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A Recreation and Ballistic Evaluation of Otto Schneeloch's Firearm Curiosity - The .307 Triangular

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A Recreation and Ballistic Evaluation of Otto Schneeloch's Firearm Curiosity –

The .307 Triangular

by

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ABSTRACT

Otto Scheeloch's U.S. Patent No. 134,442 of 1872 describes a unique firearm that uses triangular bullets. The current research effort evaluates the ballistic performance of Otto's disclosure for the very first time. To achieve this goal it was necessary to seek out surviving artifacts and scour the historical record in search of all the parameters needed to meticulously recreate the curious triangular cartridges and the corresponding gun barrel, with its matching twisted triangular bore. Every aspect of the resulting reproduction ammunition was made to be as authentic as possible, including the use of vintage civil war era bullet lead, bullet grease of period recipe, and the correct type of black powder propellant. 3D CAD (SolidWorks™) was employed in designing the components, while advanced rapid prototyping (FDM & DMLS) techniques and investment casting were used in the physical construction of the ammunition and barrel. The ballistics testing was performed from a shooting rest over a range of 10-feet. Data was obtained for five rounds using a chronograph, paper targets and ballistic gel. The triangular bullets proved to be surprisingly accurate, consistent, and stable in flight. Data was recorded for sectional density, ballistic coefficient, muzzle velocity and energy, group size and penetration.

CHAPTER 1: RESEARCH OBJECTIVES

In 1872 a German immigrant to the USA named Otto Schneeloch patented one of the most curious inventions in the annals of firearms history. His disclosure (U.S. Patent No. 134,442) describes a revolver that fires bullets of triangular cross-section through a barrel with a matching twisted triangular bore. Otto and his brothers were some of the most talented and respected armorers and gunsmiths of their day, and so Otto's filing cannot be easily dismissed as the ill-conceived idea of some amateur. Sadly, Otto Schneeloch died in 1877 as the result of a tragic accident at the age of 42, and only 5 years after his patent was granted. Otto's demise also meant that his invention essentially died with him, as without its primary proponent it was destined to become forgotten - overshadowed by what proved to be one of the most momentous periods in the history of modern firearms development.

Out of respect to the life and professional career of Otto Schneeloch, and to provide long overdue closure to this chapter, the objective of the research described in the present thesis was to recreate and test Otto's custom firearm and its singular triangular ammunition. To evaluate the merits of Otto Schneeloch's unique idea, the goal was to physically shoot the replica on a fully instrumented range, and thereby analyze the ballistic performance.

CHAPTER 2: FIREARMS HISTORICAL PERSPECTIVE

2.1 Firearms with Uniquely Shaped Ammunition

Although Otto Schneeloch's invention specifically utilized triangular bullets, which is a shape that remains unique to this day, there are many examples of non-circular bullets in the historical record. Bullet shape experimentation has been performed in many countries throughout different time periods. Some of the many shapes that have been used are square, hexagonal, triangular and more, many of which did not last. This section will look further into which uniquely shaped bullets and projectiles made an impression on history.

2.1.1 Puckle Gun

In May 1718, James Puckle patented his revolving gun called "Defence". This gun was specifically described as a portable gun or machine. There were several features that made this a unique and revolutionary gun during Puckle's time. The first feature is that it contained a revolving cylinder which allowed a more rapid rate of fire than other guns at the time. In addition to having a unique revolving cylinder, it shot very unique ammunition. What made this ammunition so unique was its square shape [1].

Although Puckle had his own reasoning behind creating square bullets, just his creating them shows the drive for bullets with a noncircular cross section. This was just the start of uniquely shaped bullets, which proves to be an interest through history. A sketch of the Puckle revolving gun is shown in Figure 1.

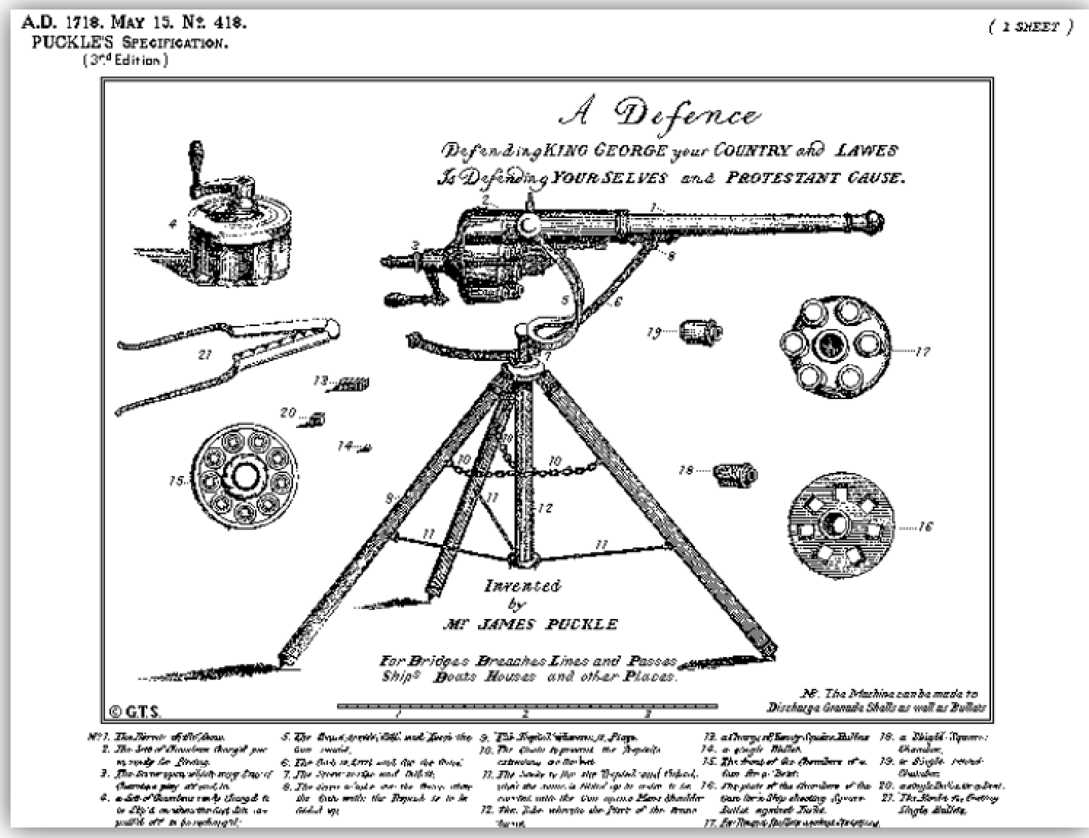


Figure 1: Patent Drawing of Puckle's Gun, the Defence [2, Public Domain Image]

2.1.2 Whitworth Rifle

Sir Joseph Whitworth began performing small arms experiments for the British government in 1854. After much experimentation specifically involving rifling, he determined that a hexagonal bore was the best option. In 1857, the Whitworth 374 was compared and tested against the Enfield 227, a popular British rifle used during this time period. Along with changing the shape of the bore and cross section of the bullet, he also made the bullet of smaller caliber, and with a larger weight and length than the bullets used for the Enfield. Another important difference between the two rifles is the rifling rate of twist. The Enfield had one twist in 61 inches, while the Whitworth had one twist in 20 inches [3].

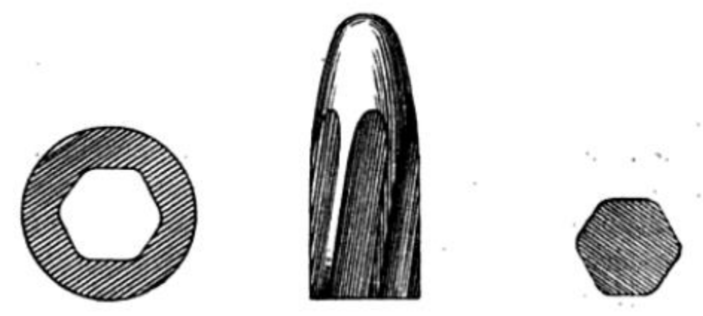


FIG. 22 FIG. 23 FIG. 24

Figure 2: Patent Drawings of the Whitworth Rifle Bore and Bullet Geometry [3, Public Domain Image]

The Whitworth rifle shows the success that can come about from a bullet with a noncircular cross section. The official results made on the comparison between the Whitworth and the Enfield were finalized in 1861. After observing the results displayed in Figure 3, it can be determined that the Whitworth rifle was much more accurate. Given the differences in caliber, bullet weight/length, and twist rate between the two rifles it is not clear how much, if at all, the hexagonal cross section contributed to the superior performance. Although hexagonal bullets did not last throughout history, this rifle proved that uniquely shaped bullets can be very successful in ballistics.

Range in Yards	Enfield		Whitworth	
	Mean Radial Deviation	Mean Angle	Mean Radial Deviation	Mean Angle
	Inches	° ′	Inches	° ′
300	12·69	0 44·8	3·86	0 56·49
500	19·80	1 45·13	7·29	1 23·37
800	41·61	2 46·6	15·67	2 17·6
1,000	95·01	4 3·33	23·13	3 5·36
1,200	133·53	5 9·48	46·92	4 3·6

Figure 3: Enfield and Whitworth Rifle Tabulated Performance Results [3,Public Domain Image]

2.1.3 Pyramid Shotgun Pellets

Shotguns shoot pellets that are contained within a shell rather than a single bullet. Therefore, when discharged, the pellets disperse (or scatter) into an ever widening pattern. Such a system is more effective against birds in flight, than a single bullet which is more likely to miss. Shotgun pellets are typically spherical in shape and are packed within the shell with gun powder and a primer as the propellant. An internal view of a common shotgun shell can be displayed in Figure 4.

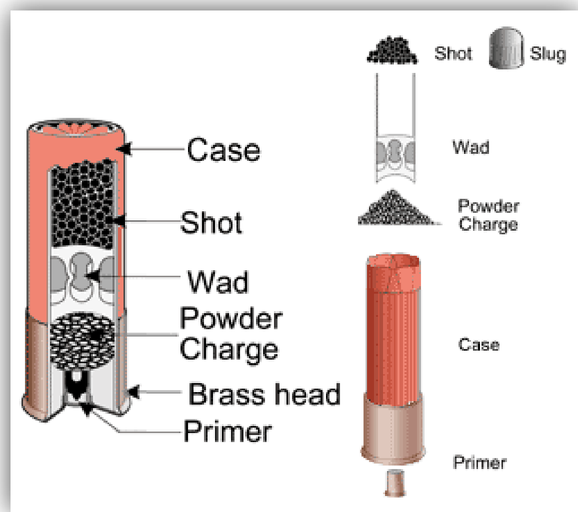


Figure 4: IHEA-USA Photo: Common Shotgun Shell Internal View and Components [4]. Permission included in Appendix A

Similar to the creation and experimentation of different bullet shapes, shot shapes have been changed as well. Gilbert A. Stafford invented pyramid shaped shot, which was patented on August 18, 1987. This pyramid-shaped shot was designed with every side being an equilateral triangle. The patent sketch of this shotgun shell can be seen in Figure 5. Stafford claimed that this configuration would result in increased range [5]. It is also reasonable to expect that pyramids would allow for better penetration due to the sharper corners. Stafford's idea was not a commercial success.

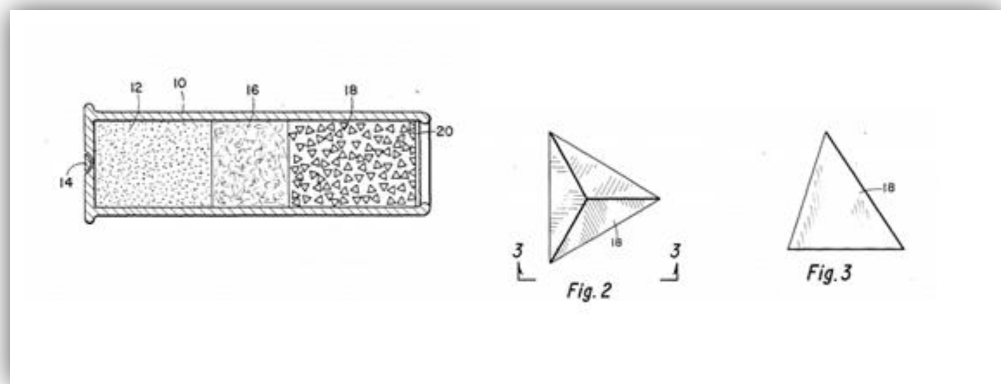


Figure 5: Patent Sketches of Shell Having Pyramid Shaped Shot [5, Public Domain Image]

2.1.4 Devel Bullets

Non-circular bullets are not just curiosities from the past, as there is also an example of a modern version. Charles C. Kelsey, Jr. was a gunsmith who invented the Devel Small Arms Bullet which was patented on July 28, 1992. The purpose of this bullet was to offer effective terminal ballistics utilizing its unique shape rather than expansion. What causes the shape of the Devel bullets to be unique is the nose portion of the bullet. It still has a base that is circular but the top portion has five or six “wings”. These wings can be seen in Figure 6 and Figure 7.

