Historic Rifling Data Characteristics: Using Forensic Techniques to Further Archeological Inquiry into Firearms Use

Douglas D. Scott
Adjunct Research Faculty
Applied Anthropology and Geography Program
Colorado Mesa University

Prepared for National Park Service
National Center for Preservation Technology and Training
Grant P17AP00228

This report was developed under a grant from the National Center for Preservation Technology and Training, a unit of the National Park Service. Its contents are solely the responsibility of the author and do not necessarily represent the official position or policies of the National Park Service or the National Center for Preservation Technology and Training.

September 2019

Table of Contents

List of Tables

List of Figures

Executive Summary

Most archeologists and curators can only identify a bullet or cartridge case to caliber. This project is an innovative use of microscopically accurate forensic casting technology and testing of digital imaging technology that resulted in a database of rifling characteristics for 788 firearms that can be used to identify some common pre-1900 rifled firearm ammunition components to type, model, or gunmaker. The database includes for each gun listed: land and groove measurements, number of land and grooves, and twist or rifling direction. The database is designed to allow users to identify or at least narrow possible identifications to gun types based on land and groove measurements found on bullets. The information will allow researchers and interpreters to determine with greater accuracy the type of guns used at sites where ammunition components are found, potentially leading to greater accuracy in the interpretation of firearms use, troop deployment, and possibly small unit actions on battlefields. It will also allow a greater understanding of the actual arms used at sites and in battles employing physical evidence as a primary identification method.

The project employed a 3D scanner to make accurate scans of the land and groove casts. The original intent was to link scans to the database, but the 3D scans were found to lack sufficient detail for comparative value. Standard digital photography and panoramic photography were tested for comparison purposes.

Additional information was collected and is presented on firing pin shapes for pre-1900 firearms that fired metallic self-contained cartridges. Firing pin shape varied significantly until the late nineteenth century. Presentation of the firing pin shape information will aid archaeologists and curators in identifying gun types represented by fired cartridges recovered in archeological contexts.

Rifling characteristics of pre-1900 rifled artillery were opportunistically recorded during the project. Rifling data on several Civil War, American Indian War, and Spanish American War rifled artillery are presented as well. These data may aid in identifying cannon type when fired projectile driving bands or sabots are recovered archeologically.

Introduction

The identification of guns or gun parts found on archeological sites is a relatively straightforward process. Most archeologists, historians, and collections managers are aware of expert literature on the subject and can readily use existing references to identify gun type as well as date guns or gun parts. Archeologists are also reasonably adept at using available references to identify cartridge case headstamps, allowing them to identify a caliber, and usually a date range, for ammunition use. However, researchers often overlook a wealth of other information contained in archeologically recovered ammunition components. Bullets, cartridge cases, cartridges, artillery shot and shell fragments, canister shot, primers, and percussion caps can also provide a range of information on dating, types of firearms present, minimum numbers of firearms, and activities of the site's occupants as they related to the use of firearms (c.f. Scott 1989; Scott et al. 1989; Scott 2013). This project introduces archeologists studying sites containing evidence of firearms use to the potential of firearms identification procedures using rifling characteristics as one means to further the study of the past and of human behavior associated with firearms use.

The project used accurate forensic casting technology and digital imaging technology that has resulted in a database of rifling characteristics that can be used to identify many pre-1900 century rifled firearm ammunition components to type, model, or gunmaker. The project documented rifling characteristics on nearly 800 pre-1900 manufactured firearms. The project result is a searchable database that will be made publicly available.

There has been an exponential growth in battlefield archeology and archeological investigations of sites where guns were an important part of the artifact assemblage over the last two decades. Reviews of site reports and published literature reveals that many archeologists, historians, and collections managers have only identified bullets and cartridge cases to caliber. There appears to be a lack of knowledge that bullets, and cartridge cases, can yield more information than caliber. Within the class characteristics, the basic marks imprinted on bullets and cartridge cases that occur during discharge of a weapon, there is information on caliber, type of firearm uses, and often the gun maker, brand, or model can be determined from those pattern transfer marks. The inability of most curators and archeologists to identify bullets and cartridge cases beyond caliber diminishes the research and interpretative information contained within these classes of physical evidence.

Rifling characteristics and firing pin imprints are unique to a gun type, thus a searchable comparative database aids in determining specific gun types that are present in a collection. The project geographically and chronologically cross-cuts most American sites containing firearms evidence. It enables researchers to achieve greater accuracy in assessing the value and meaning of bullet and cartridge case collections. The project’s purpose is to provide a publicly available searchable database to enable curators, archeologists and others to more correctly identify fired bullets, and where relevant, cartridge cases, to specific gun types, thus creating greater accuracy in interpretation of the role of firearms in past events.

The database allows users, based on land and groove measurements. to determine, with greater accuracy, the type of guns used at sites where ammunition components are found. These data can potentially lead to greater accuracy in the interpretation of firearms use. It will also allow a greater understanding of the actual arms used at sites and in battles employing physical evidence,

rather than reliance on the notoriously inaccurate ordnance returns and other historic documents. The database is applicable to common eighteenth and nineteenth century sites and battlefields where firearms were employed. Further there are national forensic firearm identification implications and values to this project. Forensic firearm examiners can use the database to identity historic firearm types that may be involved in law enforcement cases either by inclusion or exclusion in a case.

Some of the trade and common rifles recorded during the study were made by Tryon of Philadelphia. Like many of the early firearms manufactures Tryon was not a lock, stock, and barrel maker, but an importer and assembler of parts to make good quality firearms (Sadler 1998). George W. Tryon apprenticed to Frederick Goetz in 1793 and in 1811 they became partners in the arms manufacturing business. By 1814 Tryon had contracts with the U.S. Army to produce pistols. He continued in business until 1832 when he partnered with Samuel Merrick. They produced both flintlock and percussion arms. This partnership continued to 1843 when George retired, and son Edward Tryon took over the companies. The Tryon company, known as Tryon and Son continued to contract for firearms with the U.S. Army and the Republic of Texas, as well as produce private purchase arms.

George W. Tryon, Jr., Edward's son was added to the firm in 1857. The company produced arms throughout the Civil War and beyond. In 1872, Edward retired and George Jr's. brother Edward K. Tryon, Jr. joined the firm. They sold arms and merchandise under the Tryon and Brother mark. The company essentially closed out its gun making enterprises in 1894, but continued to operate as hardware merchandizers, under various brand names through the 1990s.

The foregoing illustrates the longevity and evolution of many of the firearms manufactures who produced rifled weapons used in this study. Some firearms manufacturers failed when the principal died or retired as there was no one skilled or innovative enough to carry on the work. Others like Tryon, Remington, Colt, Winchester, and Smith and Wesson adapted to changing markets and left a lasting legacy of arms that have now become collectors' items and museum acquisitions.

Firearms were once just tools for hunting, sport, and defense. Those tools left a literal impression on the bullets they fired, and this study begins the process of identifying the rifling characteristics making the impressions on bullets an aid in archeological and museum interpretations of physical evidence.

Theoretical and Methodological Background

The comparative study of ammunition components, in the field of forensics, is known as firearms identification analysis. Firearms, in their discharge, leave behind tell-tale signatures or markings on the ammunition components. These signatures, more properly termed class and individual characteristics, allow the determination of the firearm type (i.e. model or brand) in which a given cartridge or bullet was fired, including artillery. This identification then allows determination of the number of different gun types at a given site. Further, individual characteristics allow the identification of individual weapons or grouping of fired bullets or fired cartridge cases as having been fired in a common firearm. This last capability is very important because coupled with precise artifact locations, matching individual characteristics can identify activity loci. With this

information, patterns of movement can be established, and sequences of activity more precisely interpreted.

Law enforcement agencies have long used firearms identification as an aid in solving crimes. Two methods commonly used by police departments include comparison of bullets and cartridge cases to identify weapon types from which they were fired (Hatcher et al. 1977; Harris 1980; Heard 1997). Law enforcement criminalists and firearms examiners are routinely successful in identifying characteristic on bullets and/or cartridge cases that are consistent with a crime weapon simply by demonstrating that the firing pin, breech face, ejector, chamber, and extractor marks on fired cartridge cases, or the land and groove marks on fired bullets, are comparable to a specific weapon. In the event that weapons used in a crime are not recovered, the law enforcement laboratory can say with reasonable certainty, on the basis of class and individual characteristics found on recovered bullets and cartridge cases, that specific types and numbers of weapons were used.

Firearms identification procedures, often erroneously called forensic ballistics, are analogous to the archeological wear pattern analysis. Like wear pattern analysis, firearms identification did not spring up overnight, but has an evolutionary history. Firearms identification had its earliest known beginnings in an 1835 London murder case (Berg 1977:535-537). A London policeman helped secure a conviction by proving a bullet ball) with a peculiar flaw could have only been cast in the defendant's mold which had the same flaw. Another case of incipient firearms identification occurred in determining who caused the death of Confederate General Stonewall Jackson on May 2, 1863. An examination of the recovered bullet proved it to be a type and caliber used by the Confederate Army. Jackson was killed by one of his own pickets; a probable friendly fire fatality.

Other cases followed in ensuing years with each building on earlier conclusions. In 1900 Dr. Albert Hall published the first truly scientific treatment on forensic ballistics and began its advancement as a common law enforcement tool. Firearms identification, as it has become known, was used to establish responsibility in the 1907 Brownsville, Texas, race riots (Dougherty 1969). The examination resulted in cashiering three entire companies of the all black 25th U.S. Infantry based on the identification of cartridge cases found at the riot scene were fired by weapons in the hands of the soldiers.

By 1925 the field was becoming well established, and in that year the greatest single advancement occurred to ensure a solid footing for its future. The comparison microscope was used for the first time and became the firearm examiner’s standard tool. With publication of several textbooks in 1935, the field was firmly established and now nearly every major law enforcement agency has one or more firearms examiners in their laboratory (Gunther and Gunther 1935).

When a cartridge weapon is fired the firing pin strikes the cartridge primer, often leaving a distinctive imprint on the case. The primer ignites the powder, thus forcing the bullet out the barrel. Rifling in the barrel imprints the lands and grooves on the bullet in mirror image. The extractor frequently marks the fired case as it is extracted from the gun's chamber. These imprints are called class and individual characteristics. Class and individual characteristics are also present on projectiles fired from muzzle-loading firearms like flintlocks and percussion weapons including smoothbore guns.

For this study class characteristics (Wilhelm 1980:202-215) of the land and grooves found in rifled firearms dating prior to 1900 were recorded to develop the database. The number of land and groove impressions on a bullet or the size and depth of a firing pin impression are termed class

characteristics. These gross details are common to a type, model, or brand of firearm. As an example, the Smith and Wesson company designs and builds their revolver barrels with a five land and groove, right hand twist of specific dimensions. The Colt Company manufactures their barrels with a six land and groove, left hand twist of slightly different dimensions. An archeologically recovered fired bullet with five land and groove impressions with a right-hand twist to the rifling was not fired from a Colt. If the bullet's land and groove dimensions are the same as the Smith and Wesson revolver then it can be assumed the bullet was fired from a Smith and Wesson gun. By knowing caliber and researching the models made by Smith and Wesson in that caliber, it is possible to narrow the bullet down to specific models and have a firm date for when that model or caliber was introduced on the market, and thus determine an *ante quem* date for the archeological specimen.

Fired bullets retain a class and individual characteristics. The barrel of rifled guns has a series of lands and grooves that imparts spin to the bullet as it travels out the barrel. This spin gives the bullet greater aerodynamic stability and accuracy in its trajectory. For the eighteenth and nineteenth centuries bullets were generally lead or lead alloys. The gun barrels of that period were some type of mild steel. Since the bullet fitted tightly in the rifled barrel, the barrel left its land and groove impressions, in reverse, on the softer bullet. As with a firing pin, each barrel manufactured for a certain weapon type has recognizable characteristics due to the rifling tool used during the manufacturing process. Even though a bullet may be deformed on impact, it may retain sufficient striations to permit the identification of class characteristics.

These are the basic principles on which data was collected to create the pre-1900 general rifling characteristic database that is the subject of this grant effort.

A Brief History of Rifling

Wikipedia (https://en.wikipedia.org/wiki/rifling#; accessed February 10, 2019) defines rifling in firearms as a helical groove pattern that is cut or machined into the internal (bore) surface of a gun's barrel, for the purpose of exerting torque and thus imparting a spin to a projectile around its longitudinal axis during shooting. This spin serves to gyroscopically stabilize the projectile by conservation of angular momentum, improving its aerodynamic stability and accuracy over smoothbore designs.

Rifling is often described by its twist rate, which indicates the distance the rifling takes to complete one full revolution, such as "1 turn in 10 inches" (1:10 inches), or "1 turn in 254 mm" (1:254 mm). A shorter distance indicates a "faster" twist, meaning that for a given velocity the projectile will be rotating at a higher spin rate. The combination of length, weight and shape of a projectile determines the twist rate needed to stabilize the bullet. Generally barrels intended for large-diameter projectiles like spherical lead balls require a very low twist rate, such as 1 turn in 48 inches (122 cm). Barrels intended for long, small-diameter bullets, such as the modern ultra-low-drag, 80-grain 0.223 inch bullets (5.56 mm), use twist rates of 1 turn in 8 inches (20 cm) or faster. In some cases, rifling will have twist rates that increase down the length of the barrel, called a gain twist or progressive twist.

For this project twist rate was not considered. However, direction of twist, right or left, is a valuable analytical element. Twist rate could be a valuable tool in identification but there is no reliable method of determining rifling twist rate from a fired bullet. Forensic firearm examiners do not use twist rate in their examinations due to the lack of a reliable method (Haag 2006:1-25, 333).

Rifling has a long history and the inventor of the rifled barrel is alleged to be one of two inventors, both of them German-speaking. According to Greener (1995) one was Gaspard Kollner of Vienna, sometime in the fifteenth century, others allege that his grooves were straight in nature and the first spiral grooves came from Augustus Kotter of Nuremberg in 1520 (Westwood 2005:85). Regardless, much of the early rifling development came from German speaking areas. The Germans already had a history of manufacturing crossbows that would spin their bolts in flight (either by shaping the arrow head, arranging the fletching of the arrow slightly off center, or by passing the arrow through a tube with grooves in it to impart spin). Clearly gunmakers were aware of the basics of rifling and its benefits, even before they started manufacturing rifled firearms. The forces of the Landgraf of Hesse were using rifled weapons by 1631 and Maximilian I, Elector of Bavaria, had several troops using rifled harquebuses by 1640. In the early days, most infantry commanders of other countries did not like rifling because it was harder to clean gunpowder residue which fouled the grooves. By 1563 spiral grooved rifling was common enough to require the Swiss to formulate regulations regarding smoothbore versus rifled firearms match competition (Hoyem 1987:7; Thomas 1997; 2003). Rifled firearms were largely relegated to civilian hunting use for much of this same period, and due to the expense of manufacturing rifled weapons they were usually only found in the hands of the elite in Europe and Asia.

Rifles, in the muzzle loading era, were tedious to load often requiring a bullet starter or mallet to be used to seat the bullet into the barrel for some distance so that the ramrod could then be used effectively to seat the bullet on the powder charge. Most European countries experimented with rifled weapons for their armed forces in the seventeen and eighteenth centuries but employed them sparingly, largely withdrawing them from service after a short period of use. In part the rifle was too slow to load in combat situations that relied volley fire of massed troops fired at similarly arrayed lines of opposing troops

European armies began to develop and deploy flintlock rifles in the late eighteenth century as tactics and strategy in warfare began to change. One reason for the change was the development of rifled weapons in English Colonial America where rifling provided an advantage in hunting and warfare in the eastern woodlands (Hoyem 1987:7-11).

Rifled firearms became more common in the 1830s and 1840s, with most nations making them a common military weapon during the late 1840s and early 1850s. In part, the industrial revolution was responsible for the development, as the quality of steel for gun barrels, and more precise machining techniques made their appearance on the manufacturing scene all about the same time. One of the most important advancements in rifling was the result of more precise machining methods coupled with advances in making long-wearing hardened steel cutters.

Precision machining is largely owed to Joseph Whitworth, who not only developed measurement methods precise up to and beyond .001 inch, the thousandth, but was an innovator in rifling firearms using a hexagonal bore design (Hawes 1859). His exceptionally accurate rifles were used by the British in several of their gun models, but it was especially popular with Confederate snipers during the American Civil War (Atkinson 1996).

There are five barrel-rifling methods in general use today: cut, button, broach, hammer forging and ECM (electrolytic cationic machining) (https://www.nrafamily.org/articles/2017/11/21/3-methods-of-barrel-rifling; accessed February 10, 2019).

Cut Rifling

Cut rifling is the oldest method of rifling a gun barrel and is the only method seen in this study. The cut-rifling method removes metal from the surface of the bore to create the grooves using a single-bladed, hook-type cutter of groove width that is pulled through the cold barrel. It is sometimes called "hook rifling" after the fishhook-shaped cutter used. Cutter depth is adjustable, so that it removes only a small amount of metal on a pass. Each groove must be cut individually with multiple passes of the cutter. The cutter is indexed to each groove in turn and positively rotated by the rifling machine using a sine bar.

Button Rifling

Button rifling was invented in in the late 1930s in Germany and is commonly used today. The method creates the grooves in the cold surface of a rifle bore by displacing metal using a bullet-shaped, super-hard button of tungsten carbide. The rifling button has the reverse pattern of the groove profile ground into its surface. As the rifling button is pushed or pulled through the barrel, the groove pattern is ironed into the bore surface by displacement. There are several variations in button-rifling procedure. In most cases, the button remains free to rotate during this process, dependent on the angle of the grooves in its surface to cause the desired degree of rifling twist. As variations in rifling twist may occur during this procedure, some barrel makers affix the rifling button to a rod and positively rotate it with a sine bar.

Broach Rifling

Broach rifling was developed in the late nineteenth century and was common during the World War I era. It is a production-oriented variant of cut rifling that addresses some shortcomings of the cut-rifling process. While cut rifling uses a single-bladed cutter, a broach is a metal bar with sets of progressive cutting blades in its outer surface corresponding to the number of grooves. The cutting blades are fixed in spiraled succession, each blade cutting to slightly greater depth than the one in front of it. As the broach is pushed or pulled through the cold barrel, all the grooves are cut on a single pass. In some cases, a series of ever-larger broaches is run through the barrel until the desired groove depth is reached.

Hammer Forging

Developed in the mid-twentieth century the method relies on heavy specialist machinery. A slightly oversized barrel blank is hammered-swaged externally over a pre-contoured mandrel having the desired spiral lands and grooves, and sometimes even the chamber, already machined in place.

ECM
Electro Chemical Machining or more properly electrolytic cationic machining is a mid-1990s development in barrel rifling. It uses barrels that are hardened and annealed before the rifling process. The hardened barrels are then placed in the ECM machine and held stationary. The electrode is a plastic cylinder with metal strips circling around the exterior. The metal strips are a reverse image of the desired rifling and are inset into the plastic cylinder. The electrode is placed inside the barrel and the whole is immersed into an electrolytic solution of sodium nitrate which is constantly circulating under pressure. The electrode is moved down the barrel and rotated at the desired rate of rifling twist. As current flows from the cathode (the electrode) to the anode (the barrel), the material is removed from the anode to duplicate the grooves in the shape of the electrode.

The hook or cut rifling method was the only method used in the eighteenth and nineteenth centuries. With a few exceptions of very early twentieth century rifles and pistols sampled in this study cut rifling was the only rifling method observed. The cut rifling method could employ a hand operated rifling machine or one driven by water, steam, or combustible fuels.

The hand rifling method was long employed and is described by several treatises on gun making and rifling (c.f. Roberts 1952; Kauffman 1960). The skills to make the various parts of the cut-rifling machine were known to carpenters, wheel-wrights, clock-makers and blacksmiths. By the seventeenth century gun-making and blacksmith guilds worked in collaboration with carpenter and clock-making guilds to make firearms, before the advent of separate gunmaker craft specialization guilds in Europe. By the eighteenth century gunmakers combined the skills of the other trades into their own specialized craft organizations (Roberts 1957:9-12).

From the sixteenth century through the early nineteenth century the hand operated rifling machine predominated (Figure 1). With the advent of the industrial revolution mechanization occurred in the rifling of barrels (Figure 2) but was still based on the simple rifling bench concept.

Rifling followed this general process; the gunsmith would decide on how many land and grooves were to be cut. He created a template or guide by dividing a circle evenly into whatever number of parts or grooves to be cut using a straight edge and dividers or compasses. Groove widths and depths would be planned, and these, corresponding to the number of grooves required for the barrel would be marked on the outside barrel. Another method was to attach a larger indexing guide disk to the end of the barrel.

The gunsmith would then mount the barrel in the rifling machine or bench so that one of the markings aligned with a fixed marking on one of the barrel clamps or on a support block. The barrel clamps were tightened, and the gunsmith pushed and pulled on a head piece, until the cutting tool stops cutting. As the head piece is pushed forwards and backwards, it causes the indexing guide to rotate at a fixed rate. This motion is transferred to the rifling cutter inside the barrel on the extension rod to cut a helical rifling groove.

Then the gunsmith would unclamp the barrel and rotate it to the next marking and repeat the process of pushing/pulling to cut the next groove, until the required number of grooves were cut.

The gunsmith would have adjusted the cutting tool to increase the depth of cut and repeated the process until the required groove depth was reached for all the grooves. Adjusting the cutter depth was accomplished by adding wood or paper shims to the cutter slot to raise the cutting tool in order to increase the groove depth. By the 1840s the machines were redesigned so that the cutter depth was controlled by metal shims or a mechanical method to raise and lower the cutting tool. Many small shops throughout the United States continued to use the hand operated rifling bench as their output did not warrant the expenditure for the more mechanized rifling machines in use by large manufactures, like Colt or Winchester, or the U.S. military armories. The cutter was often lubricated with tallow or whale oil until the availability of lubricating oils were made possible by the development of the petroleum industry after 1858 with the drilling of the first successful oil wells in Canada and 1859 in the U.S.

The configuration of the seventeen-century rifling is difficult to pin down as noted by de Espinar (1644) who commented that grooves could be deep or shallow, many or few as a "matter of taste." These comments suggest gun makers were experimenting with the number and depth of land and grooves in this early period (Figures 3, 4, 5). Such experimentation and personal preference appear to have carried over to about 1870. The form of the rifling appears to have depended on not only local or even personal preference, but on the limitation of the tools, particularly the hardness of the iron barrel and the tools used to cut the rifling. Westwood (2005 :86) observed that seventeenth- and eighteenth-centuries rifling could be shallow hemispherical (aka – rounded, u-shaped, trough, or radiused grooves) or deep sharp-edged rectangular forms. Straight rifling was thought to be an advantage over spiraled rifling as it limited black powder fouling and provided an easy means of cleaning the rifle. Both proved to be untrue.

Until the 1850s the bullet or projectile was spherical or simply a ball. Conical bullets were known and used prior to 1850 but were not common. The development of the conical bullet as the standard projectile in the 1850s, for military firearms, resulted in numerous studies to determine which rifling configuration was best for conical bullets. Widely adopted was the French design of the hollow based Minié ball or bullet. In general, it was decided that an odd number of grooves in the rifle bore was best as it made a groove opposite of a land which optimized the fired projectile skirt being forced into the grooves giving it greater stability in flight. The U.S. Ordnance Department adopted a three land and groove, right hand twist configuration for all long arms beginning in 1855 that lasted until 1892 (Secretary of War 1856:11-12). Commercial arms manufacturers did not follow suit but rifled their arms in many different configurations as will be seen in the discussions of the study findings.

