered from a lack of precision in fit and finish. However, by making use of new methods of production such as the American System of Manufacture, along with machinery and gauges, allowed these new and more complex weapons to be produced efficiently and effectively on a massive scale, even reaching standards of full interchangeable parts. Both of these arms were produced in numbers reaching into the hundreds of thousands, despite being far more complicated than the weapons they preceded. Their contribution to the revolution in firepower came not just from their effectiveness as firearms but from the new methods of manufacture that they utilized in their construction. Here can be seen the use of industrial technology to push the firearm forwards, making ideas that had already been known but were hard to put into practice, into workable means of manufacture. Even in the case of Samuel Colt, most likely one of the most talented gunsmiths to ever have lived, in the end his return to power was as much to

do with the production skills of Eli Whitney and Elisha Root and their use of new machinery and methods, as it was to do with his skill as a salesman or the arms themselves.

The next step towards the modern firearm required the use of new ammunition, and here again it would be in manufacture that the real breakthroughs would be found. The example of the Pauly cartridge failing to see success shows exactly how important this is, as his cartridge failed not because of its design or capabilities, but because it was impossible to produce the amount of cartridges required and to the necessary quality of finish. Centrefire cartridges were successful not just because they were effective in terms of design, but because they were relatively easy to make thanks to new technology and the simple design of the primers. In fact, the expanding jacket made it less important for the chamber of the weapon to achieve a gas tight seal, making it easier to manufacture the arms themselves. This move to self contained ammunition came because it was finally practical to make the ammunition in the quantities and to the level of quality necessary.

The idea the change is welcomed and not obstructed can be shown to be false with nearly every advance of the period, such as the struggle between Sam Colt and the US government over his Patterson revolvers, but can be seen most clearly in the final generation of single shot breechloaders. The repeating rifle, having existed in concept since the 1650's had finally flourished in the crucible of the American Civil War, and represented an enormous leap in infantry firepower. The weapons had been battle proven and the machinery needed to produce them was proven and available as well. But despite having access to rapid firing repeating rifles, most militaries refused to embrace the arms, due to a mixture of reasons. While it is true that some of there were linked to the early repeaters themselves, tradition and conservatism of both the social and fiscal varieties helped stymie the progress of the repeating rifle. Of course, there were others who were more open minded, or simply less picky. It would take bloody defeats at battlefields like Little Bighorn and Plevna to show that the time of the single shot firearms had passed. The dead end generation of cartridge conversion breechloaders and their follow on rifles show how strong the resistance to change can be, and show that although the resistance to change can be broken, it takes extraordinary events that prove exactly how inefficient the technology in question is.

Finally, the arrival of bolt-action rifles and semi-automatic pistols also heralds the arrival of major arms firms, able to manufacture arms in vast quantities for sale around the world. Advanced manufacturing

technology is now so widespread that government arms production is challenged by independent companies who are able to design produce and sell advanced arms around the world. The resulting global arms market allows potentially any entity to acquire powerful and up to date arms, which in turn feeds into the growing world arms race that helped trigger the First World War. It is also in this period that we see firearms technology plateau, with the basic principles of the arms of the late nineteenth and early twentieth century being essentially identical to those used in the present day. Even types of firearm that are seen as mid to late twentieth century inventions, such as the Assault Rifle can be seen rooted in this time.

In the final analysis it is clear that any view of the development of the nineteenth century firearm must take the role of the firearms as a product into consideration. Indeed it can be seen that if it was not for the advances in industrial production that accompanied the new developments in the arms themselves then the revolution in firepower may not have occurred. While the advances seen in the arms themselves are a mixture of old and new ideas, it is the transformation of the firearms form an artisan product into a commercial good that allows its development to move forward so rapidly in the space of a century. Whereas previously it was only possible to produce advanced arms in small numbers, and with considerable difficulty, by the end of the century it had become possible to mass produce mechanically complex firearms like machine guns, semiautomatic pistols and bolt-action rifles, as well as the necessary ammunition for them. Without the industrial advances to underpin this development, it is highly likely that the path of the nineteenth century firearms would have been very different. Nevertheless, this was dependent upon demand not just invention and innovation.