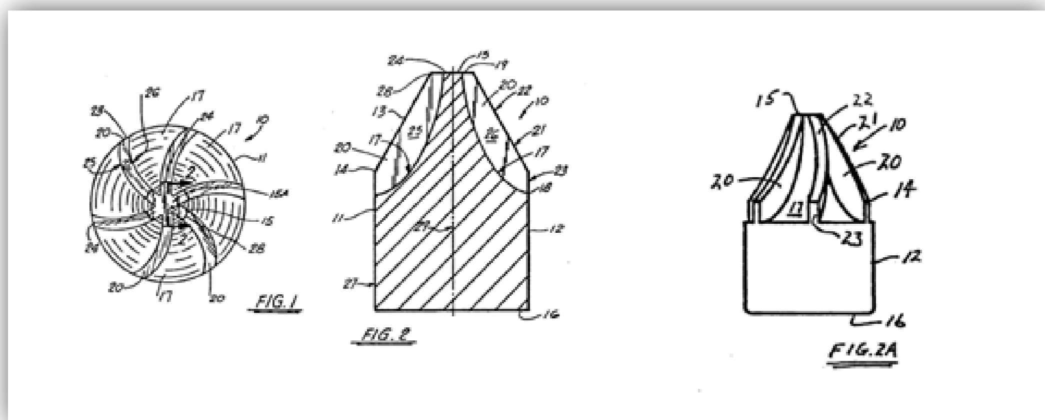


Figure 6: Patent Sketch of the Devel Bullet [6, Public Domain Image]

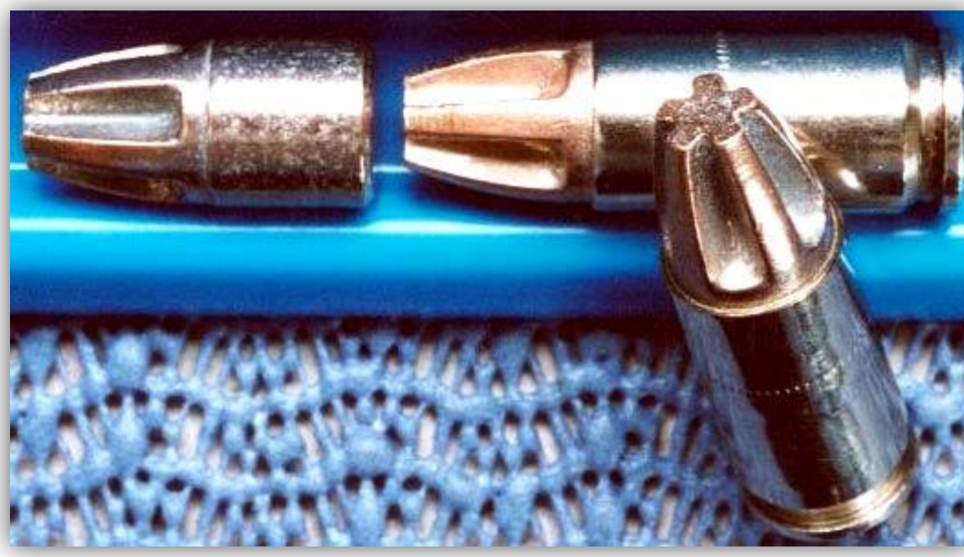


Figure 7: Photograph of the Devel Bullet [7].

This bullet's shape allows it to penetrate easily while doing damage to the test media it is shot into. After the bullet first penetrates the media, the wings cut away at the material causing damage. The bullet typically penetrates about five to six inches before it starts to tumble. In addition to the damage caused by the wings, the tumbling then causes more destruction [7]. This proves that the changes made in the shape and materials were not detrimental to the performance of this bullet but allows it to perform as well as common bullets used today.

2.2 Personal Protection Arms of the Late 1800's

The focus of Otto Schneeloch's triangular revolver invention was to create a more effective personal protection firearm. He wished it to be small, light, and easily carried, but with superior firepower to the Smith and Wesson commercial arms of the day.

2.2.1 Smith and Wesson Model 1

The Smith and Wesson Company opened their factory in Springfield, Massachusetts, which is where they began production of the Model 1 in 1858 [8]. It was a single-action, tip-up revolver with a 7-shot capacity in .22 rimfire with a barrel length of 3-3/16 inches. At the time the .22 caliber bullet was 29 grains and used under 3 grains of black powder in the cartridge. There were three issues, or styles, of the Model 1 created. The first issue, manufactured between 1857 to 1860, and second issue, 1860 to 1868, both had a blued octagonal barrel with a 1/7 left handed twist, an unfluted cylinder and a square butt [9]. These two issues were very similar and only had a few minor differences. The third issue, which was in production from 1868 to 1882, had a fluted cylinder, a round barrel and a bird's head grip, and also had the option of having a barrel length of 2-11/16 inches [9]. Each of the three issues is displayed in Figure 8.

Figure 8: Smith & Wesson Model 1: First Issue (top), Second Issue (center) and Third Issue (bottom) [8, Public Domain Image]

2.2.2 Smith and Wesson Model 2

Although the Smith and Wesson Model 1 was a wonderful gun to carry and conceal, more power was desired. Due to this, Smith and Wesson created a larger caliber pistol, the Model 2. Introduced in 1861, this was a .32 caliber revolver and was manufactured until 1874 [8]. They were able to create the larger caliber gun and cartridges to not only satisfy their customers but also to continue revolutionizing firearms. Since the caliber was enlarged, the gun needed to be designed big enough to be functional with the new ammunition. Because of the large size, the cylinder could only hold 6 shots rather than the 7 of the Model 1. The Model 2 is displayed in Figure 9.

Figure 9: Smith and Wesson Model 2 [8, Public Domain Image]

2.2.3 Smith and Wesson Model 1½

The Model 2 was a gun that was wanted on the battle field because of its larger caliber. However, it was not as desirable for a concealed gun due to its large size. The Model 2 was so large that it was not able to be easily concealed. Because customers had to decide between either concealability or larger caliber guns when it came to personally carrying, Smith and Wesson created a "hybrid" of the Model 1 and 2. The model 1½, manufactured from 1865 to 1875, was a .32 caliber revolver with a 5-shot capacity. The capacity was brought down from six to five shots, merely to shrink down the size of the gun. This allowed their customers to be able to have a larger caliber gun that is easier to conceal than the Model 2. The Models 1, 2 and 1½ are displayed in Figure 10.

Figure 10: Smith and Wesson Model 1 (bottom), Model 1½ (center) and Model 2 (top) [8, Public Domain Image]

CHAPTER 3: OTTO SCHNEELOCH THE INVENTOR

3.1 History of Otto Schneeloch

Otto Schneeloch was born in Duesseldorf Stadt, Rheinland, Preussen, Germany on January 24, 1835. At the age of nine, Schneeloch's parents were tragically killed in a runaway carriage accident. This caused his sister, two brothers and himself to be orphaned. His sister Emma stayed in Germany, while each of the three brothers eventually traveled to America. At fourteen years old, the middle brother Hugo was the first to immigrate. In 1851, Hugo ran away from his guardian to New Orleans. This is where he became an apprentice to a gun maker and eventually worked for the Winchester Company in New Haven, Connecticut. In 1861, the youngest brother, Emil, immigrated at age 18 and worked for Springfield Armory in Massachusetts for fifty years.

Otto left Bremen, Germany for New York on November 24, 1856. His occupation at the time was an armorer and was eventually listed as a gunsmith in New York by 1858. On May 3, 1861, at the age of 26, he enlisted for a two year term in the Union Army by joining Company I of the 20th New York Volunteer Infantry. Otto's rank quickly rose, when he became a corporal on July 11and then promoted to sergeant on September 14. He was involved in many battles, including the Battle of Antietam, in which the company suffered 145 casualties. After avoiding any injury during extremely deadly battles, he was wounded during the Chancellorsville Campaign at Salem Heights on May 4, 1863.

After the two year enlistment, Otto moved to Springfield, MA, in 1865, which is where him and his wife, Maria had their first child, Edward. Otto and his family then moved to Brooklyn, New York and in 1867, Maria gave birth to their daughter, Agnes. A year later, Schneeloch established a gun business and became a private in the 32^{nd} Battalion of the New York National Guard. His passion for guns was not only apparent within his career but also in personal life. The National Rifle Association (NRA) was established in New York, in 1871 and started to hold shooting competitions two years later. Otto Schneeloch enthusiastically participated in the NRA events and according to the NRA Annual Reports from 1873 to 1876, he had placed several times in not only team events but also individually. His greatest accomplishment as a marksman was in 1873 when he won first place in the Competition II – Sportsman's Match. That same year, his wife gave birth to his third child, Emil.

Due to Schneeloch's lifetime passion for firearms, he eventually became the Ordnance Sergeant and was the Armorer for the 32^{nd} Regiment. Unfortunately, this passion would be the reason for his death. Although he was able to escape death during the civil war, he died from an accidental gunshot wound. On October 15, 1877, Otto Schneeloch was shot and killed by a careless companion during a shooting match at College Point, Long Island. He had a successful career as an armorer, which was apparent not only through his ranking but through his ideas and patents.

3.2 Otto Schneeloch .307 Triangular Revolver

Otto Schneeloch realized the same issue that Smith and Wesson tried to address when they created the Model 1 ½, but he did not want to sacrifice the larger shot capacity as they had. He received a patent, No. 134,441, for his .307 triangular revolver on December 31, 1872. He created this in order to improve revolving firearms of the late 1800s. The patent includes his intent of increasing the packing density of the firearm while keeping the gun as small and light as possible. According to the patent sketch in Figure 11, he wanted to have a cylinder capable of holding 8 shots. In order to accomplish this task, he used a triangular shape instead of the common circular cross section. Triangular shaped bullets with a slight outward curvature, which is shown in the patent, are fitted in the chamber with the apex pointing inward. By using this orientation, it allows the chamber to hold more ammunition, while eliminating excess metal in the cylinder. The bullet having a triangular cross section means that the barrel must also have that same triangular bore for it to function correctly. The patent includes his desire to have a twisted triangular bore, rather than straight. This patent it displayed in Figure 12.