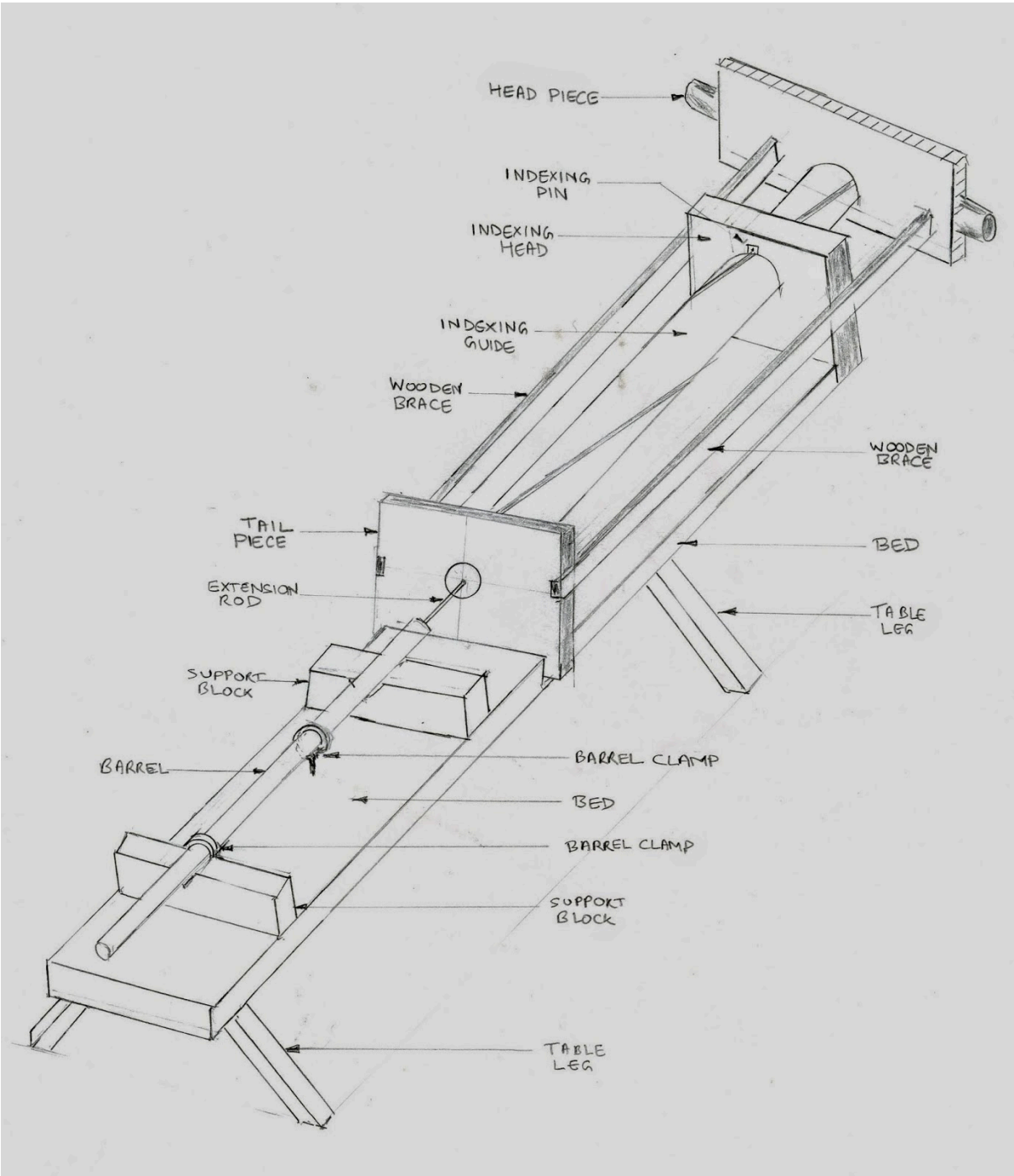


Figure 1. A simplified drawing of a hand operated rifling machine or bench. Public domain image http://firearmshistory.blogspot.com/2014/05/ancient-techniques-of-rifling-machines_13.html, accessed February 11, 2019.

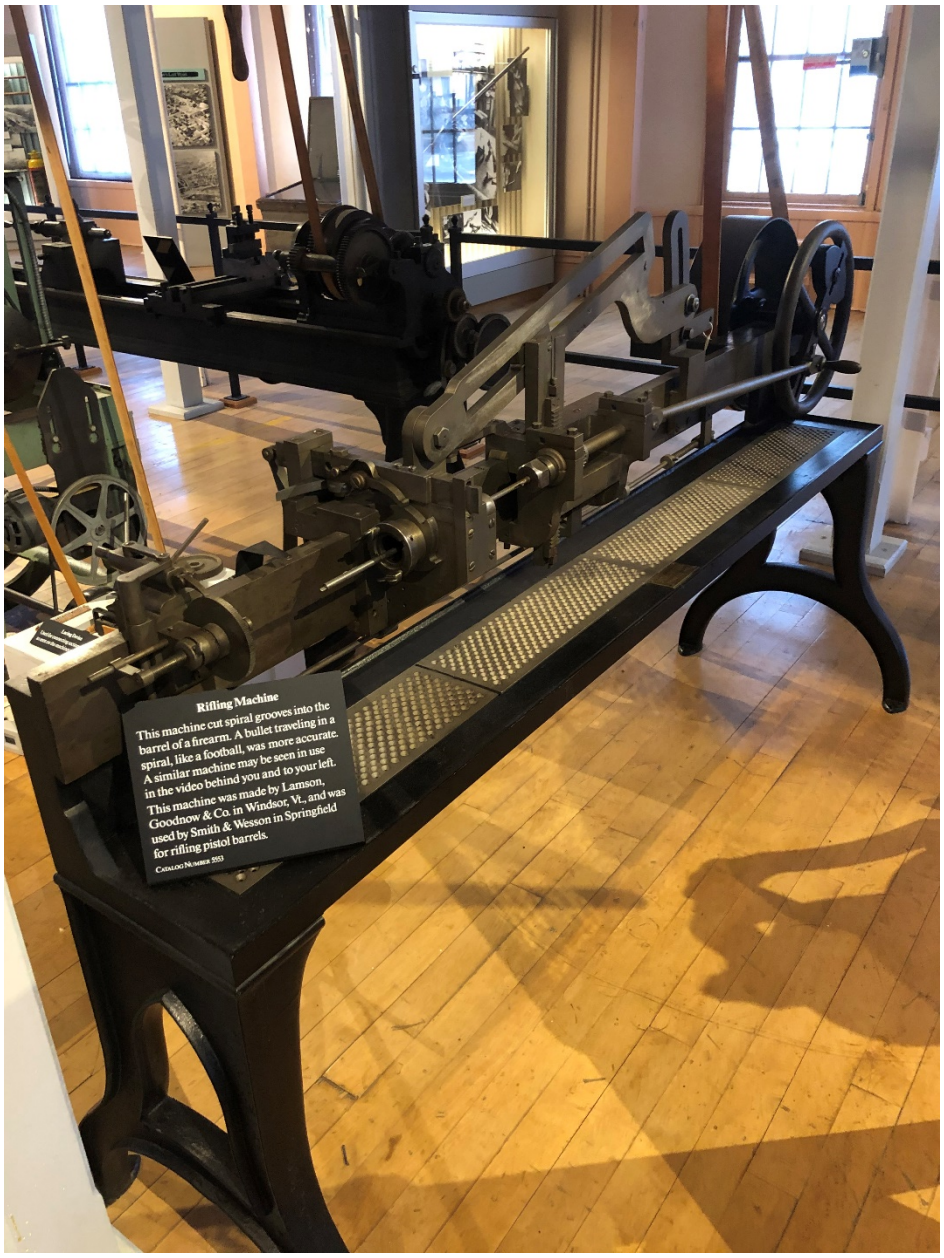


Figure 2. A mid-nineteenth century powered rifling machine from the Smith and Wesson factory, now on display at Springfield Armory National Historic Site.

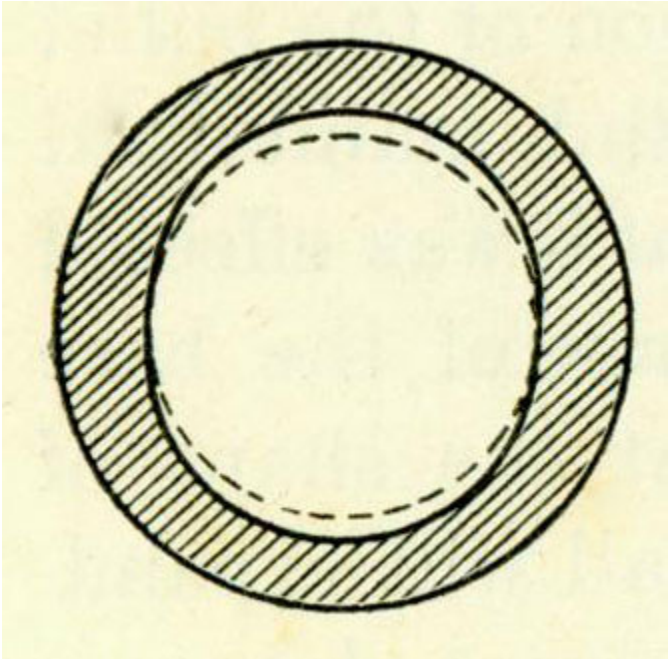


Figure 3. Oval-Bore. No obvious rifling. Rather, an oval-shaped bore cross-section that spirals as it proceeds down the barrel. The Greene Civil War Musket was the only oval bore firearm cast in this study (after Freemantle 1901).

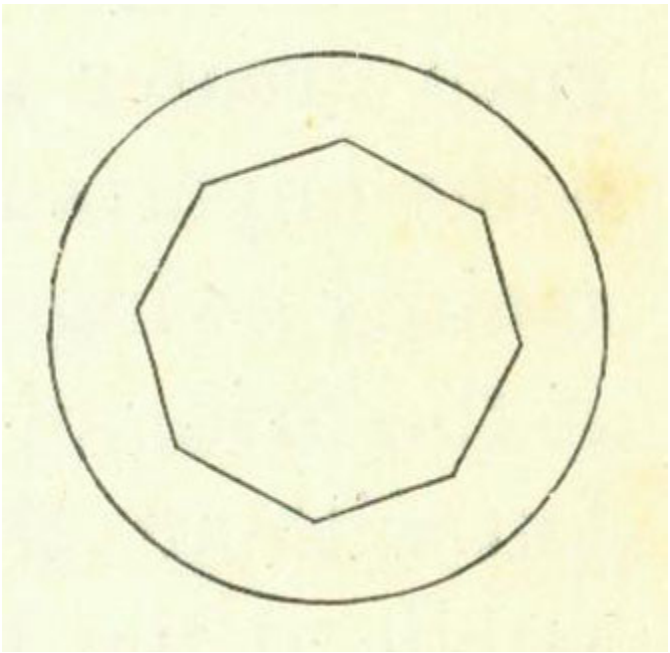


Figure 4. Whitworth rifling or polygonal rifling which requires a specific-shaped (in this case octagonal) bullet. Two firearms types were cast with polygonal rifling (after Freemantle 1901).

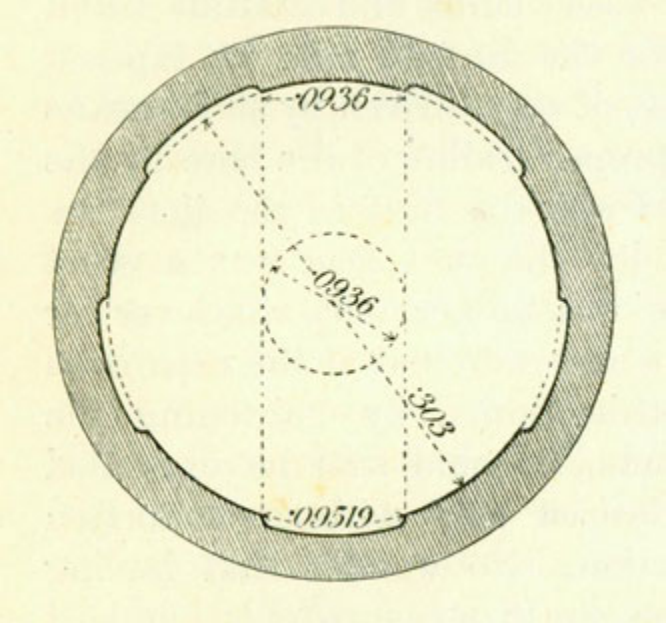


Figure 5. Conventional type rifling with equally spaced lands and grooves. This is the most common rifling encountered in the study. Grooves can be relatively flat or rounded. The number and width of lands and grooves varied according to the gunmaker's requirements (after Freemantle 1901).

Data Collection Methods

The Federal Bureau of Investigation and the Association of Firearm and Toolmark Examiners have databases of rifling characteristic listing over 14000 guns. However, access to data on rifling characteristics is limited to law enforcement and crime laboratory analysts. In addition, very few of the firearms in the databases pre-date 1900.

Prior to this project being implemented general rifling characteristics (GRC) on about 300 rifled pre-1900 firearms had been collected using the Federal Bureau of Investigations GRC collection standards. The goal of this grant was to employ their basic data collection standards to expand the database by adding another 300 firearm types. The goal was exceeded with over 480 pre-1900 firearms added to the database, now totaling 788 firearms.

While .22-caliber bullets are common archeological finds they are seldom diagnostic. For this reason, .22-caliber firearms were largely excluded from the data collection process. Firearms with calibers larger than .22 were sampled and recorded.

Data collecting methods developed prior to the grant award were used throughout the data collection process. The data collection method does not harm the firearm or leave any residue behind. Many of the pre-1900 firearms where GRC data was collected are held in private hands.

Those owners were generous in allowing the author to make bore casts of their guns but have asked to remain anonymous.

Most of the firearms are pistols, revolvers, rifles, and carbines, but the opportunity presented itself to collect GRC from rifled pre-1900 artillery pieces as well. A number of publicly and privately held collections were visited for the pre-1900 GRC data collection project. Several museums were generous in allowing bore casting to be made from specimens in their collections. These include: The Fur Trade Museum, Chadron, Nebraska; J. M. Davis Gun Museum, Claremore, Oklahoma; Nebraska History (Nebraska State Historical Society) Museum, Lincoln; Jim Gordon's private gun museum in Glorieta, New Mexico, National Rifle Association National Firearms Museum, Fairfax, Virginia; and the National Museum of American History, Smithsonian Institution, Washington, DC.

The normal rifling data collection procedure was to digitally photograph the firearm being cast, or in some cases a group of firearms being studied (Figures 6, 7). A recording form was completed that identified the gun brand, model, or maker, as well as the collection source (see appendix I).

A 10mm diameter bore light with a flexible cable and digital imaging capture capability was then placed in the firearm's bore from the muzzle (Figure 8). The bore light was an asset in determining the firearm's rifling condition. On over 100 cases a gun's bore was determined to either be a smooth bore (never rifled) or the rifling was so worn or in such poor condition from lack of maintenance that casting the bore would not yield usable data. In firearms with good rifling the bore light was occasionally used to photographically document bore land and groove characteristics as well as firing pin configuration (when present).

After examining the bore with the bore light, the next task was to make a cast of approximately 2 ½ to 3 inches of the bore from the muzzle using a silicone-based material to capture a microscopically exact cast of the bore and its rifling (Figure 9).

The project initially employed ReproCAST© Forensic Silicone for some of the work. ReproCAST became unavailable during the early casting efforts and AccuTrans© forensic silicone casting material was substituted. Both materials produce microscopically accurate casts and are nearly identical in formulation and function. The forensic casting materials are used in forensic laboratories for the recovery of a variety of forensic evidence, including tool marks and latent fingerprints, and postmortem friction ridge detail on partially decomposed human skin tissue. The casting materials are high quality flexible silicone material which produces extremely detailed casts.

Both products are vinylpolysiloxane derivatives specially formulated for forensic applications that are tear resistant and have excellent dimensional stability. Both materials are flowable material that are applied by an extruder gun. The handheld extruder device holds two parallel tubes, one of silicone casting resin and the other of hardener. A paired plunger operated by a trigger pushes the materials into a plastic mixing tip, where an auger mixes the resin and hardener in proper proportions. The mixed material is extruded into or on the surface in the desired amount.

Figure 6. A group of rifled long arms at the Gordon Gun Museum in Glorieta, New Mexico. Selected rifles were sampled during the bore casting project.

Figure 7. A Colt Walker Model 1848 revolver and a Colt Patterson revolver along with a Perry single shot pistol at the Smithsonian ready to be sampled.

Figure 8. Using the bore light to determine the condition of the rifling on a Gatling gun at the National Firearms Museum.

Figure 9. Doug Wicklund and the author making a rifling cast of an Indian used .50-70-caliber rifle at the National Firearms Museum.

At the beginning of each application with a new mixing tip a user must squeeze out a small amount of mixed casting material on to a card or piece of paper to properly blend the contents in the mixing tube. Doing this prevents large air bubbles in the casting. If small air bubbles are present in the cast, they do not interfere with the details. The mixing tips are disposable. Both materials set and are ready to be removed from the barrel in about 4 to 5 minutes at 68°F.

The resins come in colors of gray, white, brown, black, and transparent. All colors were used, but gray and brown were found to provide the best resolution for photography and 3D scanning, as well as general measurement ease and analysis.

Once the cast set it was removed from the barrel by pulling it from the gun's muzzle by hand. The bore cast was placed in a self-sealing plastic bag. The bag was marked with a Sharpie® with the name of the place of collection, name, brand, and/or model of the firearm, nominal caliber, serial number if present, collection number if appropriate, and date of collection. The same information was also entered on the paper collection form.

At the home institution each cast was examined under magnification using a Dino Lite® digital microscope capable of precise measurements up to three decimal places. The number of land and grooves were noted, direction of rifling twist, and each land and groove were measured using the digital microscope software (Dino Capture©) measurement functions (Figures 10, 11, 12). The above information and the minimum and maximum land and grooves widths were recorded in a Microsoft Excel© spreadsheet.

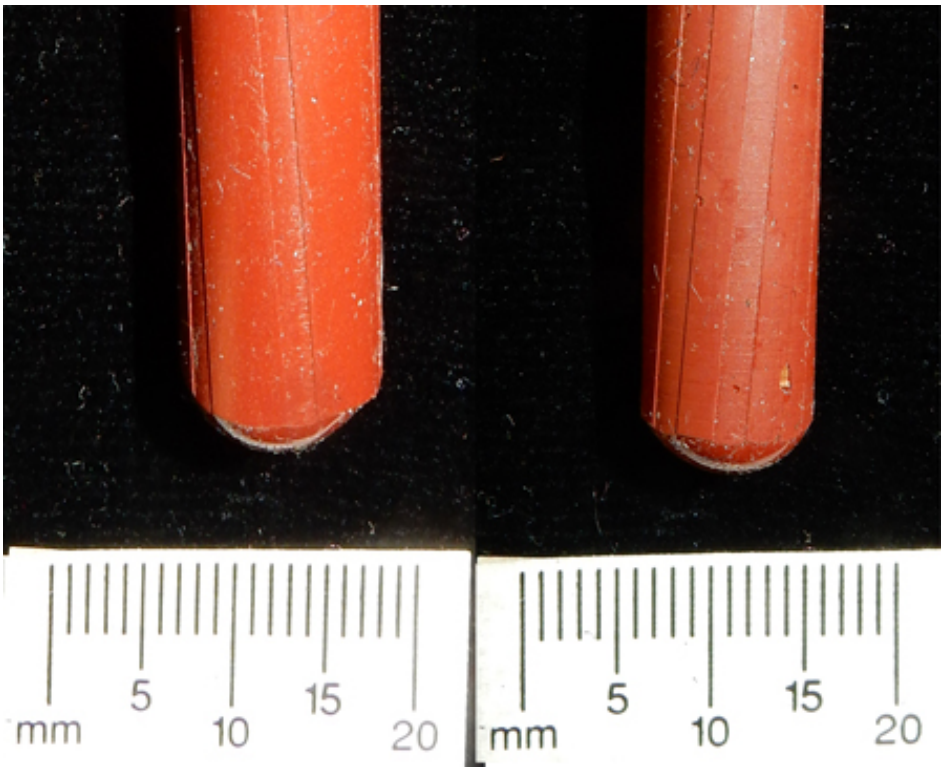


Figure 10. These rifling casts illustrate a left-hand twist on the left and a right-hand rifling twist on the right. The casts and bullets can be viewed from either end and the twist or rifling pitch will be the same.

Figure 11. Dino Lite digital microscope being used to measure land and groove dimensions.

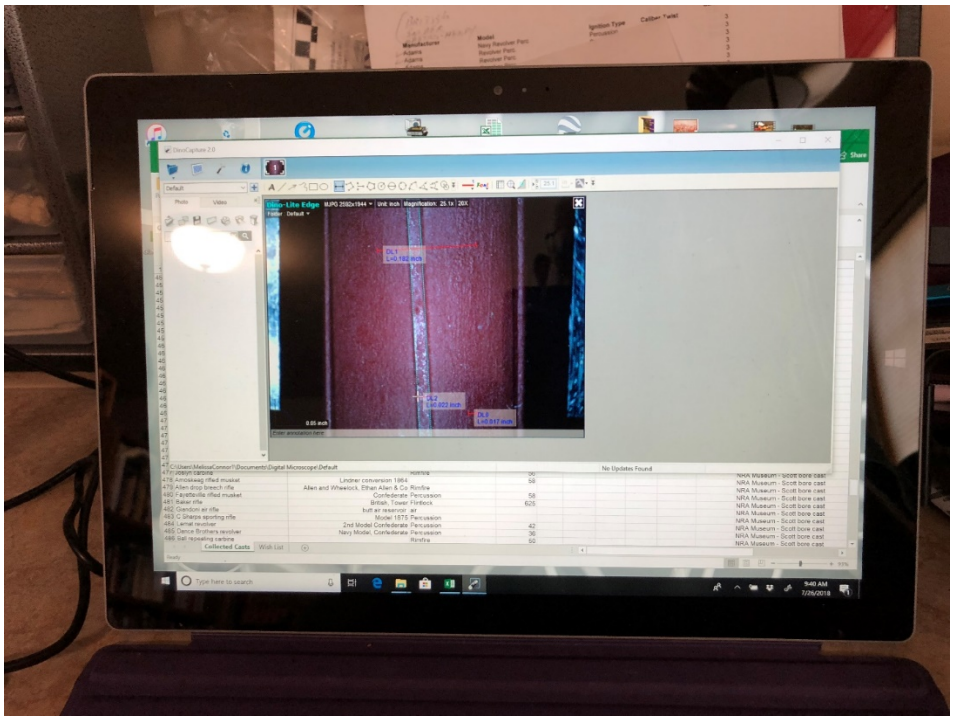


Figure 12. Screen shot of measuring and recording land and groove widths using the measurement function of the Dino Capture program.

3D Scanning

A NextEngine Scanner® was chosen as the best available 3D moderately priced scanner. NextEngine is a desktop 3D scanner that uses an array of lasers to scan objects at resolutions of 0.005 inches (.01mm). The scanner uses lasers, an active data-capture method. The scanner has a flash and camera as well, so it collects 2D images to drape the 3D models it generates. After a series of experiments with various settings on the NextEngine scanner ideal settings were determined.

A cast was placed on the drive table from six to nine inches from the scanner face (Figure 13). Two sticky note pads were placed on the drive table at 45 degrees to each other. This was necessary to provide some clear geometry for the software to record as cylindrical objects alone caused the software to fail. The cast was set on the drive table and note pads and held in place by the gripper arm. The ScanSoft© software scan panel was set to use the 360 position, with start and tilt set to 0. Divisions were set to nine (nine separate scans in a 360 rotation), points set to low end of the HD (high definition range), and the target set to neutral (Figure 14). Each scan took approximately 46 minutes to complete. The completed scan was then fused, polished using the buff function set to retain sharp edges, and output into .ply format (Figure 15). Other output formats available are: .stl, .obj, .vmrl, .and xyz.

Figure 13. NextEngine scanner during the process of scanning a rifling cast.