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Appendix 1 - Illustrations and Diagrams

Figure 1. - A sectioned breech of a loaded Pattern 1853 Enfield rifle, demonstrating the percussion ignition system, *Private Collection (A), 2012*

Figure 2. - Government proofed percussion cap by Joyce, *Private Collection (A), 2012*

Figure 3. - Belted ball for the Brunswick Rifle, *Private Collection (A), 2012*

Figure 4. - Diagram showing the flaw in the cylindrical Minié round and the correction in the regulation round, *Private Collection (A), 2012*

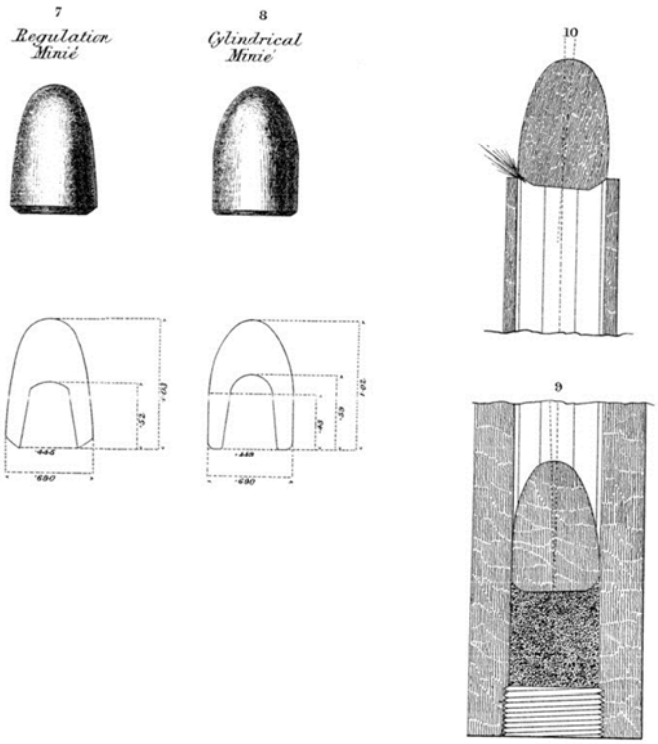

Figure 5. - Sectioned Pattern 1853 Minié bullet with expansion cup, *Private Collection (A), 2012*

Figure 6. - Diagram of Whitworth rifling, *Private Collection (A), 2012*

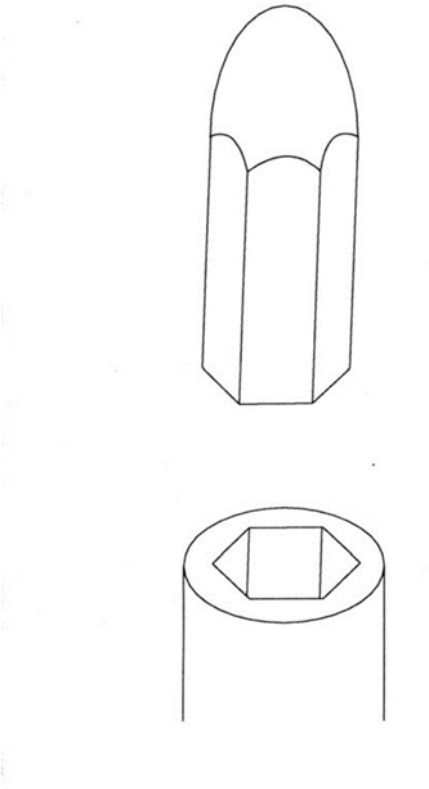

Figure 7 . - Whitworth hexagonal bullet, *Private Collection (A), 2'012*

Figure 8. - Sectioned Pinfire Cartridge, *Private Collection (A), 2012*

Figure 9 . - Pinfire Cartridge, *Private Collection (A), 2012*

Figure 10. - Sectioned Spencer .56 Rimfire cartridge. The primer is contained in the rim at the base of the cartridge, *Private Collection (A), 2012*

Figure 11. - Sectioned.577 Snider cartridge, before Powder and Anvil are added. The primer is clearly visible in the centre of the cartridge base.

Figure 12 - Lebel 1888 Flat Nose bullet, *Private Collection (A), 2012*

Figure 13 - Sectioned Lebel 1888 Flat Nose bullet, *Private Collection (A), 2012*

Figure 14 - Lebel 1898 "Balle D" Spitzer bullet, *Private Collection (A), 2012*

Figure 15 - Sectioned Lebel 1898 "**B**alle D" Spitzer bullet, the boat tail profile of the round is clearly visible, *Private Collection (A), 2012*