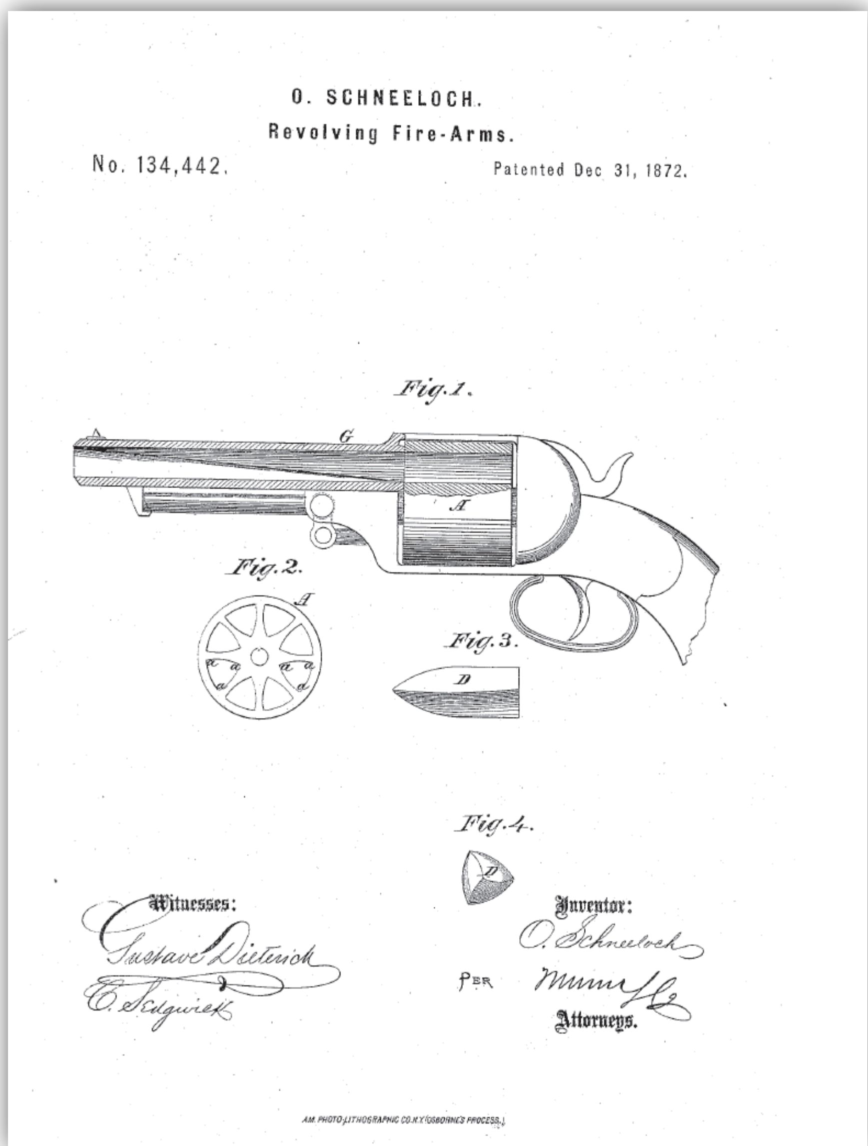
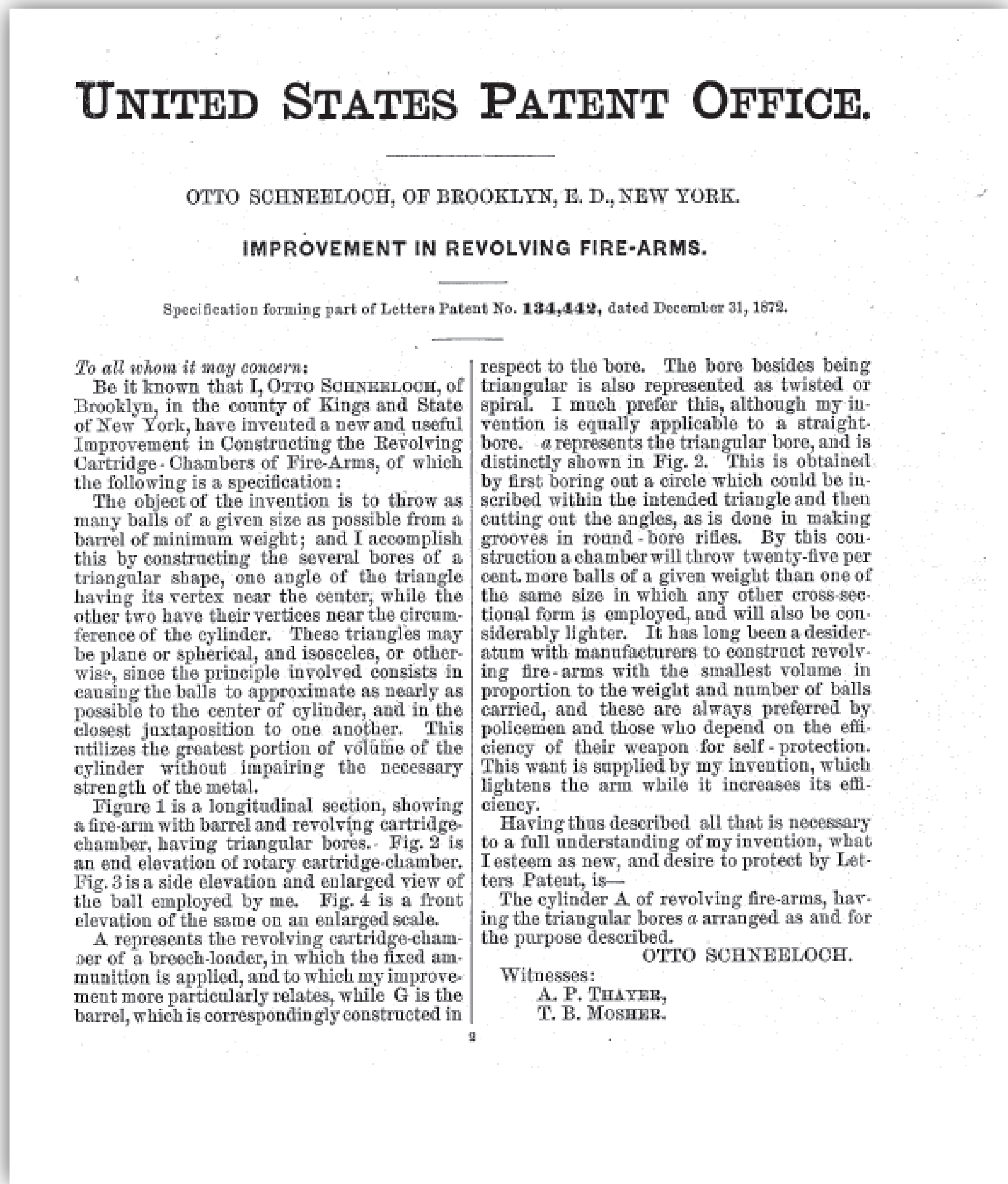


Figure 11: Patent No. 134,442 Improvement in Revolving Firearms Sketch [10, Public Domain Image]



UNITED STATES PATENT OFFICE.

OTTO SCHNEELOCH, OF BROOKLYN, E. D., NEW YORK.

IMPROVEMENT IN REVOLVING FIRE-ARMS.

Specification forming part of Letters Patent No. **134,442**, dated December 31, 1872.

To all whom it may concern:

Be it known that I, OTTO SCHNEELOCH, of Brooklyn, in the county of Kings and State of New York, have invented a new and useful Improvement in Constructing the Revolving Cartridge-Chambers of Fire-Arms, of which the following is a specification:

The object of the invention is to throw as many balls of a given size as possible from a barrel of minimum weight; and I accomplish this by constructing the several bores of a triangular shape, one angle of the triangle having its vertex near the center, while the other two have their vertices near the circumference of the cylinder. These triangles may be plane or spherical, and isosceles, or otherwise, since the principle involved consists in causing the balls to approximate as nearly as possible to the center of cylinder, and in the closest juxtaposition to one another. This utilizes the greatest portion of volume of the cylinder without impairing the necessary strength of the metal.

Figure 1 is a longitudinal section, showing a fire-arm with barrel and revolving cartridge-chamber, having triangular bores. Fig. 2 is an end elevation of rotary cartridge-chamber. Fig. 3 is a side elevation and enlarged view of the ball employed by me. Fig. 4 is a front elevation of the same on an enlarged scale.

A represents the revolving cartridge-chamber of a breech-loader, in which the fixed ammunition is applied, and to which my improvement more particularly relates, while G is the barrel, which is correspondingly constructed in respect to the bore. The bore besides being triangular is also represented as twisted or spiral. I much prefer this, although my invention is equally applicable to a straight-bore. *a* represents the triangular bore, and is distinctly shown in Fig. 2. This is obtained by first boring out a circle which could be inscribed within the intended triangle and then cutting out the angles, as is done in making grooves in round-bore rifles. By this construction a chamber will throw twenty-five per cent. more balls of a given weight than one of the same size in which any other cross-sectional form is employed, and will also be considerably lighter. It has long been a desideratum with manufacturers to construct revolving fire-arms with the smallest volume in proportion to the weight and number of balls carried, and these are always preferred by policemen and those who depend on the efficiency of their weapon for self-protection. This want is supplied by my invention, which lightens the arm while it increases its efficiency.

Having thus described all that is necessary to a full understanding of my invention, what I esteem as new, and desire to protect by Letters Patent, is—

The cylinder A of revolving fire-arms, having the triangular bores *a* arranged as and for the purpose described.

OTTO SCHNEELOCH.

Witnesses:

A. P. THAYER,

T. B. MOSHER.

2

Figure 12: Patent No. 134,442 Improvement in Revolving Firearms [10, Public Domain Image]

Along with having a patent for this specific idea, there is also a prototype. The only evidence that proves the existence of this prototype is an old photograph that can be found in *Firearms Curiosa* by Lewis Winant, pages 246 to 247 [11] This photograph is also displayed in

Figure 13. It is unknown where the prototype is today or whether or not it was created by Schneeloch himself. The last known location of it was in the collection of Leo J. Werner [11]. Between Otto and his brothers, Schneeloch obviously had all the necessary skills and access to whatever he needed to create the prototype, meaning Schneeloch most likely did create it.

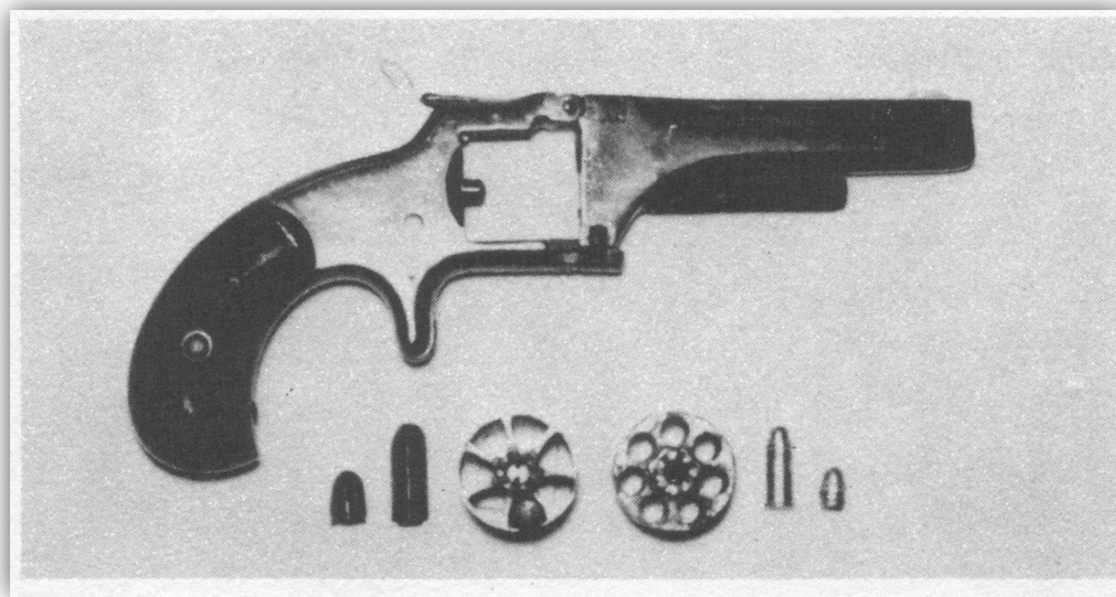
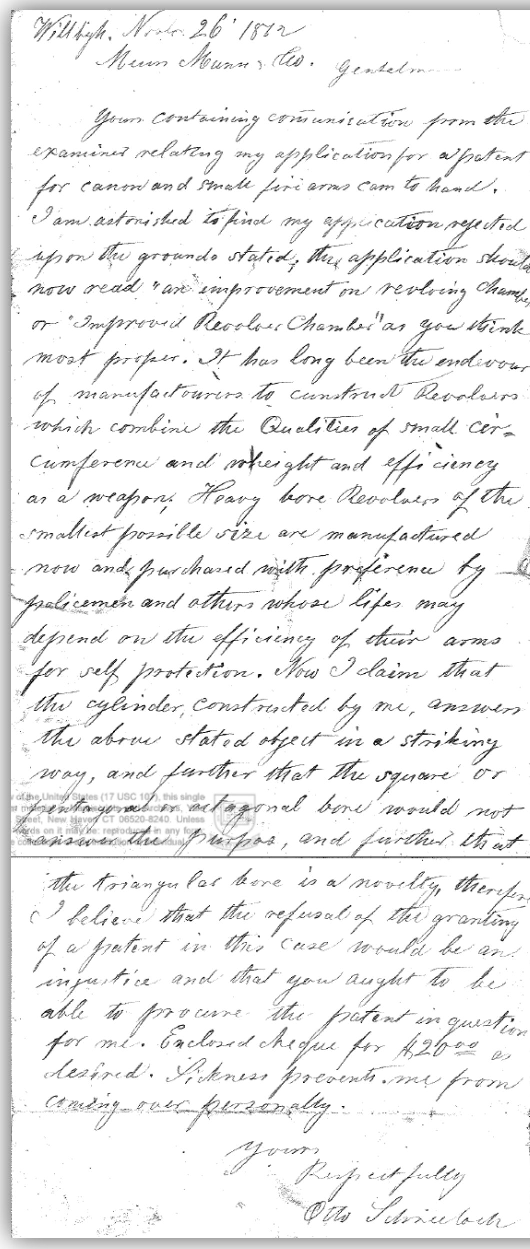


Figure 13: Photograph of the Schneeloch .307 Prototype Including a .22 Short RF, Cartridge and Bullet for Reference [11]. Permission included in Appendix A.

Additional information further proving that Schneeloch was most likely the actual manufacturer of this prototype is located in a letter found within the Bacon-Schneeloch Family Papers, Manuscripts and Archives of Yale University Library. This letter was written to Messr Munn, Co. by Schneeloch for the purpose of re-applying for the triangular revolver patent after it was initially rejected. Within this letter he states, “Now I claim that the cylinder, constructed by me…”[12], this shows that he claims to have created the cylinder. Therefore, he most likely constructed the entire prototype. This letter, along with the typed manuscript is located below in Figure 14.