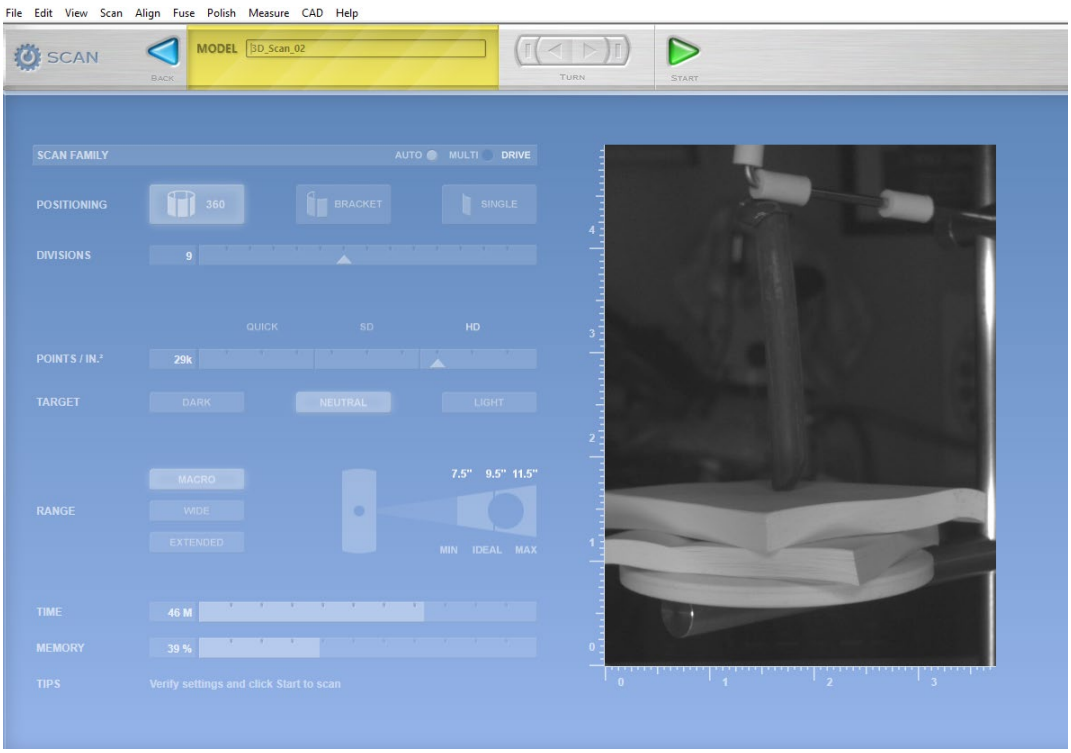


Figure 14. Screen shot of NextEngine scan settings used during the rifling characteristics study.

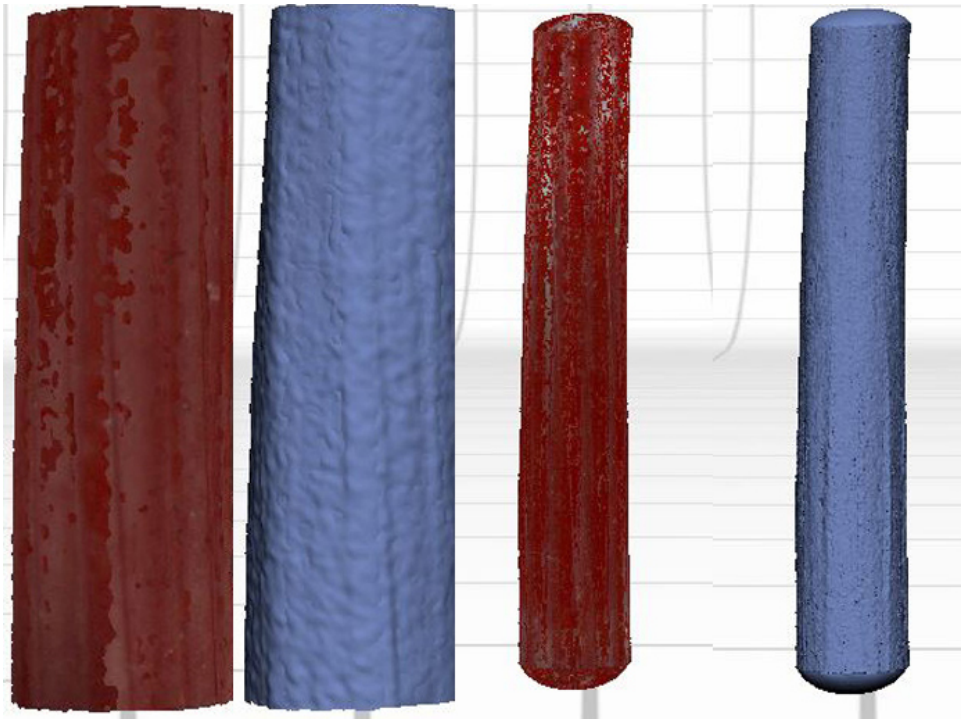


Figure 15. Photo draped and textured 3D scans of a Colt Navy revolver on the left and a Colt Russian revolver on the right. The textured scans illustrate the rifling configuration the best. The Colt Russian scans were done at the highest resolution possible but show little difference in their display quality from the standard resolution scan of the Colt Navy revolver.

The .ply format is used by Word© to allow files to be insert and viewed as 3D images by Paint or in a Microsoft Office 365 Word document. The .ply format can be used in third party software to convert the image to .u3D that can be imported to pdf documents using Adobe Acrobat Pro© and viewed by any recent Adobe PDF reader. This option was not used as Colorado Mesa University IT offices have strict rules that prohibit the use of non-vetted free software. Software vetting can take up to seven months given their workload.

Using the Database

For any given bullet collection that may be compared against the database of pre-1900 general rifling characteristics the process begins by sorting artifacts into like groups. A low power hand lens or microscope (7-40x) should be used to identify class characteristics. The process determines the presence or absence of rifling marks, and when present the direction of twist and number of land and groove impressions should be noted.

Measuring the bullet's diameter and weight as well as the widths of its land and groove marks allows further class segregation. Measure all land and groove marks as tenths, hundredths, and thousandths of an inch. A digital or analog micrometer is recommended for making the width measurements. A digital microscope with measurement capabilities can be substituted for the micrometer if available.

An archeologically well-preserved bullet with minimal impact damage can be measured to determine its diameter. All too often curators and archeologists unfamiliar with firearm caliber designations note the diameter as the gun caliber. This is a common error. Bullets, whether round ball or conical, are either slightly undersized or slightly oversized for the actual gun's nominal caliber. Gun makers and manufactures gave guns a nominal caliber, .44-inch or 7mm. In the case of the .44-caliber gun, the actual bullet could be .43-inch diameter if it was for a muzzle loading rifle that was meant to use a patched ball. If, on the other hand, the bullet measurement is .449 for instance, it is likely meant for a self-contained cartridge that was loaded via the breech. The oversized bullet was meant to more firmly grip the lands and grooves when fired which was an advantage of the self-contained breech-loading cartridge.

When fired, in either case, the bullet will be deformed to some extent on impact. That deformation will change the bullet diameter to some extent. Thus, the bullet measurement is only an approximation of caliber. When using the database, it is best to estimate caliber rather than use the actual bullet diameter. Database users can eliminate the caliber altogether and only use the number of land and grooves and their widths to determine the range of gun types, models, and calibers that most closely match the archeological sample. Using common sense will allow a reasonable determination of the best match or most likely range of guns.

Incomplete bullets are often recovered in archeological contexts. If the bullet was fired from a rifled weapon and was damaged on impact the fragment may retain only one or two land and groove impressions and the direction of twist may not be obvious. With the width of one land and one groove and an approximate bullet diameter or caliber known it is possible to approximate the number of land and grooves present on the complete bullet.

The minimum number of land and grooves needed for the formula to work is one each. By way of example a heavily impacted bullet is in the collection. In this case you have one land and one groove visible. The land impression width is 0.104 inch and the groove impression width is 0.107 inch. Divide the diameter of the bullet's suspected or measured caliber, in this case 0.44, by the sum of the width of the one land and groove impression (0.213), and then multiply that number by pi (3.14). The result is 6.5, which approximates the number land and grooves. Being 6.5 the number could be 6 or 7. Using the database will show the closest match is a 7 land and groove left twist .44-caliber Colt Dragoon revolver.

A word on determining twist direction is in order. Twist or rifling direction will be left, right, or rarely straight. The method to determine rifling direction is simple. Holding the bullet, whether a spherical ball or conical bullet, or placing it on a hard surface with good lighting contrast will reveal the direction of twist. A real or hypothetical line can be visualized as the center line of the bullet and the twist as rotating either left, right, or parallel to the center line. A conical bullet can be viewed from either end. The direction of twist on the conical bullet is the same no matter the viewing point; pointed end or the bullet base.

The GRC database contains the following information:

1. Manufacturer or gun maker, e.g. Colt
2. Model or type, and whether it is a rifle, carbine, revolver, or pistol, e.g. 3rd Model Dragoon
3. Nominal caliber, e.g. 44
4. Caliber type, inches or millimeters, e.g. 0. inch
5. Nominal caliber name if known, e.g. 44-40
6. Number of land and grooves, e.g. 7
7. Direction of twist, e.g. left
8. Minimum land width in decimal inch
9. Maximum land width in decimal inch
10. Minimum groove width in decimal inch
11. Maximum groove width in decimal inch
12. Land and Groove configuration, e.g. rounded grooves
13. Serial number of firearm if present for reference purposes

Additional information was also recorded as the source or collection where the cast was made and who made the cast. This information will not be made public and will be held in confidence to respect the privacy of the firearms owners who allowed their weapons to be sampled.

The database's search function allows the user to enter as much information as they have available. Caliber, if known, can be entered in decimal inches or millimeters. The number of land and grooves can be entered, if known. The direction of twist, left or right, can also be entered. The minimum and maximum widths of the land and grooves is entered in decimal inches. Finally, the land and groove search width range can be specified as either ± 0.003 inch or ± 0.015 inch as standard deviations for complete or partial bullets respectively.

Land and groove impressions on fired bullets, particularly lead bullets, can change due to impacts. A study of test fired bullets and the effects of impact on land and groove measurement (Marshall et al. 2008:3-12) demonstrated that intact bullets suffer less change to the land and groove widths than those more deformed by impact, or in cases where only a bullet fragment is

recovered. Despite the deformation they were able to use a rifling data database to create a list of possible firearm types for further comparative work. The important outcome of their research was to create two bullet categories, complete and partial/incomplete with a standard variation search parameter for each category.

For complete bullets, regardless of whether they are pure or soft lead or jacketed, Marshall et al. (2018) recommend a search variation of ± 0.003 inch. For partial/incomplete bullets they recommend a search variation of ± 0.015 inch.

The return or search output will list the firearms that are most consistent with the data input. Using the earlier .44-caliber example the search return may have a list of 5, 10, or 20 gun brands or models that have the same number of land and grooves, the same direction of twist, and with the rifling widths that fall in the range specified. From the extracted information the analyst can make informed decisions regarding the most likely firearm the bullet represents. For example, the .44-caliber bullet under consideration is a spherical ball with black powder stippling perpendicular to the line of the rifling impressions and has five lands and groove impressions with a right-hand twist. The database search finds two firearms, a Remington Model 1858 New Model Army revolver and a Remington Model 1875 Single Action Army revolver. A quick check of references will show that the Model 1858 fired round ball or conical bullets and the Model 1875 fired self-contained metallic cartridges with conical bullets. The Model 1875 can reasonably be excluded from further consideration.

A point to be remembered in using the database for land and groove width comparisons to determine likely gun, model, and caliber association is the database sources. The guns examined ranged from those that had no or very little use, so-called mint guns, to those which were well-used and heavily worn (Figures 16, 17, 18). Bore casts, while each very accurate and reflecting the condition of sampled bore for any given rifled gun, also clearly showed the state of the rifling. The rifling ranged from pristine condition with clear sharp edges to literally coated in rust with lands and grooves nearly obliterated due to long term use and poor maintenance. That is one of the reasons that maximum and minimum land and groove widths are provided for each rifled gun examined. Within those ranges for any give gun type or model the rifling characteristics of a bullet fired from a similar gun will fall within those maximum and minimum parameters.

Observations and Discussion

The pre-1900 GRC database contains information on nearly 800 rifled firearms. The majority date to the nineteenth century, but a few seventeenth- and eighteenth-century firearms were also sampled. American military firearms are very well represented in the database as are a good selection of common and trade firearms that were abundant in the antebellum era. Cartridge firearms of the American Civil War and commercial firearms of the post-Civil War era are also well represented. Both Union and Confederate guns are well represented for the American Civil War. There are a wide range of calibers and gun makers represented in the collected materials.

Figure 16. Digital microscope image of a Model 1890 Remington .44-caliber revolver barrel cast illustrating a near perfect bore. Note the rifling is right hand twist and the lands and grooves are flat.

Figure 17. Microscope image of well-worn rifling with rounded grooves in a Girardoni air rifle similar to the type carried by William Clark on the Lewis and Clark Expedition. Note the rusty condition of the rifling reflected in the cast which makes precise measurements more difficult but not impossible to obtain.

Figure 18. A .58-caliber Minié ball fired from a Pattern 1853 Enfield compared to an original Pattern 1853 and a reproduction Pattern 1853 bore casts. The bullet has a 3 right land and groove configuration. The middle cast is also a 3 right land and groove configuration while the right cast from the reproduction rifled musket is a 6 right land and groove configuration. The bullet is consistent with the original Pattern 1853 Enfield rifled musket.

There are also some notable data gaps in the database. These firearms were not readily available for bore casting. The intent is to continue data collection efforts as time and circumstances permit after the completion of the grant requirements. The under-represented rifled firearms include pre-1860 small gunsmith shop made firearms, so-called common or trade rifles and pistols. Pre-1800 era rifled guns are under-represented in the database. Also, under represented are both military and civilian firearms made in England and in Europe. This especially true for rifled muskets and hand guns that were imported to the U.S. from England and the continent

during the American Civil War. Arms made or used in the Latin American countries are somewhat under represented, but many of those countries imported U.S. or European made firearms for military use and for commercial sale. As the gaps are filled in with the acquisition of new data that information will be added to the database for use by researchers.

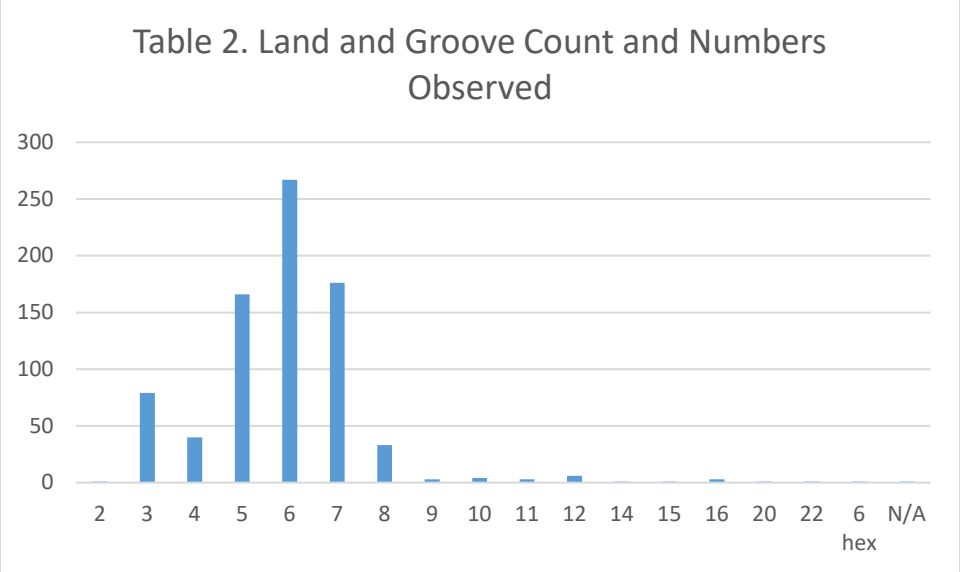
Data collection and analysis noted some variation in twist direction and rifling configuration (Tables 1, 2, 3). Out of 788 guns sampled one had an oval bore (Greene rifled musket) and two had hexagonal or polygonal bores (one English and one German). The hexagonal bore was developed by Joseph Whitworth of England, although none of his guns were available for sampling. A left-hand twist was found in guns from 35 different gun makers. Some gun makers or manufactures made firearms in both left and right twist configuration. Among those are Allen and Wheelock, Ballard, Colt, Forehand and Wadsworth, Hall (Harpers Ferry Amory), Manhattan Arms, Starr, Edward Tryon, Remington in their New Model Army and later for the Model 1917 Enfield, and the Smith carbine. Some of the late nineteenth century and early twentieth century firearms with left or right twist that was uncommon to that gun maker appear to have been arms made under military contract that likely had specific rifling twist and dimensions not normally used by the companies.

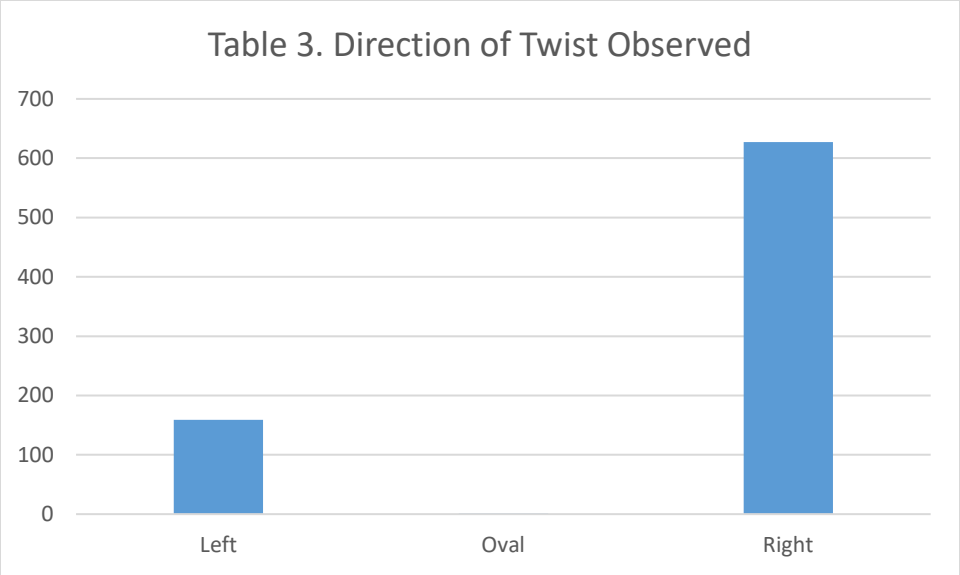
Left hand twist is a hallmark of Colt firearms and is cited in most forensic firearm identification literature as a classic example for identification. Data were collected on 106 different Colt firearms with several examples of the same model being available for casting. Thirty-five Colt guns were found to have right hand twist rifling, including one counterfeit revolver. A majority of the right-hand twist rifling dated to the late 1830s and through 1865. Colt is also known to have consistently used 6 land and grooves for their firearms. However, prior to 1865 a number of Colts have variable numbers of land and grooves. Patterson model revolvers and revolving rifles has 12 land and grooves, The Brevette model had 10, the First Model Dragoon 4, and 10, 11, and 12. The general impression is that Colt did not standardize its land and groove configuration until after the Civil War. They seem to have experimented with different land and groove configurations, even in the same model production line, a good deal prior to the Civil War.

Rounded groove rifling was present in 105 different firearms sampled during the project accounting for 63 different gun makers. Guns with rounded grooves were exclusive products of some gun makers, like the Girardoni air rifles, and most of the small trade or common rifle gun makers. Some makers like Maynard, Allen and Wheelock, Renaud Beauvais, Henry Deringer, J. Gloucher, Jacob and Samuel Hawken, Samuel Hawken, the Belgian Lefaucheux, and Henry Leman produced guns in the same era with rounded grooves and flat lands and grooves. The majority of the rounded groove guns sampled appear to pre-date 1860, suggesting that as the industrial revolution improved rifling machinery the flat land and groove configuration predominated.

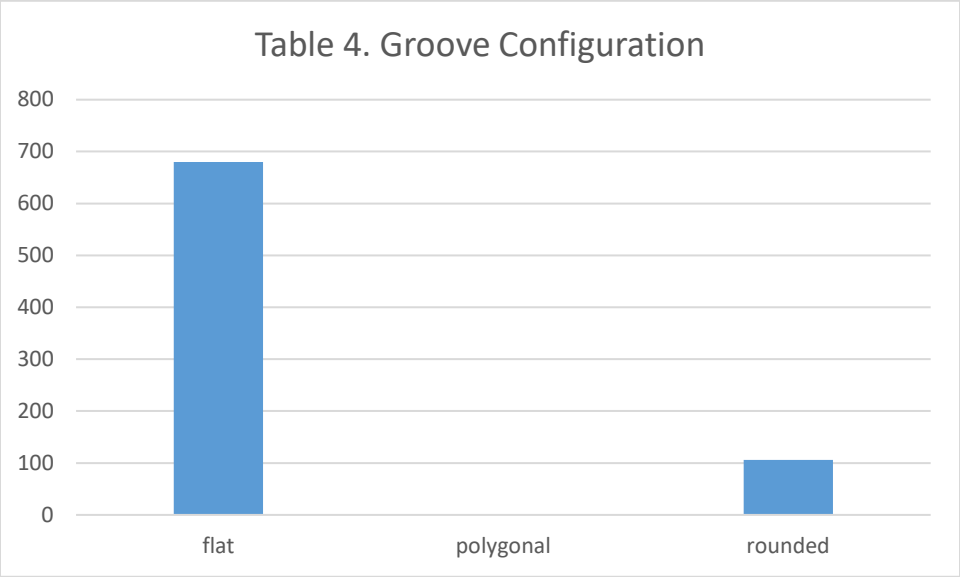
Table 1. Frequency of Number of Land and Groove Rifling Observed

Number of Land and Grooves	Number of firearms noted
2	2
3	80
4	40
5	166
6	268
7	176
8	33
9	3
10	2
11	3
12	7
14	1
15	1
16	3
20	1
22	1
	Total number of firearms = 788





Like the land and groove twist direction and the flat or rounded groove configuration the number of land and grooves varied between and among gun makers (Table 4). As was noted for Colt, the number of land and grooves varied prior to the Civil War a good deal. Just as in the sixteenth century the number and depth of and grooves varied among gun makers. By the 1850s the majority of firearms tended to have 3 or 4 land and grooves for most military armory or contract produced rifled muskets. Commercial firearms makers largely settled on 5, 6, or 7 land and grooves in that same era for their guns. As to be expected there are variations within some makers and among the different makers. For the most part the 8, 9, 10, 11, and 12 land and groove numbers will be found in guns pre-dating 1865. One exception to this are the late model, post 1895 Marlin micro groove rifles and carbines. A few have 12, 16, or 22 lands and grooves. These are unique and distinctive.



Harpers Ferry and private contract Hall Model 1819 rifles have 16 land and grooves, which is another very distinctive and recognizable rifling pattern. The Girardoni air rifles have 12 or 20 lands and grooves. These are late eighteenth century and early nineteenth century in origin. Originally these were made for the Austrian army and were used by rifle companies during the Napoleonic wars. One Girardoni style air rifle is believed to have been carried by Capt. William Clark on the Lewis and Clark expedition. Carrick (2002) and Haag (2016) are of the opinion the Girardoni air rifle carried by Clark was a .46-caliber with 12 land and grooves. A bullet found along the Missouri or Columbia Rivers with a 12, or possibly 20, land and groove configuration can almost certainly be attributed to the Corps of Discovery and become a definitive artifact of the Lewis and Clark expedition.

One goal of the project was not met, that of linking 3D scanned images to the database as a visual representation the rifling for each firearm. The project did use a 3D scanner to make scans of about 100 land and groove casts. The original intent was to link scans to the database, but the 3D scans were found to lack sufficient detail for comparative value. Standard digital photography and rollout panoramic photography were tested for comparison purposes. Standard digital photography has the best potential of the currently available visual representation techniques (Figure 29).

Figure 19. A 3D scan, a digital image, and a rollout image of a cast of a Gardner machine gun barrel. It is patently clear the digital image shows the rifling configuration and size better than the scan or rollout images.

Recent use of 3D scans and 3D printed material has been published in the forensic literature. Edwards and Rogers (2018) compared actual and 3D models and 3D prints of cranial injuries to determine their accuracy for analytical, teaching purposes, and medicolegal testimony. They found the 3D models or scans were accurate for measurement purposes compared to the original specimen, but noted that fine detail, while it resembled features in the original specimen, was not rendered in sufficient detail to be reliable. They also noted that the quality of printer and printer materials affected the quality of the print out. They observed that printed materials were good for teaching and general analysis, but some detail was not reproduced and lacked fine detail for accurate measurements.

Baier et al. (2018) found that 3D printed models added clarity to expert testimony in a UK criminal case. They observed that use of accurate 3D printed models demonstrated that law enforcement and the legal system were keeping up with twenty-first century scientific developments. They, however, cautioned that physical models should only be used where they add to the existing evidence to avoid the unjustified risk of creating cognitive bias in a jury.

Three-dimensional scanning has also been applied to fired bullets to assess and measure impact deformation. Mackie (2011) used a 3D topographic scanner on a cannonball before and after it was fired. He also used a software package to measure the scans. He concluded that the scanner resolution was not adequate to capture small details that are important to analysis of fired projectiles. In fact, he noted the data of interest was easily observable and measurable through macroscopic and microscopic inspections.

Wynne (2012) employed a NextEngine 3D laser scanner (an earlier version than used in this study) to model musket balls from a 1708 Belgian battle. His results were similar to the current study. The laser scan results were not detailed enough for the level of detailed analysis required in the study of impacted bullets. The laser scan created a good visual record of the bullets, but the measurement accuracy was inadequate to categorize deformation data. Parkman (2017:80-82) also concluded that there is no satisfactory affordable laser scanning capability for small scale measurement bullet analysis at present. These tests of projectile scanning and analysis are directly related to 3D scanning of the rifling casts conducted for this study.