Willburgh, November 26 1872

Messrs Munn, Co.

Gentlemen,

Yours containing com(m)unication from the
examiner relating my application for a patent
for canon and small fire arms cam(e) to hand.
I am astonished to find my application rejected
upon the grounds stated. This application should
now read "an improvement on rev(o)lving chamber
or "Improved Revolver Chamber" as you think
most proper. It has long been the endevour
of manufactourers to construct Revolvers
which combine the Qualitites of small cir=
cumference and wheight and efficiency
as a weapon. Heavy bore Revolvers of the
smallest possible size are manufactured
now and purchased with preference by
policemen and others whose lifes may
depend on the efficiency of their arms
for self protection. Now I claim that
the cylinder, constructed by me, answers
the above stated object in a striking
way, and further that the square or
pentagonal or octagonal bore would not
answer the purpos(e), and further that
the triangular bore is a novelty, therefore
I believe that the refusal of the granting
of a patent in this case would be an
injustice and that you aught to be
able to procure the patent in question
for me. Enclosed cheque for $20.oo as
desired. Sickness prevents me from
coming over personally.

Yours
Respectfully
Otto Schneeloch

Figure 14: Schneeloch's Letter to Messrs Munn, Co. Found in the Bacon-Schneeloch Family Papers, Manuscripts and Archives, Yale University Library [12, Public Domain Image]

The Schneeloch triangular revolver prototype appears to be made using the barrel assembly of a Smith and Wesson Model 1 first or second issue and the rear grip frame of the Smith and Wesson Model 1 third issue or Model 1½. The barrel of the prototype is octagonal, which is common for both the first and second issue. The model 1 was a .22 caliber revolver, which is the perfect sized bore to use in order to create the triangular bore. If it were a .32 caliber bore, there would be insufficient metal to cut the correct triangular shape. The model 1 second issue had three groove rifling, which would have allowed Schneeloch to follow those grooves in order to cut the triangular shaped bore. The rear grip had the birds head style which is a feature of the third issue model 1 or model 1½.

When comparing the photographs of the different model 1 issues and the prototype, it can also be noticed that the cylinder cut-out in the frame is longer in the prototype than it is for each model 1. It states in *Firearms Curiosa* that the Schneeloch cylinder is longer than the .22 caliber reference cylinder in the photograph [11]. (The reference cylinder was stated to be fluted which is a feature of the model 1 third issue) Therefore, the cylinder he created for his triangular cartridges was longer than that of the standard third issue. The longer cylinder was most likely created because the length of Schneeloch's cartridge had to be longer than a .22 short RF in order to accommodate the extra black powder needed for the heavier triangular bullet. Although the photograph is very old and is of poor quality, it appears that Schneeloch created the larger cut-out in the grip frame by adding metal to certain portions of the gun. Specifically, it appears that he added metal on the barrel assembly near the hinge connecting the two frame halves and on the rear end at the bottom near the latch which keeps the hinge in a closed position. Adding metal in these areas allowed him to avoid cutting down the overall length of the barrel or weakening the front frame.

Although the old photograph answers several questions about the prototype, it also raises several questions as well. There appears to be only a shadow image where the hammer should be located on the gun. This raises the question of whether the photograph has been doctored, or if not, whether Schneeloch actually finished making the prototype. The missing hammer would be a viable reason as to why there is no known performance data for the

Schneeloch triangular revolver. If he never completed the gun then he never actually tested it. The hammer would have also required modification from its original rimfire configuration to the centerfire system indicated by the triangular cartridges.

3.3 Otto Schneeloch .307 Triangular Cartridge

According to the 1872 patent Schneeloch received, the cartridge casing and bullets both had a triangular cross section. In addition to the patent sketch and the prototype picture, there is another older photograph, Figure15, which also displays this unique ammunition. In order to recreate Schneeloch's triangular ammunition, research had to be done in order to correctly and accurately accomplish the recreation. Part of this research included understanding the type of cartridge systems used at the time.

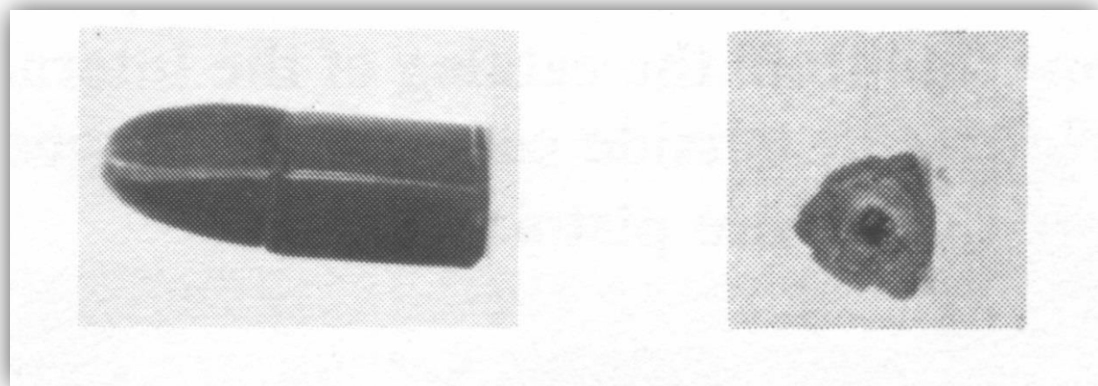


Figure 15: Schneeloch Triangular Cartridge Side View (left) and Base View (right) [13, Public Domain Image]

3.3.1 Smith and Wesson Model 1 Cartridge

As stated previously, the Smith and Wesson Model 1 was the perfect sized gun to carry and conceal but was merely a .22 caliber revolver. The cartridge used in the Model 1 is essentially the same as the.22 short of today, but it used black powder rather than today's smokeless powder, which had not yet been invented. The weight of this round was 29 grains and used less than 3 grains of black powder in the cartridge casing [9]. This cartridge was a rimfire, meaning the priming compound is located inside the rim. When the hammer strikes the rim, it crushes the priming compound between the walls, igniting the black powder.

3.3.2 Smith and Wesson Model 2 and 1 ½ Cartridges

The Smith and Wesson Model 2 and 1 ½ were both .32 caliber revolvers. Although they were different sizes, and one had a shot capacity of six while the other had only five, they both used the same ammunition. This ammunition was a .32 caliber rimfire cartridge. Because it was a rimfire cartridge, it required the same ignition process as the .22 caliber rimfire, where the hammer strikes the rim in order to ignite the black powder within the cartridge. The .32 was larger than the .22, and consequently weighed 85 grains. A weight increase of about 56 grains. Because the .32 caliber weighed so much more than the .22, it needed more black powder in order to propel it to an effective velocity. Therefore, the .32 caliber used 9 grains of black powder in the cartridge casing.

3.3.3 Primers of the mid to late 1800's

When evaluating the Schneeloch triangular cartridges, the primer used is questionable. It would have been extremely difficult, if not impossible, to build prototype cartridges in a triangular shape that employed a rimfire priming system. Reforming an existing circular rimfire cartridge into the desired triangle would have resulted in premature detonation. Folding a triangular rim out of sheet metal from scratch and introducing the priming compound would have been a challenge, while any substantial rim would tend to reduce the packing density of cartridges around the cylinder. Clearly it was necessary to adopt some type of centerfire priming system for the triangular cartridge, where ignition occurs upon striking the center portion of the base, rather than the rim. At the time of his patent there were different options for what type of primer to use in order to ignite the black powder. He could have easily used an older ignition technology, such as a percussion cap or BB cap or even the newer technology of centerfire primers.

Percussion caps were first introduced in the early 1800s. They were small copper cups that contained mercury fulminate and were placed over a hollow nipple. When the hammer strikes the percussion cap it ignites the powder. The BB cap (bulleted breach cap) was produced in 1845 by Louis Flobert. It was a basically a .22 caliber ball placed in a percussion cap [17]. There was no black powder used in addition to the charge powder. Therefore, the charge created by the BB cap was the only propellant for the bullet. Smith and Wesson believed they could improve upon this cartridge design. They created the rimfire cartridge in 1854. This is the same rimfire cartridge as was explained in the previous section. Centerfire cartridges were finally introduced in the 1860's. A centerfire primer is a brass cup that contains priming powder between the cup and an anvil. When the firing pin hits the primer, it crushes the powder between the cup base and the anvil, which then ignites the powder. Any of these style primers could have been used in order to ignite the black powder in the Schneeloch triangular cartridge.

3.3.4 Otto Schneeloch Triangular Cartridge

Originally it was thought that the only proof of the existence of the Schneeloch triangular revolver prototype and cartridges were the two older photographs of the gun and of the cartridge previously discussed. However, after much research in the topic, it was found that there are in fact three bullets and one cartridge casing that are still in existence. Photographs of the bullets and casing were discovered on a website for Alvin Olsen's Cartridge Auction. Alvin Olsen has access to these actual bullets and casing and he was extremely helpful in providing several measurements and pictures at different orientations. All these pictures are located in Figure 16 through Figure 19. In viewing the photographs, several differences in the three bullets can be seen.

In Figure 16 the three bullets show subtle differences. They each look like they have different amounts of oxidation. Oxidation is normally an indication of age and so the authenticity of the two separate bullets is in doubt. These bullets also have no “heal” which is necessary for the insertion into the case. For these reasons, the two separate bullets were not considered to be part of the historic record. The remaining bullet and its case, do however appear to be genuine historical artifacts. The primer can be seen as a protrusion on the base of the cartridge. Centerfire primers normally lay flush with the base of a cartridge but the Schneeloch primer appears to protrude from the base. This is to make up for the lack of a rim of standard thickness.

Figure 17 clearly displays the side of the bullet and cartridge casing. An important feature of the bullet is that it is heeled. It is heeled in order for the base of the bullet to fit into the cartridge casing and allows the walls to be flush with one another. This is similar to the .22 short RF cartridge and requires that cylinder chambers only be through-bored. Modern cartridges use inside-lubricated bullets (non-heeled) and demand stepped chambers. It would be almost impossible to cut triangular chambers in a stepped configuration. Heeled triangular bullets make perfect sense, and indicate authenticity, since through-bored triangular chambers are easily broached. This figure allows the two important features of the cartridge casing to be displayed: the protruding primer and the “ears” attached to the sides near the base. These “ears” are attached in order to act as a rim for the casing. Because this ammunition is for a revolver, the wings need to be there in order to prevent the cartridge from being able to slide through the chamber, similar to a modern conventional rimmed case.

Figure 16: Two Schneeloch Triangular Bullets and One Cartridge [14]

Figure 17: Schneeloch Triangular Cartridge Side View [14]

Figure 18: Schneeloch Triangular Bullet and Cartridge Casing Top View [14]

Figure 19: Schneeloch Triangular Cartridge Casing Bottom and Side Views, Displaying Primer Protrusion [14]

CHAPTER 4: DETERMINING THE DIMENSIONS OF THE .307 TRIANGULAR CARTRIDGE

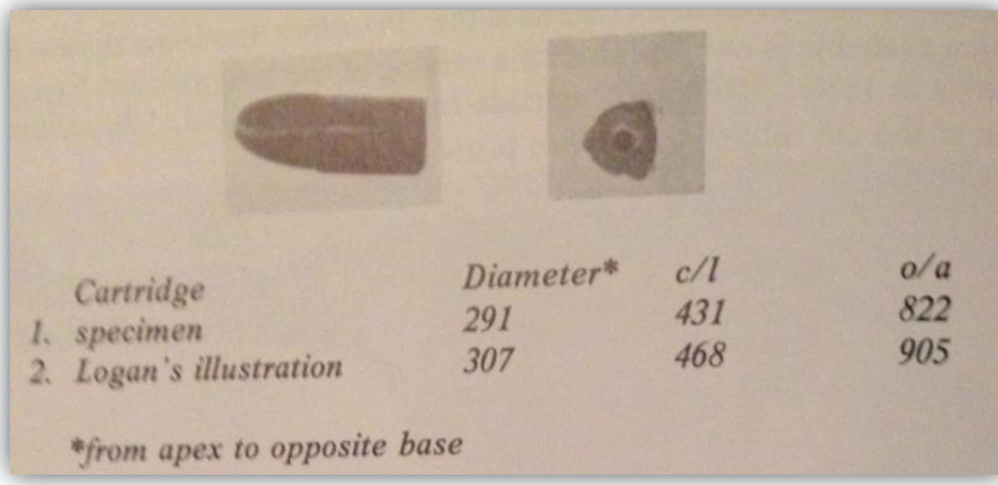
4.1 Bullet Dimensions and Shape

As stated previously, there is currently one complete Schneeloch triangular cartridge known to be in existence. Alvin Olsen provided several essential measurements of the cartridge. These measurements were used in order to determine the most accurate shape, along with other necessary measurements using SolidWorks™. SolidWorks™ is a computer aided design program commonly used by engineers for 3D modeling. In addition to utilizing this program for modeling, it was also used to find more dimensions of the cartridge. Several photographs provided by Alvin, were uploaded into SolidWorks™. Then using the measurements provided, the photographs were correctly sized in order to retrieve more important measurements, such as the outward curvature of the triangular shape.

4.1.1 Bullet Measurements and Calculated Dimensions

Several important dimensions of the bullet were provided by Alvin Olsen. The length of the cross section from the apex of the triangle to its side at 90 degrees is 0.285 inches. The weight of the bullet is about 57 grains. The overall cartridge length is 0.877 inches, the cartridge casing length is 0.492 inches and the primer protrusion is 0.042 inches. In addition to Alvin Olsen's measurements, located on page 48 of "US Cartridges & Their Handguns" is a photograph of the .307 Schneeloch Triangular cartridge and a table of measurements, displayed in Figure20. The table of measurements includes a section called, "Logan's illustration". Logan's inaccurate measurements are most likely the origin of the Schneeloch cartridge title, ".307".

Within the table of measurements, is the specimen's "diameter" which is clarified in the footnote as being the measurement from the apex to the opposite base. This measurement is extremely close to that of Olsen's measurements, which further confirms their accuracy. This provided enough information to correctly size the photographs in order to determine the most accurate design and dimensions of the bullet.



Cartridge	Diameter*	c/l	o/a
1. specimen	291	431	822
2. Logan's illustration	307	468	905

*from apex to opposite base

Figure 20: Photograph of .307 Schneeloch Triangular with Table of Measurements [13, Public Domain Image]

Figure 21 to Figure 24 display the photographs with all the necessary measurements applied using SolidWorks™. Figure 21 shows the cartridge length measurements. Using the overall cartridge length of 0.877 inches and the cartridge case length of 0.492 inches, which both include the primer protrusion of 0.042 inches; the bullet length from tip to where it meets flush with the cartridge case can be found. This length measurement is 0.385 inches, which is not the entire bullet length. Therefore, the length of the bullet's heel, the portion that sits inside of the cartridge, must still be found.

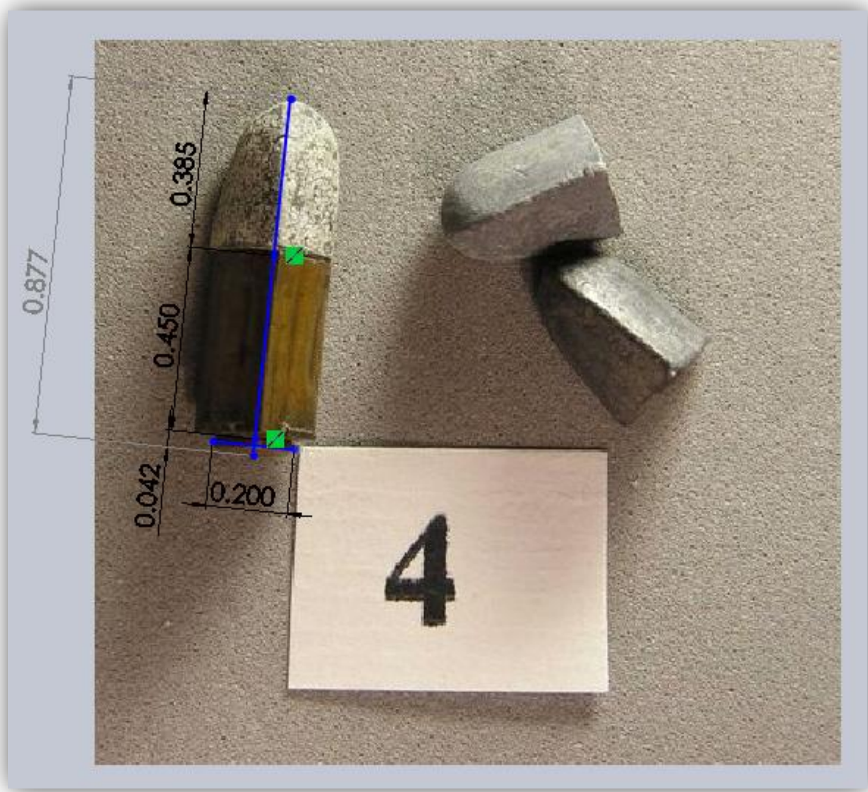


Figure 21: Schneeloch Cartridge and Bullets with Provided and Calculated Measurements [14, modified 11/2012]

The photograph of the cartridge casing separated from the bullet is the picture that was necessary in order to determine the full length of the bullet from tip to base. This photograph with the bullet measurements is displayed in Figure 22. The length from the tip to the top of the heel is 0.385 inches, which was used in order to determine other important measurements. Using SolidWorks™, the length of the heel is found to be 0.061 inches. Therefore, the entire length of the bullet is 0.446 inches. This photograph was also used to estimate a general shape of the bullet. It is estimated that the bullet has a constant equal cross section for a length of about 0.205 inches from the heel line. After that it begins its curvature towards the point of the nose. The length where the bullet curves to a point is about 0.180 inches. These estimated measurements are necessary for modeling the bullet in SolidWorks™, this estimate is verified if the bullet model has the same weight as the actual Schneeloch bullet.

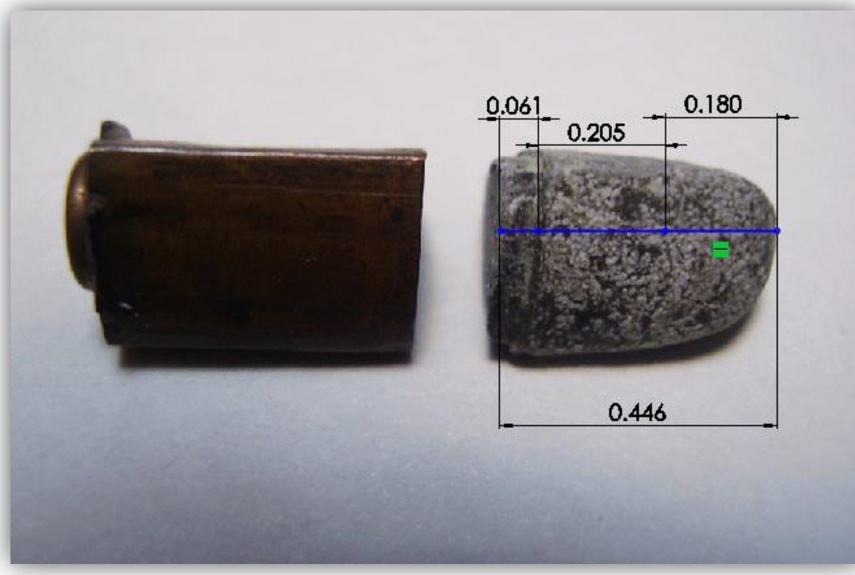


Figure 22: Schneeloch Cartridge with Calculated Measurements [14, modified 11/2012]

Lastly, the bullet measurements that are necessary are the unique triangular shape dimensions. Because the triangular cross section is not a typical straight sided triangle, there were several trial and error estimates that needed to be made. It is known that the sides are equilateral and that the length from the apex to the side with an outward curvature is 0.285 inches. Using the known information along with the old photograph of the prototype, the best estimate of the shape was found. Figure 23 displays the finalized shape measurements transposed onto the chamber's triangular shape. Note that the dimensions of the.22 short RF shown in the photograph also serves as an independent confirming reference. In order to have a clear view of all the measurements of the shape, the dimensions are displayed larger in Figure 24. Specifically the measurements displayed are the length from apex to side, the length between each apex, and the diameters of the circle circumscribed inside the triangular shape, the circle with the triangular shape circumscribed inside, and the circle with the same curvature as the triangular shape. All of the measurements provided and found are used in order to create a SolidWorks™ model, which is used to recreate the bullet.

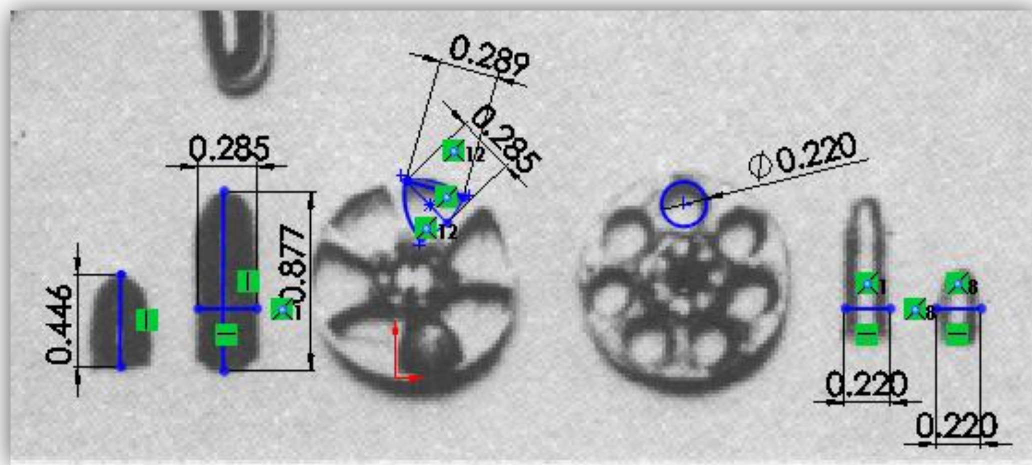


Figure 23: Old Photograph of Prototype with Measurements [11, modified 11/2012]

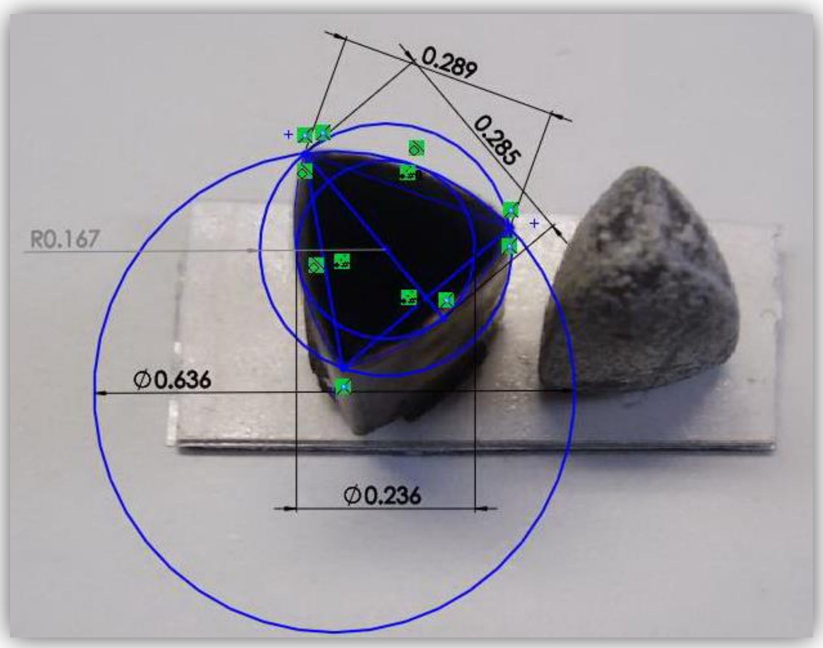


Figure 24: Schneeloch Triangular Cartridge Top View with Cross Section Dimensions [14, modified 11/2012]

4.1.2 SolidWorks™ Bullet Model

After all the necessary measurements were found, a model of the Schneeloch bullet could now be created. The model utilized all of the dimensions previously stated. It was mentioned that trial and error had to be done in order to determine if the curvature was correct. After several attempts, all of the dimensions coincided with one another; which means that the finalized and best estimated shape had been created. The SolidWorks™ bullet model is shown in Figure 25. There are six pictures of the model at different orientations to truly show the shape. Along with all the dimensions coinciding with one another, the last measurement that proves the model to be accurate is the weight. SolidWorks™ performs mass calculations for a design with a given material. The material of the bullet is most likely pure lead, which was applied to the model. SolidWorks™ calculated the weight of this bullet model to be 57.1 grains. This proves to be a good representation of the original Schneeloch bullet, which has the same key measurements, along with the same weight.