The 3D scanning approach did not meet the desired goals due to lack of sufficient details in the scans. The process was not failure as it was learned that moderately priced laser scanners and their software, while very good at rendering 3D images, do not record detailed enough information in the scans of small-scale objects to make them useful. They are valuable as illustrative figures in a report or a presentation but lack sufficient resolution and detail to differentiate two different 6 right land and groove configurations as an example. Comparing a 3 land and groove bore cast to a 7 land and groove scan would show decided differences but not in the case of two different brands with a 6 right land and groove configuration per the example.

Firing Pin Shapes as Diagnostic Indicators

Since the development of the field of firearm and tool mark examination firing pin shape has been recognized as an important aid in the identification of the firearm type (Hatcher 1943; Mathews 1973; Hatcher et al 1977). Metallic self-contained cartridge cases were introduced in the late 1850s, the iconic .22-caliber. A metal firing pin was employed to ignite the priming compound to fire the cartridge, an advance over the percussion cap system in use since the 1820s. The metal firing pin left an imprint on the cartridge case primer, whether rimfire, centerfire, or other ignition systems such as lip-fire, teat fire, or cup fire. Mathews (1973 Volume III) illustrated and described 756 different .22-caliber firing pin configurations known at that time. Larger caliber metallic cartridges are more readily identifiable as to brand or model of firearm in which they were fired.

The firearm examiner field has used several typologies to describe firing pin shapes for analytical purposes. At one-point FirearmsID.com had a rifling characteristic search application that had thirteen shapes identified by a one or two letter code to describe generic firing pin shapes. Currently the Association of Firearm and Tool Mark Examiners (https://afte.org/members/databases/class-characteristics-matrix, accessed August 6, 2019) uses six firing pin shapes in their class characteristic search function. Those shapes are: circular, D-shaped, elliptical, hemispherical, rectangular, and square.

The nineteenth century firing pins observed during this data collection effort and earlier work demonstrates, like rifling, firearm manufacturers were experimenting with firing pin shapes to find the most effective type to work with the soft copper, Bloomfield Gilding Metal, cartridge cases and the primer compounds of the era. Nineteenth century firing pin shapes can be fitted into the current nomenclature and types but there are many variations within the types. The following figures (Figures 20, 21) illustrate 21 of the most commonly observed firing pin shapes found on 1860-1900 era firearms.

A Word on Percussion Caps

This study recorded rifling characteristics on 788 firearms. Three hundred and twenty-four of those guns employed percussion caps to fire the gun, a common ignition system from about 1820 onward. Percussion caps are an untapped analytical resource for archeologists studying sites where firearms were utilized (Weber and Scott 2005; 2006). These tiny artifacts have the potential to yield information regarding the minimum number of weapons present at a site using standard firearms and tool mark identification procedures. As with cartridge cases, percussion caps come into contact with parts of the firearm that have both class and individual characteristics due to imperfections and machining techniques used during the firearms manufacturing process. On muzzle loading firearms percussion caps come into contact with both the nipple or cone and the hammer or cock. The force of the hammer striking the percussion cap, coupled with the explosive forces of the igniting compound, cause the imperfections and unique characteristics of the hammer, the nipple, or both, to be imparted onto the cap itself. It is these markings that allow the analyst to determine that multiple percussion caps were fired on the same firearm. The more unique the markings present, the greater likelihood of being able to single out a specific firearm. Percussion cap analysis demonstrates that these artifacts are a data set that can be measured, sorted, and studied microscopically and will yield information that can expand our knowledge about a site and the role that firearms contributed to the event under study.

Figure 20. Centerfire firing pin impressions which are commonly hemispherical and similar in configuration. The means to determine firearm type includes analysis of the firing pin shape and the location and type of extractor and ejector marks. a. Colt Model 1873 .45-caliber revolver, b. Gatling gun, .50-70-caliber revolving barrel artillery gun, c. Phoenix, .50-70-caliber rifle, d. Remington .50-70-caliber rolling block rifle, e. Sharps, .50-70-caliber rifle (note the firing pin drag mark which is typical of the Sharps drop action), f. Springfield Model 1873, 1877, 1879, and 1884 45-70-caliber "trapdoor" rifle, g. Starr .44-caliber centerfire conversion carbine, h. Smith and Wesson No. 3, .32-caliber revolver, i. Smith and Wesson .45-caliber Schofield revolver, j. Ward Burton .45-70-caliber bolt action rifle.

Figure 21. Rimfire firing pin impressions. a. Ball carbine .52-caliber, b. Ballard carbine .54-caliber, c. Colt Model 1872 Open top .44-caliber revolver, d. Henry and Model 1866 Winchester .44-caliber rifle, e. Jocelyn .52-caliber carbine, f. Remington .44-caliber revolver, g. Spencer 56-56 and 56-50-caliber rifles and carbines, h. Starr .54-caliber carbine, i. Smith and Wesson .32-caliber revolver, j. Warner .50-70-caliber carbine, k. F. Wesson .44-caliber rifle.

Selected Artillery Rifling Characteristics

During the course of the small arms rifling casting effort some rifled artillery pieces were opportunistically measured. These guns range in date from the American Civil War to one made in 1910. These 41 different cannon represent some of the rifled artillery used by the U.S. Army and Navy in the last half of the nineteenth century (Table 5). The data on their rifling characteristics are presented as a value-added benefit to the study. They represent only a small portion of the rifled artillery used in the Civil War, American Indian Wars, and Spanish-American War but are a start in a broader data collection effort that can be used to identify rifled artillery types used in conflict sites based on the rifling patterns impressed on driving bands of copper, tin, and lead that are often recovered from battlefield contexts.

Table 5. Rifled Cannon Rifling Characteristics. Selected Artillery that was opportunistically sampled.

Gun Identification	Model or Name	Reg. No.	Bore dia.	Rifling No.	Twist	Min. Land, in.	Max. Land, in.	Min. Groove, in.	Max. Groove, in.
10 inch Breech Loading Rifle	Model 1888, Mark I, Mark II	N/A	10	60	Right	0.135	0.148	0.369	0.373
10 pounder Parrott Rifle	10 pounder Parrot Rifle	10	2.9	6	Right	1.540	1.560	1.350	1.350
100-pounder Parrott	Rifle	137	6.4	9	Right	1.126	1.233	1.036	1.088
12 inch Breech Loading Mortar	Model 1886	N/A	12	68	Right	0.172	0.174	0.373	0.379
12 inch Breech Loading Mortar	Model1890 Mark I	N/A	12	7	Right	0.147	0.150	0.369	0.373
12 inch Breech Loading Rifle	Model 1888, Mark I, Mark II	N/A	12	72	Right	0.125	0.155	0.371	0.373
14-pounder James	Rifle	84	3.8	10	Right	0.581	0.603	0.572	0.696
14-pounder James	Rifle	72	3.8	10	Right	0.585	0.608	0.448	0.675
14-pounder James	Model 1841	N/A	3.8	15	Right	0.378	0.415	0.333	0.480
14-pounder James	Model 1841	N/A	3.8	15	Right	0.347	0.425	0.395	0.426
15 pounder Driggs-Seabury Gun	Driggs-Seabury	N/A	3.1	24	Right	0.097	0.110	0.289	0.292
24-pounder	Rifle	1	5.82	9	Right	1.030	1.041	0.593	0.694
3 inch Ordnance Rifle	Model 1861	398	3	7	Right	0.529	0.644	0.777	0.829
3 inch Ordnance Rifle	Model 1861	251	3	7	Right	0.563	0.605	0.736	0.785
3 inch Ordnance Rifle	Model 1861	544	3	7	Right	0.561	0.596	0.747	0.771
3 inch Ordnance Rifle	Model 1861	806	3	7	Right	0.507	0.577	0.749	0.802
3 inch Ordnance Rifle	Model 1861	836	3	7	Right	0.554	0.594	0.708	0.786
3.2 inch Breech Loading Rifle	Model 1885, 1890, 1897	N/A	3.2	24	Right	0.115	0.118	0.295	0.303
3.6 inch Breech Loading Rifle	Model 1891	N/A	3.6	26	Right	0.116	0.119	0.296	0.302
3.6 inch Rifled Mortar	Model 1890	N/A	3.6	20	Right	0.111	0.120	0.441	0.445
4 inch Driggs-Schroeder Rapid Fire Gun	Driggs-Schroeder	N/A	4	30	Right	0.140	0.143	0.276	0.279
4.72 inch Armstrong Gun	Armstrong	N/A	4.72	26	Right	0.228	0.231	0.337	0.340
5 inch Rapid Fire Breech Loading Rifle	Model 1897	N/A	5	30	Right	0.147	0.152	0.368	0.372
5 inch Siege Rifle	Model 1890, Model 1898, Mark I	N/A	5	30	Right	0.146	0.150	0.367	0.373
6 inch Rapid Fire Breech Loading Rifle	Model 1897, Mark I, Model 1900	N/A	6	36	Right	0.148	0.151	0.369	0.373
6 pounder American Ordnance Gun	American Ordnance Model 1898 Mark I, Mark II	N/A	2.24	18	Right	0.167	0.171	0.216	0.219
6 pounder Driggs-Seabury Gun	Driggs-Seabury Model 1898	N/A	2.55	18	Right	0.168	0.172	0.217	0.220
6-pounder Rifled Gun	Model 1841	3	3.67	10	Right	0.581	0.662	0.591	0.654
7 inch Breech Loading Howitzer	Model 1890, Model 1898	N/A	7	42	Right	0.149	0.152	0.368	0.374
7 inch Breech Loading Mortar	Model 1892	N/A	7	28	Right	0.148	0.151	0.632	0.635
8 inch Breech Loading Rifle	Model 1888, Mark I, Mark II	N/A	8	48	Right	0.310	0.373	0.130	0.150
Hotching Revolving Cannon	USN	N/A	2.1	24	Right	0.065	0.067	0.202	0.204
Hotchkiss 1.65 inch Mt. Gun	Mountain Gun	132	1.65	10	Right	0.129	0.179	0.340	0.382
Hotchkiss 1.65 inch Mt. Gun	Mountain Gun	65	1.65	10	Right	0.156	0.160	0.339	0.347
Hotchkiss Heavy 1-pdr, USN	Heavy 1-pouder	29	1.5	12	Right	0.065	0.075	0.286	0.350
Hotchkiss 3 inch Mountain Gun	3 inch	N/A	3	24	Right	0.100	0.117	0.276	0.292
Hotchkiss Revolving Cannon	Rifle	279	1.5	12	Right	0.063	0.074	0.288	0.301
Hotchkiss Revolving Cannon	Heavy Field Gun	N/A	1.45	12	Right	0.059	0.074	0.288	0.302
Hotchkiss Revolving Cannon	Flank Defense	N/A	1.57	12	Right	0.096	0.098	0.310	0.312
Hotchkiss Revolving Cannon	USN	N/A	1.85	20	Right	0.150	0.160	0.214	0.216
M1905 3 inch Field Gun	Model 1905	N/A	3	24	Right	0.112	0.168	0.237	0.278
USN 6-inch Mark III	Mark III	N/A	6	24	Right	0.757	0.807	N/A	N/A

Conclusions

The pre-1900 rifling data database provides a new tool to researchers that enables them to more accurately identify a common class of firearms-related artifact, the rifling impressed bullet. The ability to more accurately identify gun types based on rifled bullet land and groove configuration provides a new tool to aid in determining specific gun use at given locales, and in conflict sites potentially identify specific unit location on the ground based on independent archeological data compared to the historic record of unit armament.

In battlefield studies this information provides planners, managers, and historians additional data on which to make decisions regarding the extent of combat areas, which units or combatant groups were deployed, and where this deployment occurred. This enhanced information will enable a more accurate understanding of past land use. The distribution of known gun type artifacts can be used in the analytical phase of the KOCOA system (particularly the cover, obstacles, and approaches) to more fully evaluate terrain use and value for preservation.

KOCOA is an acronym, adapted from military training manuals, for identifying key aspects of battlefield terrain. The original intent as stated in United States Army Field Manuals (US Army FM 3-0, 2001; 1986) is to inform commanders and junior leaders about their area of concern in order for them to make informed decisions on their courses of action in battle. KOCOA has five key factors that aid in explaining a military unit's terrain and the potential or actual use of a terrain. The acronym stands for: Key Terrain, Obstacles, Cover and Concealment, Observation and Fields of Fire, and Avenues of Approach. Employing KOCOA with the additional accurate firearm identification data derived from this project will increase meaning and validity of and for maintaining collections, thereby increasing the accuracy of and ability to identify threats to preservation.

The historic firearm database will also have relevance to firearm examiners who are involved in modern law enforcement case work. Historic firearms are rarely used in crimes today, but they are commonly found in alleged perpetrator's possession as either stolen items or as components of collections. When a firearm is involved in a crime the examiner must determine whether any given firearm in the possession of the alleged perpetrator or in the possession of a victim is of the type used in the crime. The FBI maintains an extensive database of cartridge case and rifling characteristics that reach into the thousands. However, that database has only about two dozen pre-1900 manufactured firearms described. This pre-1900 database on historic rifled firearms allows firearm examiners a new source of information to include or exclude historic weapons associated with some criminal event by comparing the firing pin and rifling characteristics with the suspect firearm.

Acknowledgements

I am grateful to the National Rifle Association and the National Firearms Museum for allowing me to take bore casts in their remarkable and extensive collection. I gratefully acknowledge the generous assistance of Jim Supica, director, Philip Schrier, senior curator, Doug Wicklund, senior curator, and Logan Metesh, firearms specialist in providing over 150 firearms for the sampling study.

The curatorial and collections staff at History Nebraska (Nebraska State Historical Society) allowed me to make casts of many of their firearms during the early stages of developing the bore casting technique.

James Hansen and Gail Potter (retired) of the Museum of the Fur Trade provided access to many of their early nineteenth century flintlock and percussion cap firearms for which I am grateful.

James Gordon's Glorieta Gun Museum is an amazing resource for Indian Trade guns, and mountain man and fur trade guns. He generously allowed me to handle and cast many of these rare and historically important guns.

Another remarkable collection is that of the J. M. Davis Gun Museum in Claremore, Oklahoma. Curator Jason Schubert kindly allowed access to a number of Civil War and frontier era firearms that significantly expanded the rifling database.

David Miller extended every professional courtesy to me during my research at the Smithsonian Institution's Museum of American History. Deborah Hull-Walski, collections manager at the SI Natural History Museum, provided the introduction to David, and has remained a good friend and colleague for over forty years.

Patrick Severts, Dr. C Vance Haynes, Dr. William Lees, Dick Harmon and numerous anonymous private collectors and firearms dealers allowed me access to their firearms collections for the purpose of making bore casts. Joel Bohy and Chris Fox of Skinner Auctions made a number of bore casts of rifled firearms that passed through the auction house, and in private collections to which only they had access. Their very significant contributions are gratefully acknowledged. The staff of Old Steel Historical Firearms allowed access to a 37mm Naval cannon for which I am grateful.

I wish to thank my professional colleagues, Joseph Balicki and Charles Haecker for their assistance in collecting samples at several museums. Mary Jane Balicki and Lou Haecker provided important logistical support during my research trips.

Tracy Mundy, CMU Grants Specialist in the Sponsored Research office, did her usually fine job of keeping the accounts straight and advising me on the proper procedure for travel and purchasing, making project administration go smoothly. John "Tad" Britt of the National Center for Preservation Technology and Training, National Park Service was our contact on the grant. Tad provided excellent direction and advice during the course of the grant work. My sincere thanks to him for his help and advice.

References Cited

Atkinson, Norman
1996 *Sir Joseph Whitworth: "the World's Best Mechanician."* Sutton Publishing, Gloucester.

Bair, Waltraud, Jason Warnett, Mark Payne, and Mark A. Williams
2018 Introducing 3D Printed Models as Demonstrative as Evidence at Criminal Trials. *Journal of Forensic Sciences* 63(4):1298-1302.

Berg, Stanton O.
1964 Filing .22 Firing Pin Impressions. *Journal of Criminal Law and Criminology* 55(2):290-294.

1977 The Forensic Ballistic Laboratory. In *Forensic Medicine Volume I Mechanical Trauma* edited by C. G. Tedeschi, William G. Eckert, and Luke G. Tedeschi. Pp.527-569. W. B. Saunders Company, Philadelphia, PA.

Carrick, Michael F.
2002 Meriwether Lewis' Air Gun. *We Proceeded On* 28(4):15-21.

de Espinar, Alonzo Martinez
1644 *Arte de Ballestria y Monteria*. Madrid (reprint).

Dougherty, Paul M.
1969 Report on Two Early United States Firearms Identification Cases. *Journal of Forensic Sciences* 14(4):453-59.

Edwards, Julie and Tracy Rogers
2018 The Accuracy and Applicability of 3D Modeling and Printing Blunt Force and Cranial Injuries. *Journal of Forensic Sciences* 63(3):683-691.

Fremantle, H. T.
1901 *The Book of the Rifle*. Longmans, Green and Co., London.

Greener, W. W.
1995 *The Gun and Its Development*. National Rifle Association/Odysseus Editions, Fairfax, VA.

Gunther, Jack Disbrow and Charles O. Gunther
1935 *The Identification of Firearms*. London, John Wiley and Sons.

Haag, Lucien C.
2006 *Shooting Incident Reconstruction*. Academic Press, New York.

2016 The Exterior and Terminal Ballistics of the Model 1780 Girardoni Air Rifle Carried by Meriwether Lewis During the Voyage of Discovery 1803-1806. *Journal of the Association of Firearm and Toolmark Examiners* 48(3):131-137.

Harris, C. E.
1980 Sherlock Holmes Would Be Impressed. *American Rifleman* 128(5):36-39,82.

Hatcher, Julian S.
1943 *Textbook of Firearms Investigation, Identification, and Evidence together with Textbook of Pistols and Revolvers*. Small-Arms Technical Publishing Co., Plantersville, South Carolina, fourth printing.

Hatcher, Julian, Frank J. Jury, and Jac Weller
1977 *Firearms Investigation, Identification and Evidence*. Stackpole Books, Harrisburg, PA.

Hawes, Arthur B.
1859 *Rifle Ammunition, being Notes on the Manufactures connected therewith, as conducted in The Royal Arsenal, Woolwich*. W. O. Mitchell, London (reprint 2004, Thomas Publications, Gettysburg, PA).

Hoyem, George A.
1987 *The History and Development of Small Arms Ammunition, Volume Three*. Armory Publications, Tacoma, Wash.

Kauffman, Henry J.
1960 *The Pennsylvania-Kentucky Rifle*. Bonanza Books, New York.

Mackie, C.
2011 Ballistic Investigation into 15th Century Cannons. Master of Science Thesis, Cranfield University, Cranfield, Bedfordshire, UK.

Marshall, John, Jordan Galloway-Booth, Wilfred Laurier, and Daniel Hockey
2018 Variation of Land and Groove Impressions on Fired Bullets. *Association of Firearm and Tool Mark Examiners Journal* 50(1):3-12.

Mathews, J. Howard
1973 *Firearms Identification* (3 Volumes) Charles C. Thomas, Springfield, IL.

Parkman, Colin J.
2017 Experimental Firing and Analysis of Impacted 17th-18th Century Lead Bullets. PhD Dissertation, University of Huddersfield, Huddersfield, West Yorkshire, UK.

Roberts, Ned H.

1952 *The Muzzle-Loading Cap Lock Rifle*. Bonanza Books, New York.

Sadler, Robert A.
1998 100 Years of Tryon. *American Society of Arms Collectors Bulletin* 79:57-68.

Scott, Douglas
1989 Firearms Identification for the Archeologist. In From Chaco to Chaco, Archeological Society of New Mexico No. 15 publication in honor of Robert H. and Florence C. Lister edited by Meliha S. Duran and David T. Kirkpatrick, pp 141-151.

2013 Uncovering History: Archeological Investigations at the Little Bighorn Battlefield National Monument. University of Oklahoma Press, Norman.

Scott, Douglas D., Richard A. Fox, Jr., Melissa A. Connor, and Dick Harmon
1989 Archaeological Perspectives on the Battle of the Little Bighorn. Norman: University of Oklahoma Press.

Thomas, Dean S.
1997 *Round Ball to Rimfire: A History of Civil War Small Arms Ammunition*. Thomas Publications, Gettysburg, Penn.

2003 *Round Ball to Rimfire: A History of Civil War Small Arms Ammunition, Part Three, Federal Pistols, Revolvers, and Miscellaneous Essays*. Thomas Publications, Gettysburg, PA.

Secretary of War
1856 *Reports of Experiments with Small Arms for the Military Service*. A. O. P. Nicholson Public Printer, Washington, DC. (reprint undated by Dean S. Thomas, Arendtsville, PA.)

Weber, Kent P., and Douglas D. Scott
2005 Applying Firearm Identification Procedures in the Analysis of Percussion Caps. Association of Firearm and Tool Mark Examiners Journal 37(1):34-44.

2006 Uncapped Potential: Applying Firearms Identification Procedures in the Analysis of Percussion Caps. *Historical Archaeology* 40(3):131-143.

Westwood, David
2005 *Rifles: An Illustrated History of Their Impact*. ABC CLIO, Santa Barbara, CA.

Wilhelm, Russell M.
1980 General Considerations of Firearms Identification and Ballistics. In *Medicolegal Investigation of Death* by Werner U. Spitz and Russell S. Fisher, pp. 202-215, Springfield, IL., Charles C. Thomas.

Wynne, A.

2012 Establishing a Methodology to Unlock the Archaeology of Attack: A Case Study from 17th Century England. University of Huddersfield, Huddersfield, West Yorkshire, UK.