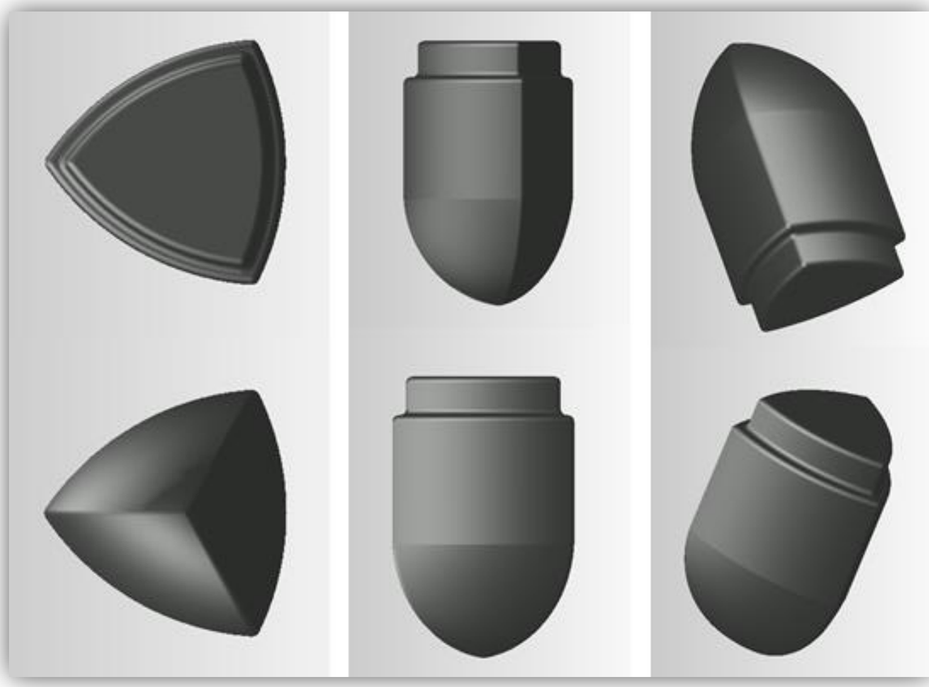


Figure 25: SolidWorks™ Model of Schneeloch Triangular Bullet. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

4.2 Cartridge Case Dimensions and Shape

Similarly to the Schneeloch triangular bullet, the cartridge case must also be evaluated using photographs, Alvin Olsen's provided measurements, and SolidWorks™. Luckily there is one cartridge still in existence with the bullets. The measurements that were provided will be applied to the photographs in SolidWorks™ in order to determine any unknown measurements and shape. The cartridge utilizes the same unique triangular shape. Since this shape was already determined using the bullet dimensions, this was used in order to create the cartridge case model in SolidWorks™.

4.2.1 Cartridge Case Measured and Calculated Dimensions

Alvin Olsen provided the overall cartridge length measurement of 0.877 inches, the cartridge case including the protruding primer length of 0.492 inches, and the primer protrusion of length 0.042 inches. Therefore, the length of the cartridge case, without including the primer, is 0.45 inches. These measurements were first used in order to determine the best possible dimensions of the "ears". These ears are applied to the cartridge case in order to prevent the cartridge from sliding completely through the chamber. According to Figure 26, the determined dimensions of the ears are a length of 0.15 inches, a width of 0.021 inches and protrude out 0.025 inches.

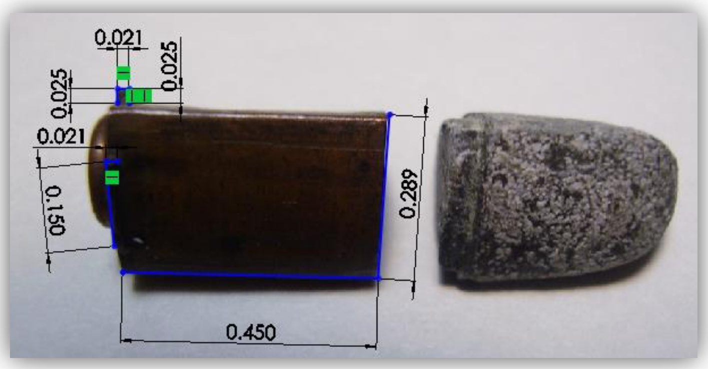


Figure 26: Side View of Cartridge with Length Measurements and Ear Dimensions [14, modified 11/2012]

After determining the wing dimensions, another important measurement to find using SolidWorks™ is the cartridge case thickness. Figure 27 displays the estimated thickness using the photograph of the top view of the cartridge case. The thickness is measured to be about 0.01 inches. It also shows the curvature to be equivalent to that of a circle with a diameter of 0.636 inches, which is the same as the triangular cross section curvature of the bullet. Therefore, it is now known that the same triangle with a slight outward curvature is used for the cartridge case as well as the bullet.

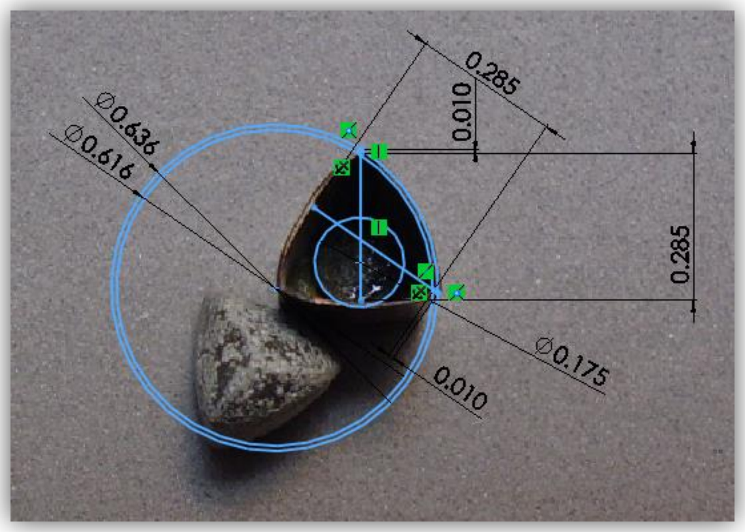


Figure 27: Top View of Schneeloch Cartridge with Thickness Measurement [14, modified 11/2012]

4.2.2 SolidWorks™ Cartridge Model

The measurements that were provided and found were all used in order to create a model of the Schneeloch cartridge. Although the bullet model needed trial and error in order to find the correct shape to fit the dimensions and weight, the shape of the cartridge was provided by the bullet's SolidWorks™ model. The predetermined shape, along with several more provided measurements allowed the cartridge model to be created more quickly. Figure 28 displays the cartridge case SolidWorks™ model at six different angle orientations.

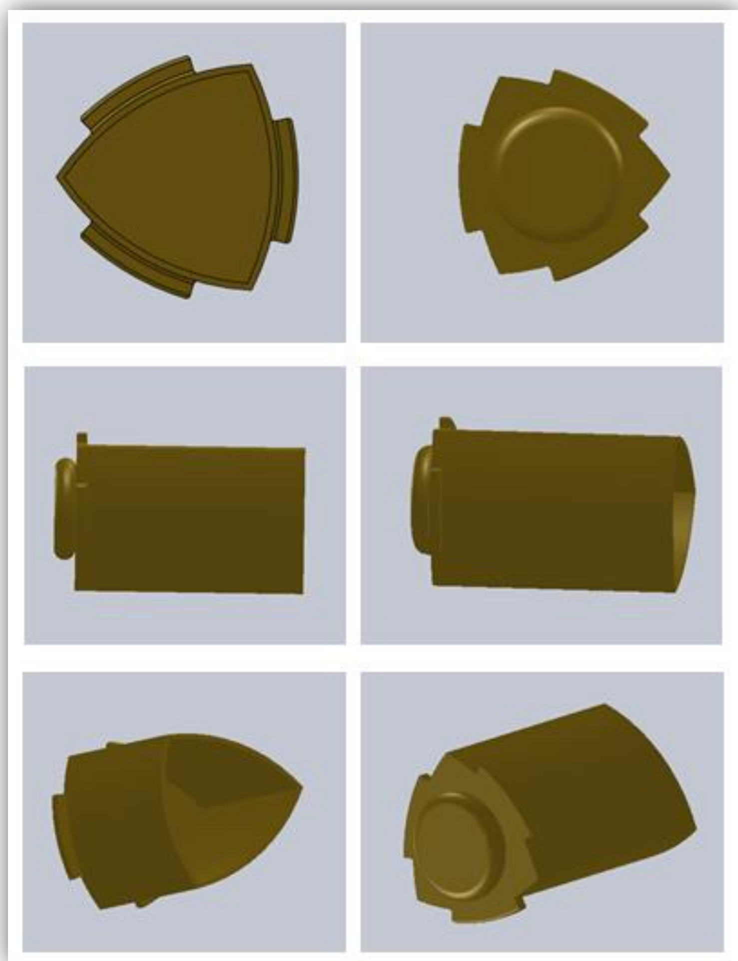


Figure 28: SolidWorks™ Model of Schneeloch Triangular Cartridge Case. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

Once the cartridge case model was created, an assembly of the bullet and case was made. This assembly makes up the model of the entire Schneeloch cartridge. Figure 29 to Figure 33 all display the actual Schneeloch cartridge with the SolidWorks™ model. Each figure can be used in order to visually compare the actual cartridge with the model at several different orientations. It can be seen that the model is an extremely accurate representation of the cartridge. Because the model has the same dimensions of the actual cartridge, along with looking visually similar, this model will be used in order to make the recreation.

Figure 29: Side View of Schneeloch Cartridge [14] (left) and SolidWorks™ Model of Schneeloch Cartridge (right)

Figure 30: Exploded Side View of Schneeloch Cartridge [14] (left) and Exploded View of SolidWorks™ Model of Schneeloch Cartridge (right)

Figure 31: Schneeloch Cartridge [14] (left) and SolidWorks™ Model of Schneeloch Cartridge (right)

Figure 32: Top View of Schneeloch Cartridge [14](left) and SolidWorks™ Model of Schneeloch Cartridge (right)

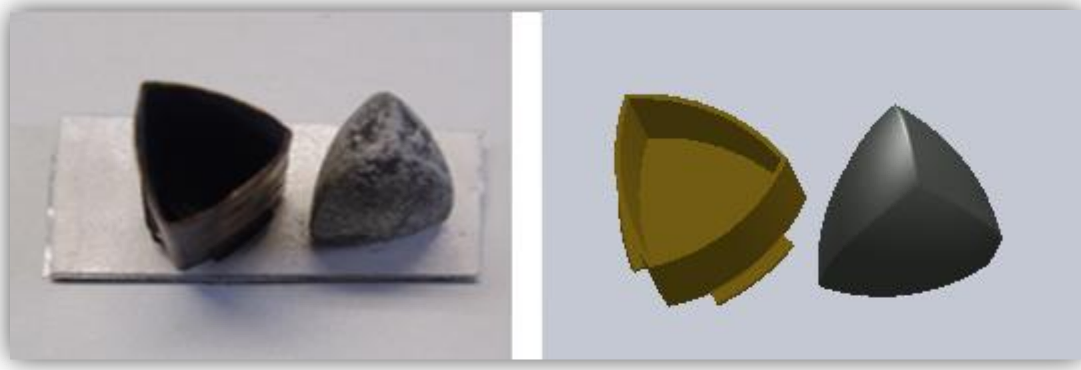


Figure 33: Angled Top View of Schneeloch Cartridge [14] (left) and SolidWorks™ Model of Schneeloch Cartridge (right)

CHAPTER 5: DETERMINING THE DIMENSIONS OF THE SCHNEELOCH'S PROTOTYPE FIREARM

5.1 Barrel Dimensions

Since the location of the prototype is unknown, as confirmed by direct communication with the NRA National Firearms Museum and Archive in Virginia, the recreation of the barrel had to be done using educated assumptions and what is known about the bullets and cartridge. Once the triangular shape with outward curvatures was determined and all the measurements were found, the barrel could be designed. This triangular shape was used as the bore shape for the barrel and the chamber. Now assumptions must be made in order to determine the other important dimensions of the barrel.

5.1.1 Triangular Firearm Determinations

The key determinations that needed to be made were the twist rate, barrel length, and cylinder length. These determinations were made based off of what is known about the prototype. As stated previously, the prototype is a hybrid between the second issue and the third issue of the Smith and Wesson model 1. Specifically, the barrel is that of the second issue. The Smith and Wesson model 1 second issue had a barrel length of 3-3/16 inches and had a left handed twist rate of 1:7 [15]. These measurements were provided by Matthew Sharpe, curator of programs for the National Firearms Museum who personally measured a Smith and Wesson Model 1 (second issue). Because the prototype had a barrel of the second issue, the length and twist rate was assumed to be the same for the prototype. The length assumption was made because there appears to be no change in the length of the barrel in the prototype photograph. The twist rate was also assumed to be the same as the second issue because of the fact that this issue had three groove rifling which could be followed with a triangular shaped broaching tool, in order to get the twisted triangular bore.

Although the barrel assumptions were determined using the photograph of the prototype and the Smith and Wesson revolvers used in the prototype, the cylinder length was determined with only the photograph. The cylinder cut-out in the prototype frame has a length of 0.945 inches. This length was used for the modeling because it was appropriate for the given space and is large enough to fit the Schneeloch cartridge, which is longer than that of the .22 caliber cartridges of that time. The measurement of the cut-out is shown in figure 34.