Appendix I
Rifling Characteristic Data Collection Form

Gun ID	Gun images #	Bore image #	Cast	Collection

Appendix II

Pre-1900 Rifling Characteristics Database

Manufacturer	Model	Ignition Type	Caliber	Inch or MM	Caliber Name	Twist	L&G No.	Land Min	Land Max	Groove Min	Groove Max
Adams	Percussion revolver	Percussion	44	0. inch		Right	5	0.021	0.025	0.223	0.224
Adams	Percussion revolver	Percussion	31	0. inch		Right	3	0.158	0.161	0.146	0.147
Adams	Britain, model 1851 revolver	Percussion	44	0.inch		Right	3	0.095	0.105	0.245	0.255
Adams (Austrian copy) revolver	Adams (Austrian copy) revolver	Percussion	52	0. inch		Right	4	0.207	0.213	0.198	0.201
Adams and Dean	Percussion revolver	Percussion	32	0. inch		Right	3	0.097	0.102	0.227	0.232
Adams and Deane revolver	Percussion revolver	Percussion	44	0. inch		Right	5	0.066	0.067	0.219	0.225
Adams, J.	Percussion revolver, London in case	Percussion	44	0. inch		Right	7	0.102	0.116	0.075	0.082
Adams, Robert	Gen. George McClellan, gold plated cased revolver	Percussion	44	0. inch		Right	5	0.119	0.129	0.136	0.145
Air rifle, unknown maker	Early - ball reservoir air rifle	Air	38	0. inch		Right	10	0.025	0.027	0.075	0.080
Albright, T. J.	Trade rifle, St. Louis	Percussion	35	0. inch		Right	7	0.060	0.070	0.089	0.095
Albright, T. J.	St. Louis, half stock Plains rifle	Percussion	45	0.inch		Left	4	0.161	0.179	0.107	0.126
Albright, T. J.	St. Louis, MO, Plains rifle	Percussion	56	0.inch		Right	7	0.143	0.148	0.056	0.062

Albright, T. J.	St. Louis, MO, Plains rifle	Percussion	50	0.inch		Right	7	0.098	0.112	0.068	0.073
All Right Palm pistol	ca 1876 palm pistol	Rimfire	22	0. inch		Right	3	0.145	0.151	0.077	0.081
Allen & Wheelock	lipfire revolver	Lipfire	44	0. inch		Right	6	0.080	0.088	0.100	0.107
Allen and Thurber	1840-1860, boot pistol	Percussion	36	0. inch		Right	6	0.098	0.104	0.086	0.088
Allen and Wheelock	Center Hammer Navy revolver	Percussion	36	0. inch		Right	6	0.081	0.094	0.095	0.101
Allen and Wheelock	Center Hammer revolver	Percussion	44	0. inch		Left	6	0.113	0.120	0.106	0.112
Allen and Wheelock	Center hammer Army revolver	Percussion	44	0. inch		Left	6	0.092	0.098	0.111	0.120
Allen and Wheelock	Side hammer Navy	Percussion	36	0. inch		Left	6	0.100	0.106	0.082	0.088
Allen and Wheelock	Ethan Allen, drop breech rifle	Rimfire	41	0. inch		Right	3	0.206	0.216	0.176	0.182
Arisaka	Japan, rifle	Centerfire	7.7	mm	7.7x58	Right	4	0.050	0.050	0.190	0.190
Austria	M1842 Engineer's Rifle	Percussion	70	0. inch		Right	4	0.300	0.309	0.276	0.280
Austria	M1849 Long Rifle	Percussion	71	0. inch		Right	12	0.109	0.110	0.090	0.095
Austria	M1854 Lorenz rifled musket	Percussion	58	0. inch		Right	4	0.231	0.238	0.208	0.228
Bacon	Pocket Model revolver	Percussion	31	0. inch		Left	5	0.089	0.091	0.089	0.091
Bacon	fluted cylinder, square butt, Pocket	Percussion	31	0. inch		Left	5	0.096	0.108	0.079	0.081

	model revolver										
Baker	British, Tower rifle	Flintlock	64	0. inch		Right	7	0.150	0.163	0.135	0.147
Baker	English short rifle	Flintlock	60	0.inch		Right	7	0.107	0.107	0.101	0.123
Baker	English, standard chief's presentation rifle	Flintlock	64	0.inch		Right	8	0.101	0.106	0.095	0.102
Baker	Pattern 1800 Infantry rifle	Percussion	64	0. inch		Right	7	0.148	0.161	0.130	0.132
Baker, T.	Half stock rifle owned by George Ruxton, ca. 1848	Percussion	58	0. inch		Right	10	0.034	0.038	0.137	0.138
Ball	carbine	Rimfire	50	0. inch		Right	5	0.157	0.164	0.164	0.166
Ball	Carbine	Rimfire	50	0. inch		Right	5	0.130	0.137	0.133	0.140
Ball	repeating carbine	Rimfire	50	0. inch		Right	5	0.148	0.155	0.163	0.168
Ballard	1851 carbine	Rimfire	44	0. inch		Left	5	0.148	0.163	0.123	0.138
Ballard	Pacific No. 5 carbine	Centerfire	38	0. inch	38-55	Right	6	0.036	0.047	0.144	0.152
Ballard - Ball & Williams	carbine	Rimfire	54	0. inch		Left	5	0.135	0.146	0.106	0.109
Ballard - Merwin and Bray	carbine	Rimfire	54	0. inch		Right	5	0.168	0.171	0.164	0.167
Ball-Williams	Carbine	Rimfire	44	0. inch		Left	5	0.111	0.120	0.096	0.099
Beals	Navy Model	Percussion	36	0.inch		Right	5	0.095	0.101	0.108	0.116
Beaumont-Adams	Britain, model 1854 revolver	Percussion	44	0.inch		Right	3	0.097	0.118	0.277	0.284
Beauvais, Rene	St. Louis, MO, half stock	Percussion	58	0.inch		Right	7	0.105	0.119	0.090	0.115

Beauvais, Renaud	Trade rifle, St. Louis	Percussion	50	0. inch		Right	7	0.117	0.120	0.098	0.102
Beauvais, Renaud	Trade rifle, St. Louis	Percussion	54	0. inch		Right	8	0.120	0.162	0.059	0.072
Belgian	Trade rifle	Percussion	38	0. inch		Right	6	0.100	0.111	0.081	0.088
Belgium	Military rifled musket	Percussion	54	0. inch		Right	4	0.212	0.214	0.203	0.206
Belgium	folding hammer ring trigger	Percussion	9	mm		Right	5	0.093	0.098	0.100	0.108
Belgium	cased pistols	Percussion	12	mm		Right	12	0.063	0.066	0.059	0.068
Belgium	single shot pistol	Percussion	13	mm		Right	14	0.040	0.045	0.074	0.078
Belgium	Liege proofed over and under shotgun/rifle	Percussion	10	mm		Right	8	0.091	0.094	0.061	0.068
Belgium Guardian	American M1877 revolver	Pinfire	36	0. inch		Right	5	0.063	0.078	0.111	0.119
Bentley	London, pistol	Percussion	42	0. inch		Right	8	0.080	0.094	0.076	0.081
Billinghurst, William	John and James Miller patent, revolving rifle	Percussion	32	0.inch		Left	6	0.050	0.060	0.090	0.093
Blanch, John	Webley style cased revolver	Percussion	44	0. inch		Right	5	0.100	0.102	0.147	0.155
Blickensdoerfer, J.	St. Louis, MO, half stock Plains rifle	Percussion	40	0.inch		Right	6	0.099	0.106	0.072	0.082
Borchardt	German Model 1893, semi-automatic pistol	Centerfire	7.65	mm	7.65x25	Right	4	0.055	0.061	0.166	0.171

Brown and Tetley	Pittsburg, PA, half stock Plains rifle	Percussion	40	0.inch		Right	6	0.096	0.109	0.048	0.069
Burnside	carbine	Percussion	54	0. inch		Right	5	0.162	0.166	0.179	0.186
Burnside	carbine	Percussion	54	0. inch		Right	5	0.158	0.160	0.171	0.177
Burnside	carbine	Percussion	54	0. inch		Right	5	0.165	0.166	0.179	0.183
Butterfield	1855 Army revolver	Special priming	41	0. inch		Right	7	0.078	0.082	0.093	0.095
Campbell, T.	St. Louis, MO, fancy half stock rifle	Percussion	38	0.inch		Right	7	0.075	0.077	0.058	0.059
Campbell, T.	St. Louis, MO, fine quality Plains rifle	Percussion	60	0.inch		Right	7	0.132	0.138	0.079	0.093
Child and Pratt	St. Louis, MO, full stock with Brown and Tetley lock	Percussion	50	0.inch		Right	7	0.131	0.136	0.054	0.056
Child and Pratt	St. Louis, MO, full stock with Brown and Tetley lock	Percussion	44	0.inch		Right	7	0.105	0.107	0.053	0.056
Cimarron Arms	Model 1873 (Winchester Copy) rifle	Centerfire	44	0. inch	44-40	Right	6	0.090	0.100	0.100	0.110
Clement, C.,	cased Clement revolver	Percussion	36	0. inch		Right	7	0.064	0.071	0.100	0.104
Colt	model not noted	Centerfire	44	0. inch	44-40	Left	6	0.030	0.062	0.159	0.194
Colt	model not noted	Centerfire	41	0. inch	41 Long	Left	6	0.029	0.041	0.158	0.173
Colt	model not noted	Centerfire	38	0. inch	38-40	Right	6	0.039	0.040	0.168	0.170
Colt	model not noted	Centerfire	38	0. inch	38-40	Left	6	0.040	0.061	0.142	0.165

Colt	model not noted	Centerfire	38	0. inch		Left	6	0.040	0.075	0.105	0.138
Colt	model not noted	Centerfire	38	0. inch	38 Long	Left	6	0.028	0.065	0.120	0.162
Colt	model not noted	Centerfire	32	0. inch	32-20	Left	6	0.040	0.067	0.095	0.120
Colt	model not noted	Centerfire	32	0. inch	32 Short	Left	6	0.050	0.053	0.107	0.110
Colt	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	6	0.080	0.085	0.080	0.087
Colt	model not noted	Centerfire	32	0. inch	32 S&W Long	Left	6	0.045	0.087	0.071	0.112
Colt	model not noted	Centerfire	32	0. inch	32 S&W	Right	6	0.080	0.082	0.078	0.080
Colt	model not noted	Centerfire	32	0. inch	32 S&W	Left	6	0.041	0.064	0.095	0.117
Colt	model not noted	Centerfire	32	0. inch	32 Long Colt	Left	6	0.045	0.065	0.100	0.115
Colt	model not noted	Centerfire	25	0. inch	25-20	Right	6	0.054	0.056	0.073	0.074
Colt	Model 1851 Navy revolver 3rd Model	Percussion	36	0. inch		Left	7	0.075	0.081	0.085	0.087
Colt	1st Model Dragoon revolver	Percussion	44	0. inch		Right	7	0.089	0.097	0.110	0.114
Colt	3rd Model Dragoon revolver	Percussion	44	0. inch		Right	7	0.092	0.104	0.102	0.107
Colt	Model 1911 and Model 1911A1 ACP	Centerfire	45	0. inch	45 ACP	Left	6	0.070	0.070	0.160	0.160
Colt	Baby Dragoon	Percussion	32	0. inch		Right	7	0.060	0.064	0.070	0.078
Colt	Baby Patterson Pocket Model No. 1	Percussion	31	0. inch		Right	11	0.035	0.041	0.042	0.046

Colt	Bisley model, ca 1912	Centerfire	38	0. inch		Left	6	0.035	0.046	0.177	0.185
Colt	1st Model Dragoon revolver	Percussion	44	0. inch		Right	4	0.177	0.181	0.155	0.161
Colt	2nd Model Dragoon revolver	Percussion	44	0. inch		Right	7	,077	0.087	0.095	0.105
Colt	Model 1894 revolver	Centerfire	38	0. inch		Left	6	0.034	0.034	0.162	0.165
Colt	Model 1895 machine gun - Rough Rider association	Centerfire	7	mm		Right	6	0.044	0.048	0.088	0.090
Colt	Patterson No. 5 Holster Model, 12 inch bbl, revolver	Percussion	36	0. inch		Right	12	0.064	0.069	0.034	0.038
Colt	Patterson revolving rifle	Percussion	44	0. inch		Right	11	0.041	0.048	0.072	0.078
Colt	Model 1849 pocket Brevette revolver	Percussion	36	0. inch		Right	10	0.026	0.038	0.046	0.054
Colt	Model 1849 Pocket revolver	Percussion	31	0. inch		Right	7	0.056	0.057	0.084	0.088
Colt	Model 1849 Pocket revolver	Percussion	31	0. inch		Left	7	0.057	0.062	0.075	0.080
Colt	Model 1862 Police revolver	Percussion	32	0. inch		Left	5	0.105	0.108	0.075	0.077

Colt	Model 1862 Police revolver	Percussion	36	0. inch		Left	7	0.085	0.086	0.086	0.090
Colt	Model 1873 revolver	Centerfire	45	0. inch		Left	6	0.030	0.021	0.191	0.195
Colt	Model 1873 revolver	Centerfire	45	0. inch		Left	6	0.178	0.193	0.022	0.043
Colt	Model 1873 revolver	Centerfire	45	0. inch		Left	6	0.038	0.047	0.172	0.190
Colt	Bisley revolver	Centerfire	44	0. inch	44-40	Left	6	0.100	0.102	0.118	0.120
Colt	Model 1877 Lightning Revolver	Centerfire	41	0. inch	41 Long	Left	6	0.040	0.042	0.165	0.170
Colt	Model 1878 Double Action Frontier revolver	Centerfire	41	0. inch	41 Long	Left	6	0.030	0.030	0.170	0.170
Colt	Model 1877 Lightning Revolver	Centerfire	38	0. inch	38-40	Right	6	0.040	0.040	0.170	0.170
Colt	New Service Revolver	Centerfire	38	0. inch	38-40	Left	6	0.060	0.060	0.140	0.170
Colt	New Service Revolver	Centerfire	38	0. inch	38-40	Left	6	0.060	0.060	0.140	0.150
Colt	Model 1892 revolver	Centerfire	38	0. inch	38 Long	Left	6	0.040	0.040	0.140	0.140
Colt	Model 1878 Double Action Frontier revolver	Centerfire	38	0. inch	38 Long	Left	6	0.030	0.030	0.160	0.160

Colt	Model 1877 Lightning revolver	Centerfire	38	0. inch	38 Long	Left	6	0.050	0.060	0.120	0.130
Colt	Model 1899 Army revolver	Centerfire	38	0. inch	38 Long	Right	5	0.090	0.100	0.110	0.120
Colt	Model 1894 Army revolver	Centerfire	38	0. inch	38 Long	Left	6	0.020	0.020	0.160	0.160
Colt	Model 1895 Navy revolver	Centerfire	38	0. inch	38 Long	Left	6	0.030	0.030	0.150	0.150
Colt	Model 1901 Army revolver	Centerfire	38	0. inch	38 Long	Left	6	0.040	0.040	0.140	0.15
Colt	Model 1894 Army revolver	Centerfire	38	0. inch	38 Special	Left	6	0.020	0.020	0.160	0.16
Colt	Model 1895 Navy revolver	Centerfire	38	0. inch	38 Special	Left	6	0.030	0.030	0.150	0.15
Colt	Model 1901 Army revolver	Centerfire	38	0. inch	38 Special	Left	6	0.040	0.040	0.140	0.15
Colt	Police Positive revolver	Centerfire	38	0. inch	38 S&W	Left	6	0.040	0.040	0.140	0.140
Colt	Police Positive revolver	Centerfire	38	0. inch	38 S&W	Left	6	0.050	0.050	0.130	0.130
Colt	Double Action revolver	Centerfire	38	0. inch	38 S&W	Left	6	0.050	0.050	0.130	0.130
Colt	Banker's Special revolver	Centerfire	38	0. inch	38 S&W	Left	6	0.050	0.050	0.120	0.130
Colt	Frontier single action revolver	Centerfire	38	0. inch	38-40	Left	6	0.040	0.040	0.160	0.170
Colt	M1851 Navy revolver	Percussion	36	0. inch		Left	7	0.080	0.093	0.070	0.033

Colt	3rd Model Dragoon revolver	Percussion	44	0. inch		Right	7	0.870	0.890	0.050	0.108
Colt	M1860 Army revolver	Percussion	44	0. inch		Right	7	0.093	0.099	0.102	0.106
Colt	Richardson Conversion revolver	Rimfire	44	0. inch		Left	7	0.092	0.099	0.090	0.104
Colt	Navy double action revolver	Centerfire	45	0. inch		Left	6	0.080	0.080	0.160	0.160
Colt	Webley revolver, for Auto rim	Centerfire	455	0. inch		Left	6	0.070	0.080	0.160	0.160
Colt	Pocket Model revolver	Percussion	31	0. inch		Left	7	0.067	0.076	0.064	0.070
Colt	Model 1878 Double Action Frontier revolver	Centerfire	45	0. inch		Left	6	0.027	0.031	0.216	0.219
Colt	Sheriffs Model revolver	Centerfire	44	0. inch		Left	6	0.052	0.055	0.149	0.156
Colt	Model 1851 Navy revolver	Percussion	36	0. inch		Left	7	0.073	0.077	0.074	0.079
Colt	Model 1860 Army revolver	Percussion	44	0. inch		Left	7	0.097	0.101	0.103	0.106
Colt	Model 1851 Navy revolver	Percussion	36	0. inch		Right	8	0.048	0.042	0.073	0.078
Colt	Model 1851 Navy	Percussion	36	0. inch		Right	7	0.067	0.073	0.073	0.079
Colt	Model 1878 Double Action	Centerfire	45	0. inch		Left	6	0.014	0.020	0.204	0.206

	Frontier revolver										
Colt	Pocket Navy with ejector, conversion revolver	Rimfire	38	0. inch		Left	7	0.075	0.083	0.074	0.084
Colt	Side hammer 1855 Model 2 revolver	Percussion	31	0. inch		Left	7	0.050	0.055	0.074	0.081
Colt	Side hammer 1855 Model 2 revolver	Percussion	28	0. inch		Left	7	0.049	0.051	0.064	0.066
Colt	Model 1848 Baby Dragoon revolver	Percussion	31	0. inch		Left	7	0.063	0.066	0.068	0.072
Colt	Side hammer 1855 Model 6 revolver	Percussion	31	0. inch		Left	7	0.048	0.052	0.077	0.080
Colt	Model 1849 Pocket revolver	Percussion	31	0. inch		Right	7	0.064	0.066	0.070	0.071
Colt	Round barrel, no ejector revolver	Rimfire	38	0. inch		Left	7	0.080	0.086	0.088	0.091
Colt	Bisley Single Action Army, Civilian revolver	Centerfire	45	0. inch		Left	6	0.048	0.049	0.168	0.173
Colt	Single Action Army, civilian	Centerfire	45	0. inch		Left	6	0.027	0.032	0.194	0.196

Colt	Single Action Army, civilian revolver	Centerfire	38	0. inch		Left	6	0.045	0.055	0.149	0.154
Colt	Bisley, 101 Ranch grips, revolver	Centerfire	44	0. inch		Left	6	0.023	0.027	0.197	0.201
Colt	Model 1877 Lightning Revolver	Centerfire	38	0. inch		Left	6	0.017	0.021	0.158	0.159
Colt	Model 1877 Lightning Revolver	Centerfire	38	0. inch		Left	6	0.017	0.023	0.176	0.182
Colt	Model 1860 Army revolver	Percussion	44	0. inch		Left	7	0.098	0.102	0.100	0.105
Colt	Model 1849 Pocket revolver	Percussion	31	0. inch		Left	7	0.053	0.054	0.077	0.080
Colt	Fluted cylinder, Model 1862 Police revolver	Percussion	36	0. inch		Left	7	0.075	0.081	0.079	0.083
Colt	Model 1860 Richards conversion, brass stock	Centerfire	38	0. inch		Right	7	0.082	0.093	0.072	0.078
Colt	Round barrel with ejector, revolver	Centerfire	38	0. inch		Left	7	,082	0.092	0.073	0.075
Colt	New Service revolver double action	Centerfire	41	0. inch		Left	6	0.023	0.027	0.165	0.172

Colt	Model 1855 revolving carbine	Percussion	50	0. inch		Right	7	0.092	0.093	0.130	0.140
Colt	Model 1855 revolving rifle	Percussion	56	0. inch		Left	7	0.112	0.119	0.125	0.140
Colt	Model 1855 revolving rifle	Percussion	56	0. inch		Right	7	0.120	0.123	0.131	0.135
Colt	Model 1855 revolving rifle	Percussion	56	0. inch		Left	5	0.082	0.099	0.096	0.104
Colt	Model 1855 revolving rifle	Percussion	56	0. inch		Right	7	0.093	0.106	0.135	0.142
Colt	Model 1855 revolving rifle	Percussion	44	0. inch		Right	7	0.104	0.115	0.086	0.103
Colt	Single Action Army revolver	Centerfire	32	0. inch	32-40	Left	6	0.066	0.069	0.091	0.093
Colt	Single Action Army revolver	Centerfire	38	0. inch	38 Special	Left	6	0.056	0.058	0.130	0.137
Colt	Single Action Army revolver	Centerfire	41	0. inch		Left	6	0.032	0.033	0.181	0.183
Colt	Single Action Army revolver	Centerfire	38	0. inch	38.4	Left	6	0.038	0.038	0.167	0.168
Colt	New Line 32, engraved, gold chased	Rimfire	32	0. inch		Left	6	0.076	0.081	0.073	0.080

	cased pistols										
Colt	Special rifled musket dated 1863	Percussion	58	0. inch		Right	3	0.286	0.289	0.289	0.292
Colt	USMR model, Walker revolver	Percussion	44	0. inch		Right	7	0.071	0.082	0.103	0.110
Colt	Model 1855 revolving rifle musket	Percussion	58	0.inch		Right	7	0.099	0.102	0.118	0.122
Colt (fake)	Walker Model 1847 revolver-fake - conversion	Rimfire	44	0. inch		Right	7	0.086	0.091	0.109	0.110
Colt Cimarron	M1860 revolver copy by Cimarron	Percussion	44	0. inch		Left	7	0.082	0.099	0.096	0.104
Colt Richards Mason	Model 1860 Army cartridge conversion revolver	Centerfire	44	0. inch		Left	5	0.032	0.038	0.174	0.179
Colt-London	revolver	Percussion	31	0. inch		Left	7	0.052	0.057	0.064	0.067
Colt-Marlin	M1895/1917 machine gun	Centerfire	30	0. inch	30-06	Right	4	0.048	0.048	0.184	0.184
Common rifle	unattributed rifle	Percussion	56	0. inch		Left	3	0.336	0.343	0.174	0.180
Cooper, J.	New York, rifle likely owned by John Charles Fremont	Percussion	45	0.inch		Right	7	0.075	0.099	0.102	0.109

Cooper, J. M.	Pocket Model revolver	Percussion	31	0. inch		Right	6	0.078	0.083	0.083	0.085
Dance Brothers	Dragoon Model, Confederate revolver	Percussion	44	0. inch		Right	7	0.093	0.094	0.104	0.108
Dance Brothers	Navy Model, Confederate revolver	Percussion	36	0. inch		Right	7	0.029	0.035	0.121	0.132
Deane, Adams, and Deane	Britain revolver	Percussion	36	0.inch		Right	3	0.163	0.171	0.105	0.206
Deringer (Henry Derringer copy)	Pocket pistol	Percussion	45	0. inch		Right	7	0.135	0.139	0.061	0.068
Deringer (Henry Derringer copy)	Pocket pistol	Percussion	45	0. inch		Right	7	0.135	0.139	0.061	0.068
Deringer, Henry	Trade rifle	Flintlock	45	0. inch		Left	8	0.116	0.125	0.061	0.065
Deringer, Henry	Trade rifle	Percussion	45	0. inch		Right	7	0.108	0.114	0.084	0.082
Deringer, Henry	Trade rifle	Percussion	50	0. inch		Right	7	0.127	0.131	0.075	0.077
Deringer, Henry	Trade rifle	Percussion	40	0. inch		Right	7	0.097	0.101	0.069	0.074
Deringer, Henry	Trade rifle	Flintlock	52	0. inch		Right	7	0.090	0.094	0.131	0.133
Deringer, Henry	pistol	Percussion	41	0. inch		Right	7	0.144	0.148	0.054	0.056
Deringer, Henry	Model 1814 common rifle	Flintlock	54	0.inch		Right	7	0.128	0.137	0.070	0.074
Derr, C.	swivel breech rifle	Percussion	45	0.inch		Right	8	0.026	0.029	0.099	0.102
Dickert, J. & Gill	Trade rifle, Lancaster, PA	Flint to Percussion Conversion	50	0. inch		Left	7	0.125	0.136	0.091	0.098

Dickinson, M.	Trade rifle, Louisville, KY	Percussion	45	0. inch		Right	7	0.100	0.107	0.083	0.091
Dickson, M.	Louisville, KY, Plains rifle	Percussion	54	0.inch		Right	7	0.068	0.078	0.120	0.126
Dickson, M. and J. J. Gilmore	Louisville, KY , full stock	Percussion	44	0.inch		Right	7	0.083	0.096	0.061	0.068
Dimick, Colt copy	Colt copy revolver	Percussion	36	0. inch		Right	7	0.065	0.069	0.106	0.110
Dimick, Horace	Pocket pistol, St. Louis, MO	Percussion	41	0. inch		Left	6	0.193	0.203	0.202	0.209
Dimick, Horace	Pocket pistol, St. Louis, MO	Percussion	41	0. inch		Left	6	0.193	0.203	0.202	0.209
Dimick, Horace	Trade rifle, St. Louis, MO	Percussion	55	0. inch		Left	6	0.164	0.178	0.112	0.123
Dimick, Horace	Dimick and Co. St. Louis, MO, pistol	Percussion	36	0.inch		Right	7	0.069	0.077	0.059	0.062
Eckhardt and Rein	St. Joseph, MO	Percussion	38	0.inch		Right	7	0.090	0.096	0.073	0.073
Elgin Cutlass pistol	Morrill, Merman, & Blair, single shot pistol with blade	Percussion	36	0. inch		Right	8	0.056	0.061	0.059	0.066
Elwell, H.	swivel breech rifle	Percussion	40	0.inch		Right	7	0.073	0.078	0.071	0.071
Enfield	P1853 rifled musket	Percussion	577	0. inch		Right	3	0.334	0.358	0.226	0.267
Enfield	Potts and Hunt contract P53 rifled musket	Percussion	577	0. inch		Right	3	0.346	0.353	0.238	0.240
Enfield	revolver	Centerfire	38	0. inch		Right	7	0.028	0.041	0.110	0.132

Enfield	Mark I revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.030	0.030	0.130	0.130
Enfield	No. 2 Mark I revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.030	0.030	0.130	0.130
Enfield	1914 Mark I revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.040	0.040	0.120	0.120
Enfield	P53, BSA, rifled musket	Percussion	577	0. inch		Right	3	0.354	0.361	0.230	0.233
Enfield	Tower marked, 1861 short rifle	Percussion	577	0. inch		Right	3	0.346	0.363	0.239	0.243
Enfield	P53, Type II, Crimean War	Percussion	577	0.inch		Right	3	0.255	0.265	0.224	0.225
Enfield	British Enfield Tower lock dated 1857 carbine	Percussion	577	0. inch		Right	3	0.352	0.361	0.229	0.242
Enfield	P53 Artillery model	Percussion	577	0.inch		Right	3	0.274	0.275	0.205	0.209
Enfield Dine Patent	Dine Patent Enfield, bolt action rifle	Centerfire	577	0.inch		Right	3	0.345	0.349	0.249	0.256
Ethan Allen	Side hammer 3rd Model revolver	Rimfire	32	0. inch		Right	3	0.127	0.132	0.067	0.072
Euroarms	Reproduction P53 Enfield rifle	Percussion	577	0.inch		Right	6	0.116	0.121	0.159	0.166
Evans	rifle	Centerfire	41	0. inch		Right	6	0.092	0.111	0.111	0.103
Fall and Cunningham	Nashville, TN, rifle	Flintlock	31	0.inch		Right	7	0.028	0.035	0.081	0.084
Fall and Cunningham	Nashville, TN, rifle	Percussion	38	0.inch		Right	7	0.065	0.069	0.065	0.071

Fay, George	Altoona, PA, half stock Plains rifle	Percussion	50	0.inch		Right	8	0.080	0.084	0.086	0.089
Fayetteville	Confederate rifled musket	Percussion	58	0. inch		Right	3	0.246	0.268	0.311	0.327
Ferguson	Flintlock breechloading rifle, reproduction	Flintlock	65	0. inch		Right	8	0.100	..10	0.100	0.100
Fitzpatrick	Baton Rouge, LA	Percussion	50	0.inch		Right	7	0.063	0.070	0.103	0.111
Folsom, Henry	St. Louis, Mo, full stock rifle, with Horace Dimick barrel	Percussion	46	0.inch		Right	7	0.078	0.086	0.081	0.083
Folsom, Henry & Co.	St. Louis, Mo, full stock rifle	Percussion	54	0.inch		Right	7	0.164	0.170	0.058	0.069
Forehand & Wadsworth	revolver	Centerfire	32	0. inch	32 S&W	Right	4	0.135	0.140	0.100	0.105
Forehand & Wadsworth	revolver	Centerfire	380	0. inch		Right	5	0.120	0.122	0.090	0.092
Forehand & Wadsworth	revolver	Centerfire	38	0. inch		Right	6	0.099	0.100	0.079	0.080
Forehand & Wadsworth	revolver	Centerfire	38	0. inch		Left	6	0.084	0.088	0.100	0.106
Forehand & Wadsworth	revolver	Centerfire	38	0. inch		Left	6	0.100	0.105	0.070	0.075
Forehand & Wadsworth	revolver	Centerfire	32	0. inch	32 Colt Short	Left	6	0.063	0.064	0.094	0.095

Forehand & Wadsworth	revolver	Centerfire	32	0. inch	32 S&W Long	Left	6	0.067	0.072	0.087	0.090
Forehand & Wadsworth	revolver	Centerfire	32	0. inch	32 S&W	Right	6	0.065	0.072	0.090	0.100
Forehand & Wadsworth	revolver	Centerfire	32	0. inch	32 S&W	Left	6	0.059	0.082	0.088	0.100
Forehand & Wadsworth	revolver	Centerfire	32	0. inch	38 S&W	Left	6	0.100	0.110	0.070	0.080
Forehand & Wadsworth	revolver	Centerfire	32	0. inch	38 S&W	Left	6	0.080	0.090	0.100	0.110
Forehand & Wadsworth	revolver	Centerfire	38	0. inch	38 Special	Left	6	0.090	0.090	0.100	0.100
French	MLE 1873	Centerfire	11	mm	11 mm Lebel	Right	4	0.168	0.170	0.148	0.150
French or Belgian	revolver	Pinfire	10	mm		Right	6	0.082	0.088	0.073	0.079
Friede, M.	St. Louis, MO, half stock	Percussion	41	0.inch		Right	6	0.092	0.113	0.064	0.074
Gallagher	carbine	Percussion	56	0. inch		Left	6	0.116	0.125	0.142	0.158
Gallagher	carbine	Percussion	50	0. inch		Left	6	0.135	0.146	0.118	0.121
Gardner	machine gun, two barrel	Centerfire	45	0. inch		Right	5	0.117	0.118	0.155	0.159
Gatling gun	Model 1874	Centerfire	50	0. inch	50-70	Right	6	0.050	0.062	0.193	0.212
Gatling gun	Colt Model 1900	Centerfire	30	0. inch	30-40	Right	4	0.043	0.044	0.163	0.164
Gatling gun	Colt Model 1887	Centerfire	45	0. inch		Right	6	0.031	0.035	0.192	0.195
Gatling gun	San Juan Hill association-relined barrels	Centerfire	30	0. inch	30-06	Right	4	0.050	0.053	0.163	0.165
Gemmer, J. P.	Trade rifle with	Rimfire	50	0. inch		Right	6	0.121	0.126	0.132	0.133

	Spencer rifle barrel										
Gemmer, J. P.	St. Louis, MO, half stock target rifle	Percussion	38	0.inch		Left	6	0.074	0.078	0.086	0.095
Gemmer, J. P.	St. Louis, MO, barrel marked H. E. Dimick	Percussion	50	0.inch		Right	7	0.088	0.091	0.088	0.093
German	L. Dieter Hofbuchen macher, cased set single shot pistols	Centerfire	7.9	mm		Right	6	0.057	0.060	0.101	0.112
German	Full stock, wheellock rifle	Wheellock	45	0. inch		Right	7	0.077	0.078	0.122	0.130
German	Full stock, wheellock rifle	Wheellock	60	0. inch		Right	9	0.053	0.161	0.105	0.115
Gesell	Swiss 1882	Centerfire	7.5	mm	7.55	Right	4	0.120	0.130	0.100	0.100
Gibbs	carbine, William F. Books, lock	Percussion	52	0. inch		Right	6	0.105	0.106	0.159	0.161
Gibbs, Henry	Mountain rifle	Flintlock	54	0. inch		Left	6	0.181	0.237	0.097	0.108
Gilmore, J. J. and M. Dickson	Louisville, KY , full stock	Percussion	54	0.inch		Right	7	0.097	0.105	0.086	0.095
Girardoni	Girardoni Model 1780 air rifle	Air	44	0. inch		Right	20	0.000	0.000	0.055	0.058
Girardoni	Girardoni Model 1780 air rifle, reproductio n of alleged Clark gun	Air	46	0. inch		Right	12	0.046	0.051	0.071	0.078
Girardoni	Girardoni Model	Air	46	0. inch		Right	12	0.018	0.027	0.087	0.095

	1780 air rifle										
Gloucher, J.	Pennsylvania style fullstock flintlock rifle with Gloucher lock	Flintlock	54	0. inch		Right	11	0.084	0.131	0.046	0.076
Gloucher, J.	fullstock percussion rifle	Percussion	45	0. inch		Right	5	0.125	0.144	0.127	0.138
Gloucher, J.	Kentucky style rifle	Percussion	44	0.inch		Right	6	0.067	0.069	0.132	0.137
Gonter, A.	Trade rifle	Percussion	54	0. inch		Right	7	0.110	0.113	0.114	0.116
Greene	rifled musket, oval bore, no formal rifling	Percussion	54	0. inch		Oval	N/A				
Griswold	Confederate revolver	Percussion	32	0. inch		Right	5	0.067	0.079	0.137	0.138
Griswold and Gunnison	Confederate revolver	Percussion	36	0. inch		Right	6	0.091	0.097	0.089	0.093
Griswold and Gunnison	Confederate revolver	Percussion	41	0. inch		Right	6	0.075	0.092	0.096	0.102
Grice, John	Staffordshire, England, trade rifle	Flintlock	60	0.inch		Right	7	0.116	0.126	0.080	0.092
Gumpf	Trade rifle	Flintlock	45	0. inch		Right	8	0.093	0.100	0.072	0.083
Gurst, J.	lock marked Drepert, Plains rifle	Flintlock	50	0.inch		Right	7	0.091	0.095	0.075	0.086
Gwyn & Campbell	aka Union carbine	Percussion	52	0. inch		Right	3	0.277	0.283	0.229	0.230
Gwyn & Campbell	aka Cosmopolitan carbine	Percussion	52	0. inch		Right	3	0.276	0.283	0.228	0.231
Gwyn and Campbell/ Union	aka Union carbine	Percussion	52	0. inch		Right	3	0.262	0.270	0.225	0.235

Hall	Model 1840 carbine	Percussion	52	0. inch		Right	6	0.125	0.129	0.149	0.150
Hall	Model 1843 carbine	Percussion	52	0. inch		Right	6	0.128	0.136	0.091	0.099
Hall	Model 1836 carbine	Percussion	52	0. inch		Right	6	0.148	0.156	0.112	0.117
Hall	Model 1819 dated 1824 rifle	Flintlock	54	0. inch		Right	16	0.030	0.040	0.057	0.058
Hall	Model 1819 rifle	Flintlock	52	0. inch		Right	16	0.041	0.045	0.054	0.060
Hall	circa 1811, commercial version rifle	Flintlock	58	0. inch		Left	8	0.120	0.129	0.082	0.087
Hammond, Henry	Deluxe Sporting rifle	Centerfire	45	0. inch		Right	3	0.213	0.217	0.214	0.219
Harpers Ferry	Model 1803 dated 1804 rifle	Flintlock	54	0. inch		Right	7	0.149	0.153	0.082	0.089
Harpers Ferry	Model 1803 dated 1819 rifle	Flintlock	54	0. inch		Right	7	0.164	0.174	0.074	0.078
Harrington and Richards	model not noted	Centerfire	30	0. inch	30-30	Right	4	0.050	0.054	0.176	0.177
Harrington and Richards	model not noted	Centerfire	38	0. inch		Right	5	0.090	0.124	0.090	0.130
Harrington and Richards	model not noted	Centerfire	32	0. inch	32 Short	Right	5	0.090	0.095	0.095	0.105
Harrington and Richards	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	5	0.085	0.087	0.103	0.105
Harrington and Richards	model not noted	Centerfire	32	0. inch	32 S&W	Right	5	0.085	0.130	0.068	0.110

Harrington and Richards	model not noted	Centerfire	32	0. inch	32 Long Colt	Right	5	0.089	0.093	0.098	0.100
Harrington and Richards	model not noted	Centerfire	38	0. inch	38 Short	Right	6	0.104	0.106	0.114	0.117
Harrington and Richards	model not noted	Centerfire	38	0. inch		Right	6	0.053	0.100	0.080	0.127
Harrington and Richards	model not noted	Centerfire	32	0. inch	32 Colt Short	Right	6	0.061	0.062	0.093	0.097
Harrington and Richards	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	6	0.053	0.095	0.070	0.110
Harrington and Richards	model not noted	Centerfire	32	0. inch	32 S&W	Right	6	0.053	0.076	0.081	0.106
Hawken, D. T.	full stock rifle	Percussion	40	0. inch		Right	7	0.100	0.102	0.078	0.083
Hawken, Jacob and Samuel	St. Louis, Mo, full stock rifle	Percussion	54	0.inch		Right	7	0.117	0.118	0.086	0.092
Hawken, Jacob and Samuel	St. louis, MO, owned by Thomas T. Tobin, half stock Plains rifle	Percussion	54	0.inch		Right	7	0.115	0.117	0.085	0.088
Hawken, S.	Half stock Plains rifle	Percussion	54	0. inch		Right	7	0.172	0.154	0.071	0.091
Hawken, Samuel	Trade rifle, St. Louis, MO	Percussion	54	0. inch		Right	7	0.124	0.128	0.101	0.105
Hawken, Samuel	Half stock rifle, St. Louis, MO	Percussion	45	0. inch		Right	7	0.121	0.131	0.079	0.081
Hawken, Samuel	Half stock rifle, St. Louis, MO	Percussion	60	0. inch		Right	7	0.148	0.155	0.108	0.111
Hawken, Samuel	full stock rifle	Percussion	45	0. inch		Right	7	0.095	0.099	0.087	0.089
Hawken, Samuel	St. Louis, MO, owned	Percussion	60	0.inch		Right	7	0.124	0.126	0.087	0.089

	by Mariano Medina, half stock Plains rifle										
Hawken-Gemmer-Spencer conversion	Conversion of 1865 Spencer action with Hawken-Gemmer barrel	Rimfire	55	0.inch		Right	7	0.105	0.114	0.092	0.095
Hellinghaus	St. Louis, Plains rifle	Percussion	55	0.inch		Right	8	0.087	0.090	0.099	0.101
Henry	rifle	Rimfire	44	0. inch		Right	6	0.095	0.105	0.114	0.121
Henry	rifle	Rimfire	44	0. inch		Right	6	0.102	0.114	0.114	0.120
Henry, J.	U.S. trade gun rifle	Percussion	40	0. inch		Right	6	0.106	0.120	0.084	0.102
Henry, J.	half stock Plains rifle	Percussion	45	0. inch		Right	6	0.176	0.186	0.062	0.077
Henry, J.	Half stock	Percussion	45	0. inch		Right	8	0.071	0.071	0.096	0.096
Henry, J.	Half stock rifle	Percussion	40	0. inch		Right	8	0.050	0.054	0.083	0.089
Henry, J & Sons	rifle	Percussion	48	0. inch		Right	8	0.017	0.107	0.074	0.077
Hoffman, C.	St. Louis, MO	Percussion	45	0.inch		Right	7	0.067	0.079	0.070	0.075
Hopkins & Allen	XL Bulldog revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.120	0.120	0.100	0.100
Hopkins & Allen	model not noted	Centerfire	32	0. inch	32 S&W	Right	5	0.093	0.097	0.095	0.100
Hopkins & Allen	model not noted	Centerfire	32	0. inch	32 S&W	Left	5	0.090	0.115	0.069	0.100
Hopkins & Allen	model not noted	Centerfire	38	0. inch		Right	6	0.080	0.092	0.090	0.090
Hopkins & Allen	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	6	0.065	0.082	0.084	0.100
Hopkins & Allen	model not noted	Centerfire	32	0. inch	32 S&W	Right	6	0.035	0.083	0.080	0.123
Hopkins & Allen	horizontal firing pin, revolver	Rimfire	32	0. inch		Right	6	0.061	0.077	0.083	0.093

Hopkins & Allen	Safety Police revolver	Centerfire	38	0. inch	38 S&W	Right	6	0.080	0.080	0.100	0.100
Hopkins & Allen	Hammerless revolver	Centerfire	38	0. inch	38 S&W	Right	6	0.080	0.080	0.100	0.100
Hopkins & Allen	Double action No. 6 revolver	Centerfire	38	0. inch	38 S&W	Right	6	0.080	0.080	0.090	0.100
Howard	Thunderbolt carbine	Rimfire	44	0. inch		Right	6	0.099	0.104	0.122	0.125
Howard, W. P.	rifle	Percussion	45	0. inch		Right	7	0.109	0.116	0.091	0.097
Hunt, Edwin	Fullstock long rifle, lock marked Edwin Hunt	Percussion	44	0. inch		Right	7	0.092	0.097	0.089	0.090
Hyde and Goodrich - Tranter	New Orleans, LA, 3rd model Tranter revolver	Percussion	33	0.inch		Right	5	0.049	0.058	0.121	0.123
Iver Johsnon	model not noted	Centerfire	38	0. inch		Right	5	0.100	0.152	0.070	0.120
Iver Johsnon	model not noted	Centerfire	32	0. inch	32 Short	Right	5	0.120	0.125	0.075	0.080
Iver Johsnon	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	5	0.090	0.097	0.095	0.105
Iver Johsnon	model not noted	Centerfire	32	0. inch	32 S&W	Right	5	0.085	0.120	0.070	0.110
Iver Johsnon	model not noted	Centerfire	44	0. inch	44-40	Right	6	0.062	0.063	0.150	0.152
Iver Johsnon	model not noted	Centerfire	38	0. inch	38 Short	Right	6	0.120	0.120	0.060	0.060
Iver Johsnon	model not noted	Centerfire	38	0. inch		Right	6	0.060	0.130	0.045	0.120
Iver Johsnon	model not noted	Centerfire	32	0. inch	32 Short	Right	6	0.050	0.055	0.110	0.115
Iver Johsnon	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	6	0.075	0.085	0.078	0.090
Iver Johsnon	model not noted	Centerfire	32	0. inch	32 S&W	Right	6	0.073	0.083	0.080	0.095

Iver Johsnon	Top break revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.100	0.110	0.110	0.120
Iver Johsnon	American Bulldog revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.100	0.110	0.120	0.120
Iver Johsnon	Model 1900 revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.100	0.110	0.110	0.120
Iver Johsnon	Hammerless revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.110	0.110	0.100	0.100
Iver Johsnon	Model 1900 revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.120	0.120	0.100	0.100
J star mark W	Kentucky rifle, Louisville lock	Percussion	36	0. inch		Right	7	0.085	0.088	0.066	0.070
James, Morgan	Target rifle	Percussion	36	0.inch		Left	6	0.101	0.107	0.079	0.080
Jenks	USN 1845 rifle	Percussion	54	0. inch		Right	6	0.151	0.155	0.118	0.122
Jenks	USN 1845 rifle	Percussion	54	0. inch		Right	6	0.153	0.161	0.116	0.117
Joslyn	M1864 carbine	Rimfire	52	0. inch		Right	3	0.287	0.296	0.260	0.264
Joslyn	M1862 carbine	Rimfire	52	0. inch		Right	3	0.241	0.249	0.267	0.272
Joslyn	M1862 carbine	Rimfire	52	0. inch		Right	3	0.264	0.266	0.283	0.286
Joslyn	carbine	Rimfire	52	0. inch		Right	3	0.257	0.264	0.278	0.282
Joslyn	Army Model revolver	Percussion	44	0. inch		Right	5	0.126	0.134	0.122	0.132
Kendall, N.	under hammer rifle, 1830-1840s Windsor, VT	Percussion	44	0. inch		Right	9	0.063	0.067	0.080	0.090
Kerr	revolver	Percussion	44	0. inch		Left	5	0.129	0.132	0.124	0.128
Kerr	revolver	Percussion	44	0. inch		Left	5	0.103	0.107	0.153	0.156

Ketland, Thomas	Trade rifle, circa 1790, England	Flintlock	55	0. inch		Right	7	0.125	0.130	0.082	0.098
Ketland, William	Birmingham, England, trade rifle	Flintlock	64	0.inch		Right	7	0.153	0.162	0.080	,087
Krider, John	full stock rifle	Percussion	54	0. inch		Right	7	0.145	0.157	0.094	0.108
Lebel FM	French 1908 rifle	Centerfire	8	mm		Left	4	0.080	0.080	0.170	0.170
Lebel MAT	French MAT 1920 rifle	Centerfire	8	mm		Left	4	0.077	0.077	0.166	0.169
Leech and Rigdon	Navy Model, Confederate revolver	Percussion	36	0. inch		Right	7	0.069	0.077	0.085	0.093
Lefaucheux	Belgian revolver	Pinfire	8	mm		Right	5	0.077	0.079	0.075	0.076
Lefaucheux	Belgian revolver	Pinfire	11	mm		Right	4	0.075	0.079	0.240	0.244
Lefaucheux	Belgian revolver	Pinfire	12	mm		Right	7	0.038	0.049	0.132	0.150
Lefaucheux	Fabrica de Durango, Spanish	Pinfire	12	mm		Right	5	0.112	0.135	0.108	0.115
Leman, H. E.	rifle, Leman lock, possible parts gun	Percussion	36	0. inch		Right	5	0.105	0.016	0.099	0.102
Leman, H. E.	rifle	Percussion	38	0. inch		Right	7	0.111	0.113	0.055	0.058
Leman, H. E.	rifle	Percussion	60	0. inch		Right	7	0.118	0.119	0.152	0.154
Leman, H. E.	rifle	Percussion	42	0. inch		Right	7	0.126	0.128	0.054	0.056
Leman, H. E.	fullstock rifle	Percussion	54	0. inch		Right	7	0.143	0.182	0.081	0.111
Leman, H. E.	full stock rifle	Percussion	50	0. inch		Right	7	0.141	0.145	0.073	0.077
Leman, H. E.	Half stock, bear rifle	Percussion	70	0. inch		Right	7	0.190	0.193	0.106	0.110

Leman, Henry	Trade rifle, Lancaster, PA	Percussion	50	0. inch		Right	7	0.144	0.149	0.071	0.079
Leman, Henry	Trade rifle, Lancaster, PA	Percussion	45	0. inch		Right	8	0.104	0.114	0.064	0.069
Lemat	1st Model Confederate revolver	Percussion	42	0. inch		Right	5	0.108	0.115	0.133	0.136
Lemat	2nd Model Confederate revolver	Percussion	42	0. inch		Right	5	0.106	0.114	0.132	0.140
Lenzel, A. E.	St. Louis, MO	Percussion	40	0.inch		Left	4	0.130	0.140	0.110	0.115
Liddle, R.	San Francisco, CA, half stock rifle	Percussion	58	0.inch		Left	7	0.089	0.111	0.114	0.132
Lindner	Amoskeag rifled musket conversion	Percussion	58	0. inch		Right	5	0.183	0.187	0.181	0.189
Lindner	First Type carbine	Percussion	58	0. inch		Right	3	0.272	0.280	0.299	0.304
Lindner	Model 1863 rifled musket	Percussion	58	0. inch		Right	3	0.279	0.281	0.300	0.304
Lindsay	Model 1863 rifled musket	Percussion	58	0. inch		Right	3	0.290	0.294	0.295	0.296
Lorenz	Austrian Model 1854 carbine, Confederate use at Glorieta	Percussion	58	0.inch		Right	4	0.234	0.241	0.204	0.219
Lower, J. P.	Trade rifle, Philadelphia, PA	Percussion	33	0. inch		Right	6	0.013	0.013	0.044	0.048
Luger	German 1914 Luger Pistol	Centerfire	9	mm	9mm Luger	Right	6	0.070	0.080	0.100	0.110

Luger	German 1915 Luger pistol	Centerfire	9	mm	9mm Luger	Right	6	0.080	0.080	0.100	0.100
Luger	German Navy 1917 Luger pistol	Centerfire	9	mm	9mm Luger	Right	6	0.080	0.080	0.100	0.100
Luger	German 1918 Luger pistol	Centerfire	9	mm	9mm Luger	Right	6	0.080	0.080	0.100	0.100
Luger	German 1908 Luger pistol	Centerfire	9	mm	9mm Luger	Right	6	0.080	0.080	0.090	1.000
Luger	German 1916 Luger pistol	Centerfire	9	mm	9mm Luger	Right	6	0.080	0.080	0.100	0.100
Luger	German Mauser 1912 Luger pistol	Centerfire	9	mm	9mm Luger	Right	6	0.050	0.050	0.130	0.130
Manhattan	Navy Revolver	Percussion	36	0. inch		Right	5	0.122	0.124	0.112	0.119
Manhattan Arms	Series I Pocket model revolver	Percussion	31	0. inch		Left	7	0.066	0.071	0.066	0.078
Manhattan Arms	Series III Navy Type revolver	Percussion	36	0. inch		Right	5	0.104	0.110	0.110	0.116
Marlin	model not noted	Centerfire	45	0. inch	45-90	Right	6	0.094	0.094	0.141	0.141
Marlin	Model 1895	Centerfire	45	0. inch	45-70	Right	6	0.094	0.094	0.141	0.141
Marlin	model not noted	Centerfire	44	0. inch	44-40	Right	6	0.087	0.088	0.131	0.132
Marlin	model not noted	Centerfire	40	0. inch	40-82	Right	6	0.082	0.083	0.124	0.125
Marlin	model not noted	Centerfire	40	0. inch	40-70	Right	6	0.083	0.084	0.124	0.125
Marlin	model not noted	Centerfire	40	0. inch	40-65	Right	6	0.083	0.084	0.124	0.125
Marlin	model not noted	Centerfire	38	0. inch	38-55	Right	6	0.077	0.078	0.116	0.117