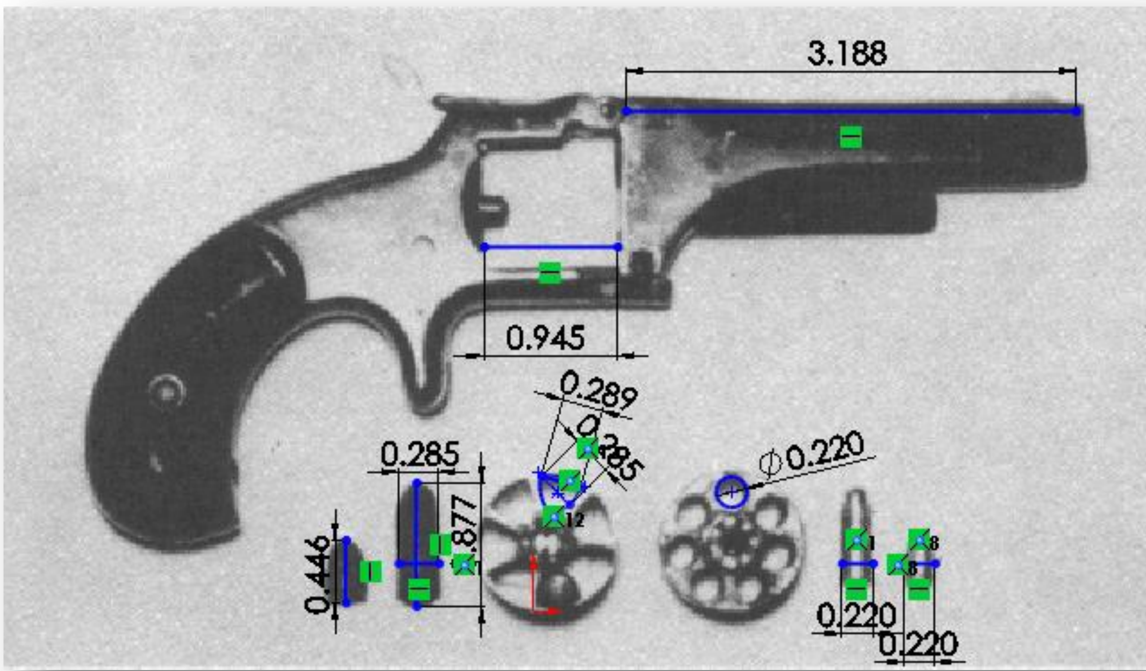


Figure 34: Photograph of Schneeloch Prototype with Measurements [14, modified 11/2012]

CHAPTER 6: PRODUCTION PROCESS

6.1 SolidWorks™ Barrel Design

Using the triangular shape and the determined dimensions, the barrel and cylinder could be modeled in SolidWorks™. The barrel is modeled with an outer diameter of one inch. This diameter was chosen in order to have a very strong barrel that will withstand all the testing. Different orientations of the model of the barrel and cylinder are displayed in Figure 35. Note: For evaluation purposes it was not necessary to create a revolving cylinder with multiple chambers. Instead a single shot design was adopted with a single chamber located centrally in the cylinder. It was still necessary to create a cylinder separate from the barrel in order to properly represent the cylinder/barrel gap on a typically revolver.

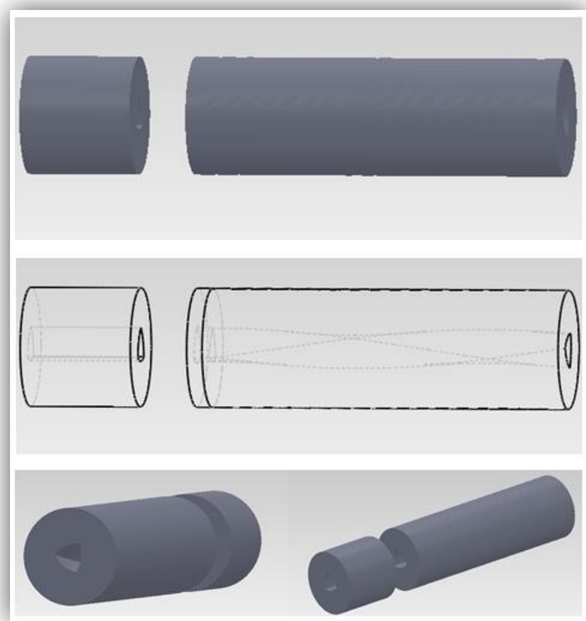


Figure 35: Original SolidWorks™ Model of the Schneeloch Triangular Barrel. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

6.2 Triangular Barrel Manufacturing

Once the SolidWorks™ model of the barrel was completed then the production process could begin. There were several manufacturing processes that were researched in order to determine the best option. The processes researched were broaching, button rifling, hammer forging, computer numerical control machining and direct metal laser sintering.

6.2.1 Broaching

Broaching is a common barrel manufacturing process, typically used for applying the rifling into the bore. The tool necessary for this manufacturing process is a broach. For barrel broaches, the tool is a rod that has a ring of cutting teeth. These cutting teeth are small cutters that are arranged around the rod diameter and can be adjusted for depth-of-cut. The cutting teeth will have the same number around the diameter of the rod as the number of desired grooves in the barrel.

This process is done by first drilling the bore slightly smaller than is desired. Once the bore is created it can then be polished. After the polishing process, the diameter of the bore is now the desired size. The bore of the barrel is large enough to fit the end of the broach. The broach is pulled through the bore and is also rotated as it is pulled through. This creates the rifling grooves along the inside of the barrel. Broaching is a possible manufacturing process for the Schneeloch barrel and was most likely the method used by Schneeloch.

In order for Schneeloch to have used broaching, he must have made a broach with the same triangular configuration that was desired for the bore. Most likely this process would need to be done several times with a few different sized broaches before the barrel was finalized. Schneeloch worked as a gunsmith; therefore, he would have possessed the skills needed to create his own broaching tools and to cut the bore. Given the strength of modern stainless steel (the preferred metal for this application) compared to 1800's steel, the cost of purchasing custom broaching tooling was prohibitive.

6.2.2 Button Rifling

Another barrel manufacturing process that is used today is button rifling. This process is similar to that of the broaching method because it is a process performed after the bore hole is drilled. After the hole is drilled, the button tool is what applies the rifling. Rather than cutting away the metal to form grooves, the button applies pressure to form the grooves. This tool is typically shaped similarly to a tiny football and is made of tool steel. It is slightly oversized compared to the bore and is able to rotate on the rod it is attached to. The button is forced through the bore, typically by being pulled. As it is forced down the barrel, the pressure from being oversized impresses the rifling grooves. This is a quick and common rifling process used today. Although it is quick, this is not a likely method to be used in order to recreate the Schneeloch triangular barrel. This is because too much metal would have to be formed to achieve a transition from a round bore to a triangular one, while button rifling can't produce the sharp corners required.

6.2.3 Hammer Forging

Another common barrel manufacturing method is hammer forging. This process is completely different than that of the broaching and button rifling processes mentioned previously. It utilizes a mandrel, which is a piece of hard steel that is the shape of the barrel's interior. Therefore, it is simply a rod with the rifling protruding out of the side with the correct twist rate. This is inserted into the drilled bore, which is larger than that of the finalized bore diameter. Once the mandrel is inserted, the barrel is then hammered continuously (swaged) until the bore takes on the outer shape of the mandrel. The mandrel is then removed by unscrewing it and the bore is the correct diameter and is now rifled. This process could easily create the desired triangular bored barrel that Schneeloch had designed. Although it is a possible method, it requires a custom mandrel and very large swaging machines to accomplish. It is more for production applications than a single prototype.

6.2.4 CNC Machining

CNC machining is a manufacturing process that although is not typically used for creating barrels, was researched to determine the possibility of being utilized, specifically CNC milling. CNC milling machines utilize computer programming in order to create a product that is accurately sized and shaped. Milling machines use different types of cutters to manufacture a product and can cut in several different directions. The direction possibilities all depend upon the machine. For example, if it is a five axis machine, the cutter has five degrees of freedom. Because of the unique triangular shape and the twist inside the barrel, it was originally thought that this would be an impossible process to use. Then the idea of having a split barrel, made CNC milling a possibility.

The first idea was to have a barrel split straight into two halves. The SolidWorks™ model of the split barrel is displayed in Figure 36. Again because of the curved triangular shape with a 1:7 twist rate, a five axis CNC milling machine would not be able to create the correct cuts necessary to create both halves. Therefore, the barrel was then split into three pieces. Each of these thirds has a twisted cut that matches the twist rate inside the barrel. Therefore, each piece contains one of the curved triangular sides as it curves down the barrel. Although this process should be possible with a CNC milling machine, it would be extremely time consuming and more manufacturing processes must be used in order to hold the three pieces together to form the finalized barrel.

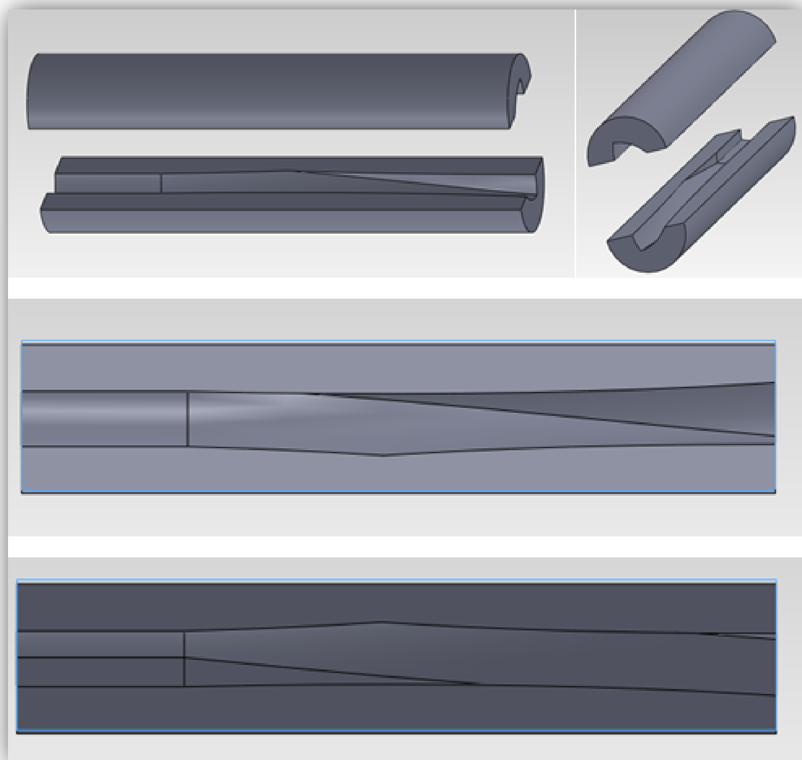


Figure 36: Original SolidWorks™ Model of the Barrel Split in Two Halves. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

6.2.5 Direct Metal Laser Sintering

Direct metal laser sintering, DMLS, is another type of manufacturing process. This process allows uniquely shaped objects to be created from metal. It is a form of three dimensional printing. This process works by first having a thin layer of a specific metallic powder located on the DMLS table. Then a laser is used to sinter the metallic particles together at specific locations. These locations are where the final product will have metal located, and the locations that are not sintered are where the product lacks metal. After the layer is completed and all the necessary sintering is done, a blade swipes over that initial layer. The blade applies another thin layer of metallic powder for another sintering session. This process is repeated until each layer is completed and the final product is created. The product is then removed from the powder that was not sintered to the product. Surface finishing can also be performed depending on what finish is desired.

Since this process is ideal for creating uniquely shaped objects, it was the most viable way to recreate the Schneeloch triangular barrel. Not only is it able to create the twisted triangular bore but it also allows for all the desired extra features of the barrel to be applied as well. Although this process is expensive, compared to the difficulty and price of the other processes and its ability to produce desired features, it was the process used to recreate the barrel.

6.3 Modified Barrel Design

DMLS provided the ability to add different features to the barrel, such as a forcing cone, muzzle crown, and attachment features. The actual barrel and cylinder were created by GPI Prototype & Manufacturing Services, a company that utilizes DMLS processing to create products for their customers.

6.3.1 Attachment Features

Since DMLS is an expensive manufacturing process, the entire gun could not be made. Because there is only a barrel and cylinder, some type of support system was necessary. In order to securely fasten the barrel and cylinder to the flat support base, a few attachment features needed to be applied. A flat base was ideal to allow the barrel and cylinder to lay on the support without rolling. To do this, a portion of the bottom was “shaved off”. This was done by removing the bottom curvature, a distance of 3/8 inch from the center. This caused the cross section of the barrel and cylinder to resemble a capital D-shape rather than the original circular shape.