Marlin	model not noted	Centerfire	38	0. inch	38-55	Right	6	0.080	0.080	0.120	0.120
Marlin	model not noted	Centerfire	38	0. inch	38-40	Right	6	0.061	0.083	0.124	0.152
Marlin	model not noted	Centerfire	38	0. inch	38	Right	6	0.060	0.060	0.120	0.120
Marlin	model not noted	Centerfire	32	0. inch	32-40	Right	6	0.065	0.066	0.098	0.099
Marlin	model not noted	Centerfire	30	0. inch	30-30	Right	6	0.057	0.063	0.093	0.097
Marlin	Model 1895	Centerfire	45	0. inch	45-70	Right	8	0.065	0.066	0.112	0.114
Marlin	model not noted	Centerfire	30	0. inch	30-30	Right	12	0.026	0.041	0.040	0.054
Marlin	model not noted	Centerfire	30	0. inch	30-30	Right	16	0.021	0.028	0.029	0.038
Marlin	model not noted	Centerfire	30	0. inch	30-30	Right	22	0.016	0.017	0.026	0.027
Marlin	Model 1893	Centerfire	38	0. inch	38-40	Right	6	0.060	0.060	0.150	0.150
Marlin	Model 1895	Centerfire	40	0. inch	40-65	Right	6	0.080	0.080	0.120	0.130
Marlin	Model 1895	Centerfire	40	0. inch	40-70	Right	6	0.080	0.080	0.120	0.130
Marlin	Model 1894	Centerfire	44	0. inch	44-40	Right	6	0.090	0.090	0.130	0.130
Mass. Arms, Adams Patent	Adams patent revolver	Percussion	31	0. inch		Right	7	0.049	0.057	0.066	0.076
Massachus etts Arms	Pocket Revolver	Maynard primed	28	0. inch		Right	7	0.051	0.053	0.063	0.067
Massachus etts Arms	Belt revolver	Maynard primed	31	0. inch		Right	7	0.052	0.055	0.076	0.079
Mauser	German GE 1891 rifle	Centerfire	7.65	mm	7.65X50	Right	4	0.070	0.080	0.170	0.170
Mauser	German 1908 rifle	Centerfire	7	mm	7 mm Mauser	Right	4	0.060	0.060	0.150	0.160
Mauser	German GE 1898 rifle	Centerfire	8	mm	8mm Mauser	Right	4	0.060	0.060	0.180	0.180

Mauser	German GE K43 rifle	Centerfire	8	mm	8mm Mauser	Right	4	0.070	0.070	0.180	0.180
Mauser	C96 Broom handle semi-automatic pistol	Centerfire	30	0. inch		Right	6	0.050	0.050	0.110	0.110
Maynard	2nd Model carbine	Maynard primed	50	0. inch		Right	3	0.226	0.235	0.266	0.269
Maynard	Model 1865 sporter rifle	Maynard primed	31	0. inch		Right	6	0.047	0.048	0.108	0.109
Maynard (Mass. Arms)	carbine	Maynard primed	50	0. inch		Right	3	0.244	0.256	0.245	0.251
Maynard (Mass. Arms)	1854-60 pistol	Maynard primed	31	0. inch		Right	7	0.059	0.062	0.066	0.070
Maynard copy	Confederate Maynard carbine	Percussion	54	0. inch		Right	7	0.122	0.141	0.012	0.104
Meier, Adolph	St. Louis, MO, full stock	Percussion	38	0.inch		Right	8	0.056	0.061	0.061	0.062
Meier, Adolph	St. Louis, MO, full stock	Percussion	41	0.inch		Right	7	0.076	0.082	0.080	0.082
Meier, Adolph	St. Louis, MO, full stock	Percussion	45	0.inch		Right	7	0.091	0.103	0.066	0.071
Merrill	First type carbine	Percussion	54	0. inch		Right	3	0.322	0.344	0.244	0.257
Merrill	carbine	Percussion	54	0. inch		Right	7	0.129	0.134	0.111	0.115
Merrill	Baltimore, 2nd type carbine	Percussion	54	0. inch		Right	3	0.324	0.333	0.206	0.232
Merrill, James	First type Merrill carbine	Percussion	54	0.inch		Right	3	0.186	0.198	0.216	0.242
Merwin & Hulbert	Pocket Model revolver	Centerfire	32	0. inch	32 S&W Long	Right	5	0.088	0.090	0.100	0.102

Merwin & Hulbert	Pocket Model revolver	Centerfire	32	0. inch	32 S&W	Right	5	0.092	0.095	0.100	0.110
Merwin & Hulbert	Double action Pocket revolver	Centerfire	44	0. inch		Left	5	0.101	0.103	0.142	0.147
Merwin and Bray, Plant	Pocket Revolver	Cup Primed	42	0. inch		Right	6	0.091	0.099	0.094	0.098
Merwin and Bray, Plant	Plant revolver	Percussion	30	0. inch		Right	4	0.134	0.134	0.148	0.155
Merwin and Hulbert	Pocket single action revolver	Centerfire	32	0. inch		Right	5	0.086	0.093	0.110	0.119
Merwin and Hulbert	Early model Army revolver	Centerfire	44	0. inch		Right	5	0.126	0.127	0.128	0.131
Merwin and Hulbert	Early model Army, birdshead grip revolver	Centerfire	44	0. inch		Right	5	0.123	0.125	0.133	0.134
Miles lock, rifle	Penn fullstock flintlock converted to percussion rifle	Percussion	45	0. inch		Right	12	0.051	0.066	0.072	0.098
Mills, Benjamin	Harrodsburg, KY, rifle	Percussion	41	0.inch		Left	4	0.076	0.078	0.194	0.206
Mills, Benjamin	Harrodsburg, KY, over and under rifle	Percussion	38	0.inch		Right	5	0.068	0.084	0.117	0.129
Mills, Benjamin	Harrodsburg, KY, under	Percussion	45	0.inch		Right	8	0.083	0.089	0.080	0.081

	hammer pistol										
Milstead	Palmyra, MO.	Percussion	42	0.inch		Right	7	0.073	0.800	0.066	0.074
Moore Patent	Belt revolver	Rimfire	32	0. inch		Left	5	0.076	0.082	0.094	0.098
Moore, D.	Belt revolver	Rimfire	32	0. inch		Left	5	0.094	0.098	0.082	0.084
Morse	Confederate carbine	Centerfire/ Percussion cap	50	0. inch		Right	3	0.221	0.228	0.249	0.256
Mosin-Nagant	Russian 1891 rifle	Centerfire	7.62	mm	7.62x45mm	Right	4	0.070	0.080	0.160	0.170
Nagant - Norway	Norwegian 1893 rifle	Centerfire	7.55	mm		Right	4	0.110	0.110	0.120	0.120
Nagant - Sweden	Swedish 1887 rifle	Centerfire	7.55	mm		Right	4	0.110	0.110	0.120	0.120
Nambu	Japan Nambu 1914 pistol	Centerfire	8	mm		Right	6	0.030	0.030	0.130	0.130
National Arms	No. 2 derringer pistol	Rimfire	38	0. inch		Left	5	0.109	0.199	0.113	0.135
Needham proto-type conversion	British trial carbine	Percussion	58	0. inch		Right	5	0.084	0.102	0.256	0.261
Nordheim	St. Louis, MO, half stock	Percussion	44	0.inch		Right	7	0.097	0.100	0.067	0.069
North and Skinner	North and Savage Pat 1852 Revolving Rifle	Percussion	44	0. inch		Left	15	0.036	0.038	0.044	0.047
Odell, S.	Natchez, TN, rifle	Percussion	44	0.inch		Right	7	0.096	0.105	0.083	0.091
O'Dell, S.	Trade rifle, Natchez, MS	Percussion	46	0. inch		Right	7	0.110	0.115	0.089	0.093
Odenbaugh	Wheeling, WV, half stock rifle	Percussion	32	0.inch		Right	7	0.062	0.065	0.048	0.049

Orbea Hermanos Eibar	Spanish revolver	Pinfire	9	mm		Left	4	0.129	0.132	0.139	0.141
Palmer	carbine	Rimfire	50	0. inch		Right	5	0.114	0.137	0.133	0.140
Palmer	carbine	Rimfire	50	0. inch		Right	5	0.145	0.157	0.159	0.160
Parker lock	Pennsylvania style fullstock rifle, Parker lock	Percussion	54	0. inch		Right	5	0.179	0.202	0.101	0.118
Parts	Pennsylvania type rifle, parts pistol	Percussion	30	0. inch		Right	7	0.102	0.108	0.041	0.046
Peabody	carbine	Rimfire	44	0. inch		Right	3	0.212	0.215	0.225	0.227
Peabody	British trial rifle	Centerfire	50	0. inch		Right	3	0.232	0.235	0.271	0.277
Peabody	rifled musket	Rimfire	43	0. inch		Right	3	0.204	0.217	0.212	0.224
Perrin, Louis	French revolver	Centerfire	12	mm		Right	6	0.047	0.053	0.141	0.143
Perrins and Son	Cased revolver, Worchester, Mass.	Percussion	32	0. inch		Right	7	0.066	0.078	0.062	0.067
Perry	carbine	Percussion	54	0. inch		Right	7	0.074	0.081	0.161	0.166
Perry	2nd type breechloading pistol	Percussion	52	0. inch		Right	6	0.113	0.125	0.136	0.148
Perry, A. D.	carbine	Percussion	50	0. inch		Right	7	0.097	0.101	0.118	0.122
Pettengill (Allen & Wheelock)	1856 Army revolver	Percussion	44	0. inch		Right	6	0.102	0.107	0.120	0.125
Pettengill (Allen & Wheelock)	1856 Army revolver	Percussion	44	0. inch		Right	6	0.112	0.119	0.112	0.118
Pettengill (Allen & Wheelock)	3rd Model revolver	Percussion	32	0. inch		Right	6	0.069	0.070	0.089	0.091
Phillips and Rogers	model not noted	Centerfire	380	0. inch		Right	6	0.055	0.065	0.125	0.135

Phillips and Rogers	model not noted	Centerfire	38	0. inch	38 Long	Right	6	0.055	0.065	0.125	0.135
Phillips and Rogers	model not noted	Centerfire	32	0. inch	32-20	Right	6	0.055	0.065	0.125	0.135
Phillips and Rogers	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	6	0.055	0.065	0.125	0.135
Phillips and Rogers	model not noted	Centerfire	25	0. inch	25-20	Right	6	0.055	0.065	0.125	0.135
Plains rifle, modern parts	Dixie gun parts, made 1966, half stock Plains style	Percussion	45	0. inch		Right	8	0.068	0.073	0.101	0.107
Plant/Eagle Arms/Merwin & Bray	3rd Model	Cup Primed	42	0. inch		Right	7	0.086	0.091	0.107	0.109
Plant/Eagle Arms/Merwin & Bray	revolver	Cup Primed	32	0. inch		Right	5	0.093	0.102	0.078	0.080
Plymouth	rifled musket	Percussion	60	0. inch		Right	3	0.343	0.349	0.349	0.353
Plymouth	dated 1862, aka Whitneyville rifled musket	Percussion	69	0. inch		Right	3	0.350	0.353	0.356	0.358
Pond	revolver	Rimfire	32	0. inch		Left	5	0.096	0.103	0.096	0.100
Pratt, Alvin	Concord, MA, half stock rifle	Percussion	38	0.inch		Left	6	0.102	0.108	0.087	0.089
Pratt, Alvin	Concord, MA, half stock rifle	Percussion	36	0.inch		Right	6	0.095	0.096	0.073	0.075
Pratt, Alvin	Concord, MA, half stock rifle	Percussion	54	0.inch		Right	6	0.167	0.173	0.103	0.104
Pratt, Alvin	Concord, MA, half stock rifle	Percussion	60	0.inch		Left	6	0.161	0.189	0.098	0.101
Pratt, Alvin	Concord, MA, half stock rifle	Percussion	50	0.inch		Left	6	0.077	0.080	0.097	0.107

Pratt, Alvin	Concord, MA, half stock rifle	Percussion	40	0.inch		Left	8	0.073	0.078	0.077	0.079
Pratt, Alvin	Concord, MA, half stock rifle	Percussion	40	0.inch		Left	8	0.063	0.069	0.079	0.091
Raphael, George	Fine and Race, French revolver,	Centerfire	11.5	mm		Right	8	0.112	0.115	0.023	0.027
Remington	No. 1 sporting rifle	Centerfire	50	0. inch		Right	5	0.138	0.142	0.151	0.158
Remington	Model 1895 derringer	Centerfire	41	0. inch	41 Short	Left	5	0.080	0.080	0.170	0.170
Remington	M1870 experimental musket	Centerfire	50	0. inch	50-70	Right	3	0.224	0.236	0.283	0.286
Remington	Rolling block Model 1871 Army pistol	Centerfire	50	0. inch	50-70	Right	3	0.253	0.258	0.241	0.248
Remington	M1858 New Model revolver	Percussion	44	0. inch		Left	5	0.110	0.141	0.145	0.155
Remington	M1858 New Model revolver	Percussion	44	0. inch		Left	5	0.124	0.128	0.153	0.159
Remington	Model 1875 Single Action Army revolver	Centerfire	44	0. inch	44-40	Left	5	0.128	0.135	0.130	0.137
Remington	model not noted revolver	Centerfire	32	0. inch	32 Short	Right	5	0.076	0.076	0.115	0.115
Remington	model not noted revolver	Centerfire	32	0. inch	32 Long	Right	5	0.076	0.076	0.115	0.115

Remington	New Model Pocket revolver	Percussion	31	0. inch		Left	5	0.072	0.077	0.083	0.086
Remington	model not noted revolver	Centerfire	38	0. inch	38-40	Right	6	0.035	0.035	0.170	0.170
Remington	model not noted revolver	Centerfire	38	0. inch	38-40	Right	6	0.040	0.040	0.170	0.170
Remington	model not noted revolver	Centerfire	32	0. inch	32-20	Right	6	0.050	0.050	0.110	0.110
Remington	model not noted revolver	Centerfire	30	0. inch	30-30	Right	6	0.039	0.042	0.114	0.115
Remington	Model 1890 revolver	Centerfire	44	0. inch		Right	8	0.063	0.071	0.107	0.110
Remington	Model 1890 revolver	Centerfire	44	0. inch		Left	5	0.109	0.115	0.122	0.142
Remington	New Model Army, cased revolver	Percussion	38	0. inch		Right	7	0.079	0.083	0.084	0.086
Remington	Navy revolver	C or Rimfire - check	38	0. inch		Right	7	0.073	0.085	0.080	0.085
Remington	New Model Police revolver	Rimfire	38	0. inch		Left	5	0.110	0.111	0.101	0.103
Remington	New Model Army revolver	Percussion	44	0. inch		Left	5	0.131	0.138	0.113	0.120
Remington	New Model Army revolver	Percussion	44	0. inch		Left	5	0.121	0.127	0.141	0.150
Remington	ca. 1866-1879 revolving rifle	Percussion	36	0. inch		Right	5	0.062	0.065	0.120	0.129
Remington	No. 1 sporting rifle	Centerfire	50	0. inch		Right	5	0.138	0.142	0.151	0.158

Remington	M1871 rifle	Centerfire	50	0. inch	50-70	Right	5	0.147	0.154	0.160	0.168
Remington	model not noted rifle	Centerfire	25	0. inch	25-20	Right	6	0.036	0.036	0.095	0.095
Remington	Model 1903 rifle	Centerfire	30	0. inch	30-06	Right	4	0.050	0.050	0.180	0.180
Remington	Model 1903-A3 rifle	Centerfire	30	0. inch	30-06	Right	2	0.300	0.300	0.180	0.180
Remington	Model 1917 rifle	Centerfire	30	0. inch	30-06	Left	5	0.090	0.090	0.100	0.100
Remington	No. 1Sporting Rifle	Centerfire	50	0. inch	50-70	Right	5	0.130	0.135	0.173	0.176
Remington	dated 1863 rifled musket	Percussion	58	0. inch		Right	7	0.120	0.124	0.132	0.135
Remington	Split-Breech carbine	Centerfire	46	0. inch		Right	3	0.216	0.218	0.237	0.245
Remington	Model 1863 Remington Zouave rifled musket	Percussion	58	0.inch		Right	7	0.124	0.131	0.137	0.149
Remington	New Model 1858 Navy revolver	Percussion	36	0.inch		Left	5	0.082	0.088	0.104	0.107
Remington	Rolling Block model 1866 and 1867 Navy pistol	Centerfire	50	0.inch	50-pistol	Right	3	0.202	0.209	0.221	0.223
Remington	Rolling Block model 1867 Cadet rifle	Centerfire	50	0.inch	50-cadet	Right	3	0.194	0.196	0.228	0.234
Remington Elliot	ca 1880-1896 derringer	Rimfire	32	0. inch		Right	5	0.096	0.096	0.096	0.099
Remington-Beals	3rd Model Pocket revolver	Percussion	31	0. inch		Left	5	0.092	0.095	0.099	0.103

Remington-Keene	bolt action Navy rifle	Centerfire	45	0.inch	45-70	Right	5	0.077	0.088	0.142	0.150
Remington-Lee	bolt action Navy rifle	Centerfire	45	0.inch	45-70	Right	5	0.082	0.091	0.141	0.146
Richmond	Type II Confederate carbine	Percussion	58	0. inch		Right	3	0.281	0.288	0.149	0.178
Robbins and Lawrence	Mississippi, Model 1841, dated 1850 rifled musket	Percussion	54	0. inch		Right	7	0.110	0.112	0.119	0.123
Rogers	Teat fire revolver	Teat fire	32	0. inch		Left	5	0.079	0.089	0.107	0.112
Rogers and Spencer	revolver	Percussion	44	0. inch		Right	5	0.139	0.149	0.130	0.141
Rogers and Spencer	Army revolver	Percussion	44	0. inch		Right	5	0.123	0.124	0.139	0.152
Rood, M. L.	Denver City, CO Territory, 3 barrel swivel breech	Percussion	40	0.inch		Left	6	0.063	0.091	0.085	0.091
Rotten, William	Trade rifle, Nebraska City, NE	Percussion	50	0. inch		Right	6	0.145	0.148	0.106	0.111
Savage	Navy Model revolver	Percussion	36	0. inch		Right	5	0.089	0.102	0.118	0.120
Savage	300 Savage, Model 1899 rifle	Centerfire	300	0. inch	300 Savage	Right	6	0.050	0.050	0.100	0.100
Savage	Navy revolver	Percussion	36	0.inch		Right	5	0.079	0.089	0.099	0.105
Savage and North	1st Model, patent office model revolver	Percussion	36	0. inch		Right	5	0.086	0.088	0.128	0.130
Shapleigh and Day	St. Louis, MO, lock marked	Percussion	45	0.inch		Right	7	0.082	0.085	0.075	0.078

	Brown and Tetley										
Sharps	M1874 business rifle	Centerfire	45	0. inch	45-75	Right	6	0.076	0.078	0.144	0.145
Sharps	Model 1859 carbine conversion	Centerfire	50	0. inch	50-70	Right	3	0.243	0.251	0.251	0.265
Sharps	Model 1859 carbine conversion	Centerfire	50	0. inch	50-70	Right	3	0.236	0.249	0.258	0.264
Sharps	1874 Sporting rifle CF	Centerfire	44	0. inch	44-77	Right	6	0.054	0.059	0.160	0.169
Sharps	Model 1863 conversion carbine	Centerfire	50	0. inch		Right	6	0.053	0.057	0.157	0.166
Sharps	Model 1863 carbine	Percussion	52	0. inch		Right	6	0.117	0.123	0.133	0.141
Sharps	M1865 experimental rifled musket	Centerfire	50	0. inch	50-70	Right	3	0.224	0.228	0.259	0.262
Sharps	single shot 1st Type pistol	Percussion	31	0. inch		Right	5	0.079	0.083	0.093	0.099
Sharps	single shot 1st Type pistol	Percussion	36	0. inch		Right	6	0.072	0.080	0.095	0.098
Sharps	1859 carbine conversion	Centerfire	50	0. inch	50-70	Right	6	0.106	0.125	0.131	0.158
Sharps	Model 1853 slant breech carbine	Percussion	52	0. inch		Right	6	0.109	0.102	0.153	0.165
Sharps	Model 1874 sporting rifle	Percussion	40	0. inch		Right	6	0.096	0.102	0.107	0.110

Sharps	4-barrel derringer	Rimfire	22	0.inch		Right	6	0.039	0.059	0.040	0.066
Sharps	Model 1852 slant breech carbine	Percussion	44	0. inch		Right	6	0.118	0.119	0.118	0.123
Sharps and Hankins	Navy Model carbine	Rimfire	52	0. inch		Left	6	0.114	0.121	0.156	0.166
Sharps Meecham	commercial carbine	Centerfire	40	0. inch		Right	6	0.101	0.108	0.110	0.125
Sharps Meecham	commercial carbine	Centerfire	45	0. inch	45-70	Right	6	0.091	0.092	0.107	0.116
Sharps, C.	Model 1875 sporting rifle	Percussion	40	0. inch		Right	6	0.107	0.114	0.089	0.090
Shiloh Sharps	rifle	Centerfire	50	0. inch	50-110	Right	6	0.080	0.085	0.170	0.175
Single shot turn off barrel	Unknown civilian pistol	Percussion	41	0.inch		Left	8	0.094	0.101	0.042	0.047
Sites, John	Booneville, MO, half stock	Percussion	46	0.inch		Right	8	0.050	0.052	0.095	0.100
Sites, John	Booneville, MO, half stock	Percussion	50	0.inch		Left	7	0.092	0.107	0.081	0.095
Slack	half stock plains rifle	Percussion	45	0. inch		Left	6	0.134	0.146	0.112	0.122
Slotter & Co.	Philadelphia half stock plains rifle Made for J. Bach, SF, CA	Percussion	57	0. inch		Right	9	0.044	0.068	0.141	0.146
Smith	carbine	Percussion	50	0. inch		Right	3	0.250	0.255	0.252	0.257
Smith	Poultney & Trimble carbine	Percussion	50	0. inch		Left	3	0.248	0.256	0.244	0.247
Smith	carbine	Percussion	50	0. inch		Right	3	0.242	0.243	0.274	0.275
Smith & Wesson	Model 1 1/2 revolver	Rimfire	32	0. inch		Right	5	0.094	0.105	0.080	0.096

Smith & Wesson	Model 1 1/2 revolver	Rimfire	32	0. inch		Right	5	0.103	0.108	0.081	0.084
Smith & Wesson	Model 1899 Navy revolver	Centerfire	38	0. inch		Right	5	0.143	0.156	0.116	0.122
Smith & Wesson	Enfield pattern revolver	Centerfire	455	0. inch		Right	5	0.136	0.137	0.144	0.144
Smith & Wesson	New Model No. 3 revolver	Centerfire	44	0. inch	44-40	Right	5	0.133	0.134	0.128	0.129
Smith & Wesson	Russian model revolver	Centerfire	44	0. inch	44 Russian	Right	5	0.130	0.135	0.140	0.145
Smith & Wesson	model not noted	Centerfire	38	0. inch	38-40	Right	5	0.128	0.130	0.114	0.114
Smith & Wesson	model not noted	Centerfire	380	0. inch		Right	5	0.104	0.108	0.112	0.116
Smith & Wesson	model not noted	Centerfire	38	0. inch		Right	5	0.080	0.120	0.100	0.140
Smith & Wesson	model not noted	Centerfire	38	0. inch	38 Long	Right	5	0.094	0.097	0.114	0.117
Smith & Wesson	model not noted	Centerfire	32	0. inch	32-20	Right	5	0.091	0.105	0.095	0.100
Smith & Wesson	model not noted	Centerfire	32	0. inch	32 S&W Long	Right	5	0.080	0.102	0.090	0.140
Smith & Wesson	model not noted	Centerfire	32	0. inch	32 S&W	Right	5	0.084	0.105	0.085	0.110
Smith & Wesson	model not noted	Centerfire	32	0. inch	32 Long Rifle	Right	5	0.105	0.110	0.090	0.095
Smith & Wesson	model not noted	Centerfire	32	0. inch	32 Long	Right	5	0.110	0.114	0.086	0.090
Smith & Wesson	No. 3, 1st Model American revolver	Centerfire	44	0. inch		Right	5	0.037	0.040	0.025	0.027
Smith & Wesson	American Model 1877 revolver	Centerfire	44	0. inch		Right	5	0.124	0.135	0.093	0.095
Smith & Wesson	1st Model Schofield revolver	Centerfire	45	0. inch		Right	5	0.018	0.022	0.038	0.041

Smith & Wesson	Safety First Double Action revolver	Centerfire	32	0. inch		Right	5	0.084	0.086	0.107	0.108
Smith & Wesson	Model 1917 revolver	Centerfire	45	0. inch		Right	6	0.067	0.076	0.152	0.162
Smith & Wesson	Model 1899 Army revolver	Centerfire	38	0. inch	38 Long	Right	5	0.090	0.100	0.110	0.120
Smith & Wesson	Regulation Police revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.090	0.090	0.130	0.130
Smith & Wesson	Hammerless revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.090	0.090	0.130	0.130
Smith & Wesson	Top break revolver	Centerfire	38	0. inch	38 S&W	Right	5	0.090	0.090	0.130	0.130
Smith & Wesson	Model 1905 revolver	Centerfire	38	0. inch	38 Special	Right	5	0.090	0.090	0.130	0.130
Smith & Wesson	Model 1902 revolver	Centerfire	38	0. inch	38 Special	Right	5	0.090	0.100	0.120	0.120
Smith & Wesson	Lady Smith revolver	Centerfire	38	0. inch	38 Special	Right	5	0.100	0.100	0.110	0.120
Smith & Wesson	Victory revolver	Centerfire	38	0. inch	38 Special	Right	5	0.100	0.100	0.130	0.130
Smith & Wesson	Navy revolver	Centerfire	38	0. inch	38 Special	Right	5	0.100	0.100	0.120	0.130
Smith & Wesson	Enfield pattern revolver	Centerfire	455	0. inch		Right	5	0.140	0.140	0.140	0.140
Smith & Wesson	No. 1, aka iron frame Volcanic, ca 1854-1855 pistol	Volcanic	31	0. inch		Left	5	0.120	0.121	0.065	0.068
Smith & Wesson	3rd Model, single action revolver	Centerfire	44	0. inch		Right	5	0.114	0.117	0.129	0.131
Smith & Wesson	No. 3, Second	Centerfire	44	0. inch		Right	5	0.128	0.131	0.132	0.137

	Model revolver										
Smith & Wesson	1st Model double action revolver	Centerfire	44	0. inch		Right	5	0.115	0.120	0.132	0.136
Smith & Wesson	No. 3 1st Model revolver	Centerfire	44	0. inch		Right	7	0.033	0.036	0.154	0.156
Smith & Wesson	1st Model double action revolver	Centerfire	44	0. inch		Right	5	0.109	0.115	0.136	0.138
Smith & Wesson	Schofield revolver	Centerfire	45	0. inch		Right	5	0.142	0.144	0.107	0.109
Smith & Wesson	No. 2 revolver	Rimfire	32	0. inch		Right	5	0.089	0.091	0.092	0.099
Smith & Wesson	Model 2 Old Model revolver	Rimfire	32	0. inch		Right	5	0.094	0.095	0.086	0.087
Smith & Wesson	Schofield 1st Model revolver	Centerfire	45	0. inch		Right	5	0.123	0.138	0.134	0.138
Smith & Wesson	3rd Model single action revolver	Centerfire	41	0. inch		Right	5	0.013	0.106	0.129	0.130
Smith & Wesson	320 No. 3 Model 2 New Model Target revolver	Centerfire	320	0. inch		Right	6	0.051	,055	0.104	0.108
Smith & Wesson	No. 3, Japanese contract, ca 1889 revolver	Centerfire	44	0. inch		Right	5	0.123	0.126	0.141	0.143
Snider Enfield	British Mark II carbine	Centerfire	577	0. inch		Right	5	0.096	0.100	0.242	0.247
Snider Enfield	British Type III action - pistol	Centerfire	577	0. inch		Right	3	0.313	0.317	0.243	0.248

Snider Enfield	British Mark II carbine	Centerfire	577	0. inch		Right	5	0.096	0.100	0.242	0.247
Snider Enfield	British Type III action - pistol	Centerfire	577	0. inch		Right	3	0.313	0.317	0.243	0.248
Spanenburg & Sauer	Model 1860 German rifle	Percussion	12.7	mm		Right	6 hex	0.277	0.299	N/A	N/A
Spencer	Model 1860 carbine	Rimfire	52	0. inch	56-56, .52	Right	6	0.127	0.129	0.139	145.000
Spencer	repeating carbine	Rimfire	52	0. inch	.56-56, .52	Right	6	0.127	0.128	0.149	0.152
Spencer & Rogers	revolver	Percussion	44	0. inch		Right	5	0.121	0.135	0.142	0.152
Spencer (Boston)	Model 1865 carbine	Rimfire	50	0. inch	56-50, .50	Right	6	0.120	0.133	0.124	0.131
Spencer (Burnside)	Model 1865 carbine	Rimfire	50	0. inch	56-50, .50	Right	3	0.235	0.245	0.262	0.277
Spencer sporter	sporter, Kendall barrel	Rimfire	52	0. inch		Right	7	0.114	0.118	0.113	0.119
Spiller and Burr	Confederat e revolver	Percussion	36	0. inch		Right	5	0.124	0.133	0.056	0.059
Spiller and Burr	Confederat e copy or style revolver	Percussion	36	0. inch		Right	7	0.149	0.152	0.078	0.081
Springfield	Model 1873 carbine	Centerfire	45	0. inch	45-55	Right	3	0.210	0.217	0.250	0.251
Springfield	cut down Model 1868 rifle-owned by Kicking Bear	Centerfire	50	0. inch		Right	3	0.234	0.239	0.260	0.266

Springfield	Model 1855 pistol carbine	Percussion	58	0. inch		Right	3	0.268	0.278	0.300	0.317
Springfield	Model 1861 rifled musket	Percussion	58	0. inch		Right	3	0.282	0.298	0.277	0.280
Springfield	recovered after Wounded Knee, cut down Model 1873 rifle	Centerfire	45	0. inch		Right	3	0.188	0.195	0.228	0.254
Springfield	M1869 single shot pistol	Centerfire	50	0. inch		Right	3	0.234	0.238	0.270	0.274
Springfield	Model 1875 Officers rifle	Centerfire	45	0. inch	45-70	Right	3	0.201	0.205	0.242	0.254
Springfield	Model 1870 rifle	Centerfire	50	0. inch		Right	3	0.231	0.253	0.261	0.272
Springfield	Model 1884 rifle	Centerfire	45	0. inch	45-70	Right	3	0.235	0.240	0.235	0.240
Springfield	Model 1892 or 1894 rifle	Centerfire	30	0. inch	30-40 Krag	Right	4	0.050	0.050	0.180	0.180
Springfield	Model 1896 rifle	Centerfire	30	0. inch	30-40 Krag	Right	4	0.050	0.060	0.180	0.190
Springfield	Model 1898 rifle	Centerfire	30	0. inch	30-40 Krag	Right	4	0.060	0.060	0.170	0.170
Springfield	Model 1903 rifle	Centerfire	30	0. inch	30-06	Right	4	0.040	0.040	0.180	0.180
Springfield	Model 1879 rifle	Centerfire	45	0. inch	45-55	Right	3	0.208	0.209	0.243	0.247
Springfield	Model 1863 rifled musket	Percussion	58	0. inch		Right	3	0.265	0.315	0.295	0.311
Springfield	Model 1855, rifled musket, Maynard tape primer	Percussion	58	0. inch		Right	3	0.271	0.282	0.289	0.292

Springfield	Model 1851 Cadet rifled musket	Percussion	58	0.inch		Right	3	0.240	0.243	0.248	0.251
Springfield	Model 1842 rifled musket	Percussion	69	0.inch		Right	3	0.372	0.375	0.341	0.342
Springfield Arms Co.	Double Trigger Belt Model revolver	Percussion	36	0. inch		Right	7	0.070	0.077	0.092	0.095
Springfield with J.P. Lower bbl.	M1873/modified	Centerfire	45	0. inch		Right	6	0.046	0.057	0.135	0.146
Springfield -Needham Conversion	Bridesburg rifle musket conversion to .58	Centerfire	58	0. inch		Right	3	0.285	0.286	0.295	0.301
Starr	carbine	Percussion	54	0. inch		Right	5	0.147	0.160	0.179	0.187
Starr	carbine	Rimfire	54	0. inch		Right	5	0.152	0.161	0.175	0.177
Starr	carbine	Percussion	54	0. inch		Right	5	0.168	0.172	0.168	0.172
Starr	carbine	Rimfire	52	0. inch		Right	5	0.153	0.158	0.176	0.179
Starr	conversion revolver	Rimfire	44	0. inch		Left	6	0.123	0.125	0.115	0.117
Starr	1856 revolver	Percussion	44	0. inch		Left	6	0.103	0.117	0.118	0.127
Starr	Single Action Army revolver	Percussion	44	0. inch		Left	6	0.123	0.136	0.108	0.119
Starr	Double Action revolver	Percussion	44	0. inch		Left	6	0.104	0.125	0.117	0.123
Stevens	rifle	Centerfire	32	0. inch	32 Long Rifle	Right	6	0.045	0.046	0.114	0.116
Stevens	rifle	Centerfire	32	0. inch	32 Long	Right	6	0.021	0.022	0.130	0.130
Stevens	rifle	Centerfire	30	0. inch	30-30	Right	6	0.030	0.032	0.119	0.112
Stevens	rifle	Centerfire	30	0. inch	30-30	Right	6	0.035	0.037	0.115	0.120
Stevens	single shot pistol	Rimfire	41	0.inch		Right	5	0.106	0.111	0.127	0.129

Tallassee, Confederate	Alabama made carbine	Percussion	58	0. inch		Right	3	0.339	0.341	0.249	0.251
Tarpley, Confederate	carbine	Percussion	52	0. inch		Right	7	0.126	0.129	0.106	0.107
Thompson Center	Flint Plains Rifle style kit	Flintlock	50	0. inch		Right	8	0.090	0.099	0.096	0.104
Thoni, S. B.	Double barrel, rifle shotgun	Percussion	44	0.inch		Right	7	0.073	0.084	0.079	0.082
Tradition Kentucky	short rifle modern type based on Kentucky style	Flintlock	50	0. inch		Right	8	0.083	0.084	0.111	0.126
Tranter	revolver	Percussion	44	0. inch		Right	5	0.077	0.078	0.173	0.184
Tranter	revolver	Percussion	450	0.inch		Right	5	0.070	0.080	0.192	0.198
Tranter,	Double Action revolver	Percussion	44	0. inch		Right	3	0.210	0.218	0.203	0.222
Tranter, W.	Adams style Tranter cased revolver	Percussion	38	0. inch		Right	5	0.054	0.058	0.159	0.164
Triplett & Scott	carbine	Rimfire	50	0. inch		Right	3	0.242	0.247	0.257	0.258
Triplett & Scott	carbine	Percussion	50	0. inch		Right	3	0.255	0.263	0.236	0.256
Tryon	Philadelphia made half stock rifle	Percussion	36	0. inch		Right	7	0.079	0.083	0.073	0.076
Tryon, Edward	Trade rifle, Philadelphia	Percussion	50	0. inch		Left	6	0.137	0.144	0.106	0.107
Tryon, Edward	Trade rifle, Philadelphia	Flintlock	54	0. inch		Right	7	0.157	0.162	0.720	0.080
Tryon, Edward	Trade rifle, Philadelphia	Percussion	45	0. inch		Right	7	0.101	0.105	0.960	0.970

Tryon, George	Half stock rifle	Percussion	42	0. inch		Right	6	0.137	0.143	0.069	0.072
Tryon, George	Half stock rifle - J. Duggan, Trinidad	Percussion	50	0. inch		Right	7	0.132	0.134	0.082	0.085
Tryon, George	South Carolina Militia Rifle	Flintlock	50	0.inch		Right	6	0.166	0.171	0.054	0.057
Tucker, L. E. and Sons	Confederate, Lancaster, TX, Dragoon revolver, poss. Fake	Percussion	44	0.inch		Right	7	0.079	0.081	0.088	0.090
Uberti	Model 1875 Army (Colt Copy)	Centerfire	44	0. inch	44-40	Right	6	0.060	0.070	0.150	0.160
Uberti	Model 1873 (Winchester Copy) rifle	Centerfire	44	0. inch	44-40	Right	6	0.080	0.080	0.130	0.140
Uhlinger, William/ W. L. Grant	revolver	Rimfire	32	0. inch		Right	6	0.066	0.075	0.089	0.094
Unknown box lock	Ivory inlays, engraved case set	Percussion	44	0. inch		Right	8	0.083	0.094	0.073	0.079
Unknown Confederate	Enfield pattern revolver	Percussion	44	0. inch		Right	7	0.058	0.068	0.115	0.172
Unknown English	unknown English made bayonet revolver	Percussion	41	0. inch		Right	7	0.109	0.121	0.058	0.054
Unknown French	Possibly French	Percussion	32	0. inch		Right	6	0.090	0.099	0.084	0.086

	made revolver										
Unknown, European	unknown European made revolver	Pinfire	8	mm		Left	4	0.134	0.154	0.094	0.101
US Enfield	Model 1917 rifle	Centerfire	30	0. inch	30-06	Left	5	0.090	0.090	0.090	0.090
Veterli	Swiss Veterli Model 1866 rifle	Rimfire	10.4	mm	10.4x38mm	Right	4	0.126	0.132	0.182	0.199
Veterli	Model 1870 rifle	Centerfire	10.4	mm	10.4x38mm	Right	4	0.127	0.129	0.170	0.171
Virginia Common Rifle, reproduction	18th Century long rifle, Virginia style	Flintlock	61	0. inch		Right	7	0.159	0.172	0.112	0.118
Volcanic	carbine	Self-contained	41	0. inch		Right	6	0.122	0.125	0.082	0.091
Volcanic	Lever Action No. 1 pistol	Volcanic	31	0. inch		Right	6	0.072	0.075	0.083	0.091
Walch, John	Pocket Model revolver	Percussion	31	0. inch		Right	6	0.068	0.071	0.081	0.084
Ward Burton	Model 1871 carbine	Centerfire	50	0. inch		Right	3	0.231	0.241	0.263	0.270
Warner	carbine	Rimfire	50	0. inch		Right	3	0.260	0.272	0.246	0.247
Watts, J.	Chippewa Township, OH, swivel breech	Percussion	48	0.inch		Right	8	0.042	0.050	0.098	0.104
Webley	revolver	Centerfire	38	0. inch		Right	7	0.030	0.030	0.140	0.140
Webley	revolver	Centerfire	38	0. inch		Right	7	0.024	0.050	0.105	0.133
Webley	revolver	Centerfire	380	0. inch		Right	7	0.026	0.030	0.124	0.128
Webley	revolver	Centerfire	455	0. inch		Right	7	0.034	0.036	0.168	0.172
Webley	Mark II	Centerfire	455	0. inch		Right	7	0.035	0.043	0.158	0.162
Webley and Scott	Russian	Centerfire	44	0. inch		Right	7	0.047	0.048	0.140	0.140

Webley and Scott	revolver	Centerfire	32	0. inch	32 S&W Long	Right	7	0.032	0.036	0.100	0.100
Webley and Scott	revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.030	0.030	0.120	0.120
Webley and Scott	revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.030	0.030	0.120	0.130
Webley and Scott	revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.030	0.030	0.130	0.130
Webley and Scott	revolver	Centerfire	38	0. inch	38 S&W	Right	7	0.030	0.030	0.130	0.130
Webley and Scott	No. 5 revolver	Centerfire	38	0. inch	38 Special	Right	7	0.400	0.400	0.110	0.120
Webley and Scott	No. 5 revolver	Centerfire	38	0. inch	38 Special	Right	7	0.400	0.400	0.120	0.120
Webley and Scott	Bulldog 1883 and Royal Irish Constabulary	Centerfire	455	0. inch		Right	5	0.050	0.050	0.150	0.150
Webley and Scott	Mark II revolver	Centerfire	455	0. inch		Right	6	0.042	0.056	0.150	0.155
Webley and Scott	revolver	Centerfire	38	0. inch		Right	7	0.026	0.040	0.114	0.130
Webley and Scott	Mark I revolver	Centerfire	45	0. inch	45 Auto	Right	7	0.040	0.040	0.160	0.170
Wesson and Harrington	rifle	Centerfire	32	0. inch	32 Short	Right	5	0.110	0.115	0.085	0.090
Wesson and Leavitt	Early type revolver	Percussion	40	0. inch		Right	7	0.072	0.085	0.095	0.098
Wesson and Leavitt	Dragoon Model, Patent Model revolver	Percussion	44	0. inch		Left	7	0.101	0.114	0.076	0.084
Wesson, F.	rifle	Rimfire	44	0. inch		Left	5	0.138	0.145	0.118	0.122
Wesson, F.	Model 1870 rifle	Rimfire	30	0. inch		Left	5	0.082	0.090	0.099	0.108
Wesson, F.	rifle	Rimfire	44	0. inch		Left	5	0.145	0.163	0.090	0.105
Westley Bentley	Double Action revolver	Percussion	36	0. inch		Right	5	0.083	0.089	0.128	0.129

Westley Richards	1867 dated lockplate (Whitworth rifling), carbine	Percussion	450	0. inch		Right	8	0.173	0.193	N/A	N/A
Wheelock pistol	European, ivory inlays, pistol	Wheelock	14	mm		Right	4	0.193	0.202	0.211	0.224
Whitmore	Boston, MA, target rifle	Percussion	46	0.inch		Right	8	0.072	0.081	0.081	0.086
Whitney	No. 1, ca 1871-1879, revolver	Rimfire	32	0. inch		Right	5	0.102	0.107	0.084	0.088
Whitney	Navy	Percussion	36	0. inch		Right	7	0.091	0.094	0.073	0.076
Whitney	Model 1841, Mississippi, dated 1850 rifled musket	Percussion	54	0. inch		Right	7	0.115	0.117	0.122	0.128
Whitney	Enfield rifled musket	Percussion	58	0. inch		Right	3	0.304	0.318	0.290	0.291
Whitney	Model 1841 Mississippi rifled musket	Percussion	58	0. inch		Right	5	0.190	0.193	0.161	0.164
Whitney, R.	Model 1841 Mississippi rifled musket	Percussion	58	0.inch		Right	7	0.124	0.126	0.085	0.087
Whitney-Phoenix	1874 patent single shot rifle	Rimfire	44	0.inch	44 RF	Right	6	0.030	0.040	0.146	0.148
Will & John Rigby	Percussion revolver	Percussion	44	0. inch		Right	3	0.123	0.127	0.313	0.314
Williams	Belt model, teat fire revolver	Teat fire	32	0. inch		Left	5	0.084	0.101	0.081	0.093

Winchester	Model 1876	Centerfire	40	0. inch	40-60	Right	6	0.084	0.084	0.124	0.125
Winchester	model not noted	Centerfire	38	0. inch	38-40	Right	6	0.071	0.084	0.123	0.128
Winchester	model not noted	Centerfire	32	0. inch	32-40	Right	6	0.065	0.066	0.097	0.100
Winchester	model not noted	Centerfire	32	0. inch	32-20	Right	6	0.064	0.066	0.092	0.099
Winchester	model not noted	Centerfire	32	0. inch	32-20	Right	6	0.064	0.064	0.096	0.096
Winchester	model not noted	Centerfire	32	0. inch	32 Short	Right	6	0.064	0.064	0.096	0.096
Winchester	Model 1894	Centerfire	30	0. inch	30-30	Right	6	0.063	0.063	0.094	0.095
Winchester	model not noted	Centerfire	30	0. inch	30-30	Right	6	0.045	0.077	0.080	0.106
Winchester	model not noted	Centerfire	25	0. inch	25-35	Right	6	0.043	0.060	0.075	0.086
Winchester	model not noted	Centerfire	25	0. inch	25-20	Right	6	0.052	0.052	0.078	0.079
Winchester	Model 1866 carbine	Rimfire	44	0. inch	44 Henry	Right	5	0.121	0.126	0.139	0.145
Winchester	Model 1873 carbine	Centerfire	44	0. inch	44-40	Right	6	0.074	0.083	0.136	0.145
Winchester	M1894 carbine	Centerfire	30	0. inch	30 WCF	Right	6	0.055	0.058	0.102	0.105
Winchester	Model 1892 carbine	Centerfire	32	0. inch		Right	6	0.053	0.055	0.103	0.107
Winchester	Model 1886 Deluxe rifle	Centerfire	40	0. inch	40-82	Right	6	0.075	0.077	0.158	0.162
Winchester	Model 1886 Lightweigh t rifle	Centerfire	33	0. inch		Right	6	0.051	0.057	0.121	0.122
Winchester	Model 1885 Low Wall	Centerfire	32	0. inch	32-40	Right	6	0.052	0.057	0.109	0.113

Winchester	Model 1876 musket	Centerfire	44	0. inch	44-60	Right	5	0.085	0.088	0.223	0.236
Winchester	Model 1892 rifle	Centerfire	25	0. inch	25-20	Right	6	0.050	0.050	0.080	0.080
Winchester	Model 1894 rifle	Centerfire	25	0. inch	25-35	Right	6	0.050	0.050	0.080	0.080
Winchester	Model 1894 rifle	Centerfire	30	0. inch	30-30	Right	4	0.046	0.047	0.182	0.186
Winchester	Model 1866 rifle	Centerfire	44	0. inch		Right	6	0.090	0.090	0.130	0.130
Winchester	Model 1873 rifle	Centerfire	44	0. inch		Right	5	0.124	0.145	0.119	0.142
Winchester	Model 1873 rifle	Centerfire	38	0. inch	38-40	Right	6	0.070	0.077	0.121	0.123
Winchester	Model 1886 rifle	Centerfire	40	0. inch	40-32	Right	6	0.053	0.061	0.136	0.151
Winchester	Model 1876 rifle	Centerfire	40	0. inch	40-62	Right	6	0.053	0.056	0.143	0.159
Winchester	Model 1876 rifle	Centerfire	50	0. inch	50-95	Right	6	0.090	0.090	0.140	0.140
Winchester	Model 1886 rifle	Centerfire	50	0. inch	50-110	Right	6	0.105	0.105	0.157	0.157
Winchester	Model 1886 rifle	Centerfire	45	0. inch	45-90	Right	6	0.095	0.095	0.142	0.142
Winchester	model not noted rifle	Centerfire	45	0. inch	45-75	Right	6	0.094	0.094	0.141	0.141
Winchester	Model 1876 rifle	Centerfire	45	0. inch	45-60	Right	6	0.094	0.094	0.141	0.141
Winchester	Model 1873 rifle	Centerfire	44	0. inch	44-40	Right	6	0.081	0.110	0.106	0.135
Winchester	Model 1892 rifle	Centerfire	44	0. inch	44-40	Right	6	0.090	0.090	0.130	0.130
Winchester	Henry rifle	Centerfire	44	0. inch	44 Henry	Right	6	0.088	0.088	0.133	0.133
Winchester	Model 1886 rifle	Centerfire	40	0. inch	40-82	Right	6	0.081	0.081	0.129	0.129
Winchester	Model 1895 rifle	Centerfire	40	0. inch	40-72	Right	6	0.084	0.084	0.125	0.126
Winchester	Model 1886 rifle	Centerfire	40	0. inch	40-70	Right	6	0.085	0.085	0.125	0.125
Winchester	Model 1886 rifle	Centerfire	40	0. inch	40-65	Right	6	0.084	0.084	0.125	0.125

Winchester	model not noted rifle	Centerfire	30	0. inch	30-40 Krag	Right	6	0.050	0.055	0.104	0.106
Winchester	Model 1892 rifle	Centerfire	38	0. inch	38-40	Right	6	0.080	0.080	0.120	0.120
Winchester	Model 1892 rifle	Centerfire	38	0. inch	38-40	Right	6	0.800	0.800	0.130	0.130
Winchester	Model 1892 rifle	Centerfire	38	0. inch	38-40	Right	6	0.080	0.080	0.130	0.130
Winchester	Winchester Lee Straight Pull, rifle, from USS Maine	Centerfire	6	mm		Right	6	0.049	0.049	0.074	0.074
Winchester	Model 1895 rifle	Centerfire	30	0. inch	.30-06	Right	6	0.049	0.053	0.101	0.102
Winchester	M1894 in Winchester smokeless powder, rifle	Centerfire	32	0. inch	32 WS	Right	6	0.051	0.056	0.110	0.115
Winchester	Model 1876	Centerfire	45	0. inch	45-60	Right	6	0.077	0.079	0.159	0.162
Winchester	Model 1895 rifle	Centerfire	405	0. inch		Right	6	0.077	0.077	0.137	0.139
Winchester	Model 1894 rifle	Centerfire	38	0. inch	.38-55	Right	6	0.058	0.059	0.136	0.139
Winchester -Hotchkiss	bolt action Navy rifle	Centerfire	45	0.inch	45-70	Right	3	0.164	0.168	0.206	0.211
Wurfflien, Andrew	half stock Plains rifle	Percussion	52	0. inch		Right	6	0.143	0.146	0.108	0.115