In addition to sitting flat on the surface, it was necessary to have a feature forcing the barrel and cylinder to stay in place while in use. Therefore, three grooves were created, two on the barrel and one on the cylinder. These grooves were carefully designed to allow a one inch U-bolt to fit snug inside. The U-bolts will prevent the barrel from having any torsional movement during use and they will also prevent the barrel and cylinder from moving in any forward, backward, or upward direction. The deepest portion of the groove is located a distance of 3/8 from the triangular center. Therefore, between the grooves and the flattened bottom, the barrel and cylinder's effective diameter is ¾ inch. The flat bottom and U-bolt grooves are displayed in the SolidWorks™ model in Figure 37.

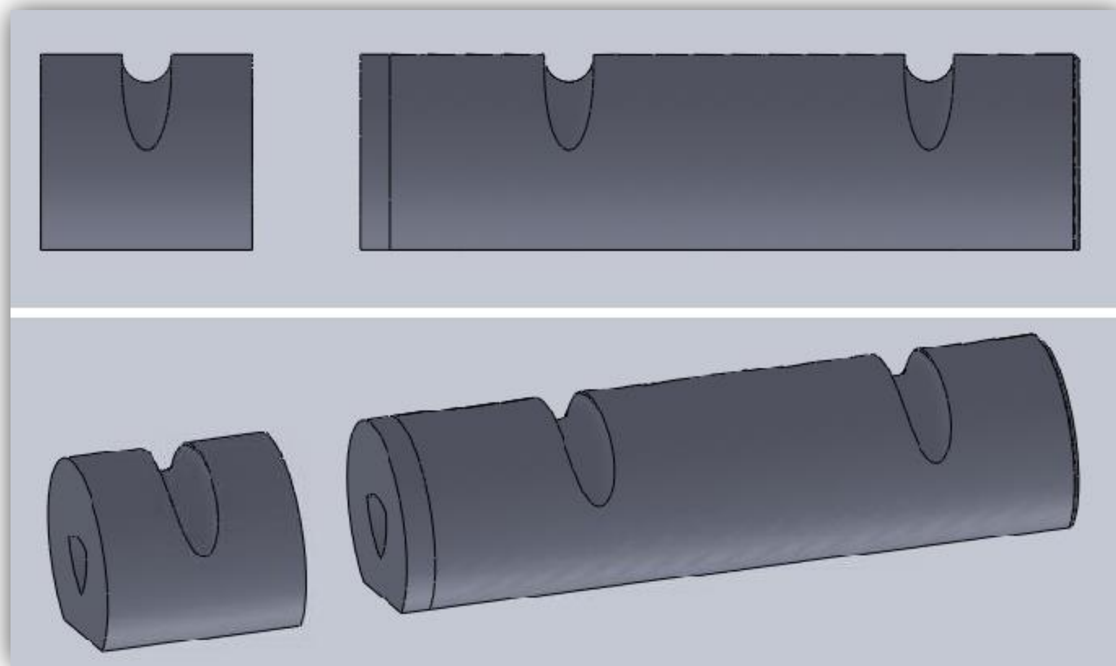


Figure 37: SolidWorks™ Model of the Recreated Schneeloch Barrel and Cylinder: Displaying the Flat Bottom and U-bolt Grooves. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

6.3.2 Forcing Cone

The forcing cone is a transitioning funnel located inside of the barrel on the opposing side of the muzzle and acts as an entrance to the bore. It has a larger opening where the bullet enters, and it tapers down until it reaches the bore diameter where the twisted groove rifling then begins. Specifically, the forcing cone for the Schneeloch recreated barrel has the triangular shape throughout it. It starts as a larger triangle with convex sides and tapers down with an apex angle of eleven degrees, having a length of about 1/8 inches long. Eleven degrees was chosen because it is a common angle used for forcing cones in firearm manufacturing. In addition to this the larger opening size was determined. Having this feature added to the Schneeloch barrel will provide correction to any minimal misalignments that may occur. The SolidWorks™ model of the forcing cone is displayed below in Figure 38.

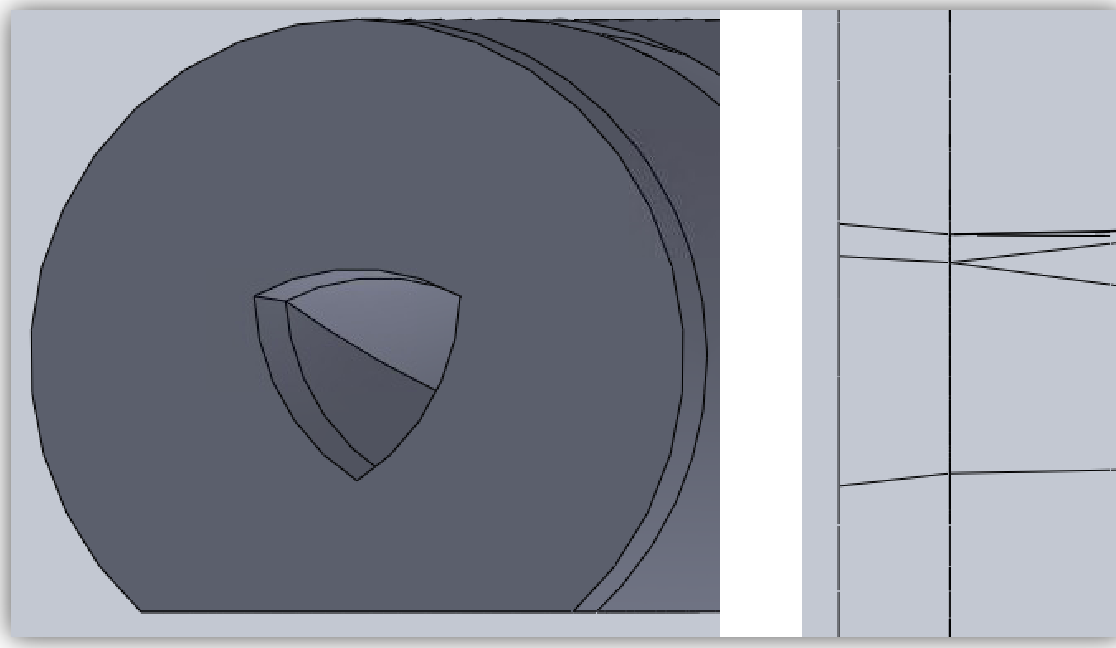


Figure 38: SolidWorks™ Model of the Recreated Schneeloch Barrel Forcing Cone: Front View (left) and Internal Side View (right). Courtesy of A. Shukitis taken March 2013 in Tampa, FL

6.3.3 Muzzle Crown

The recreated Schneeloch barrel was designed to be thicker than a common revolver barrel. This was done to increase the strength to account for the extra localized stresses that may occur within the sharp triangular corners of the bore. Because of the thicker barrel, the muzzle needed a crown. A muzzle crown allows the gasses to correctly exit the barrel to avoid interference with the bullet. In order to accurately create the triangularly oriented muzzle crown, the correct ratio of the locations for each recession and fillet needed to be established. This ratio was determined with the use of a rifle muzzle crown photograph and SolidWorks™. The actual measurements were not of any importance, simply the ratio was necessary. Therefore, the muzzle was given an overall diameter of one inch (same as the Schneeloch muzzle) and each of the recessions and fillet widths with respect to the overall diameter were determined. This photograph, including all the ratio dimensions, is located in Figure 39.

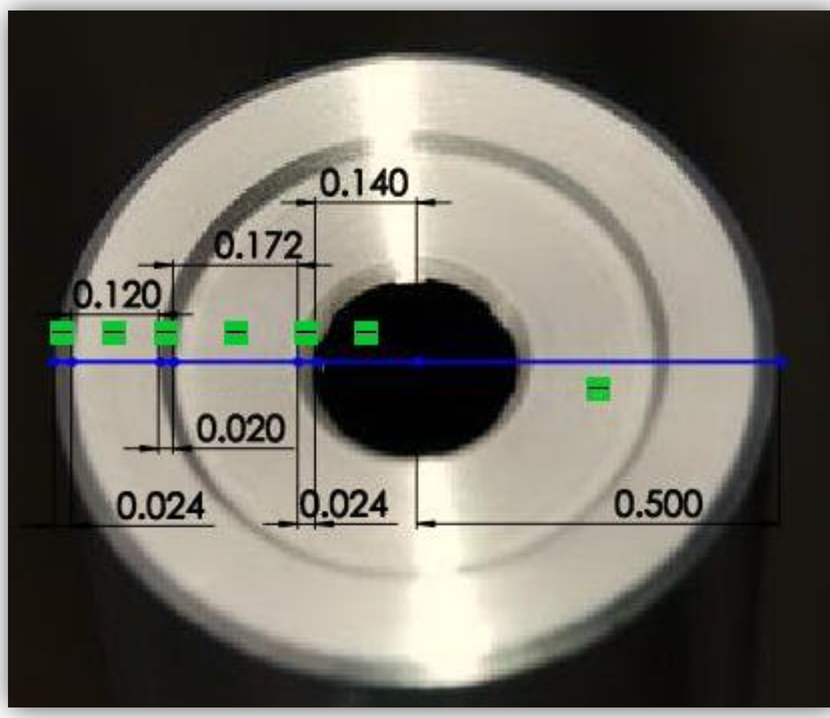


Figure 39: Photograph of Rifle Muzzle Crown with Ratio Dimensions Used for the Schneeloch Muzzle Crown. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

Once the ratios were established using SolidWorks™, the recessed crown could then be added to the Schneeloch barrel model. Because the initial fillet of the bore is triangular, the ratio needed to be considered and applied carefully. After the initial fillet, the rest of the recessions were circular like that of the rifle muzzle crown. Each recession was placed a distance corresponding to the ratios established and the fillet each had a width that also corresponded. The SolidWorks™ model of the triangular muzzle crown is displayed in Figure 40.

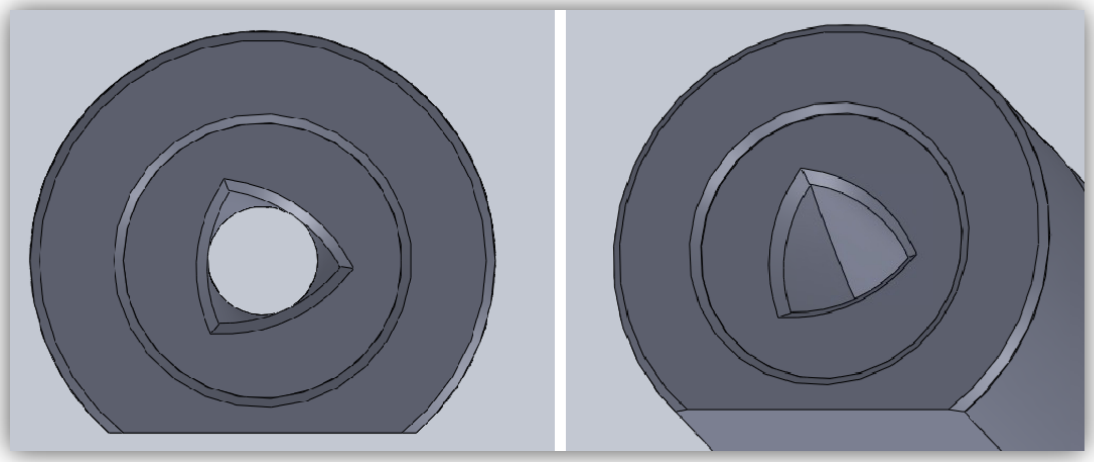


Figure 40: SolidWorks™ Model of the Recreated Schneeloch Triangular Muzzle Crown. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

6.3.4 Material

Once the triangular bored barrel and cylinder were modeled, they could then be made using DMLS, but a material needed to be chosen. The DMLS process is limited to certain materials, therefore before one could be chosen, the common materials used in firearms must be known. The most common material used in making firearms is steel, but there are several different types of steel and different finishes that can be applied. For example, a common finish that can be applied to steel barrels is bluing. Bluing is a chemical process that can be performed on steel barrels, which creates an oxide layer that serves as a protective finish. Stainless steel, such as 17-4, is also a desired material option because it also has non-corrosive properties to protect the integrity of the barrel.

Luckily, GPIprototype, the prototyping company used for creating the barrel, has two types of stainless steels options for the DMLS process. These two stainless steels are labeled as PH1 and GP1. PH1 has the mechanical properties of 15-4 stainless steel and GP1 has the mechanical properties of 17-4. Therefore, GP1 was the option chosen specifically because 17-4 stainless steel is a commonly used material for manufacturing firearms. The finalized SolidWorks™ barrel design used for creating the barrel is displayed in Figure 41. The barrel created with GP1 stainless steel using DMLS is displayed in Figure 42.

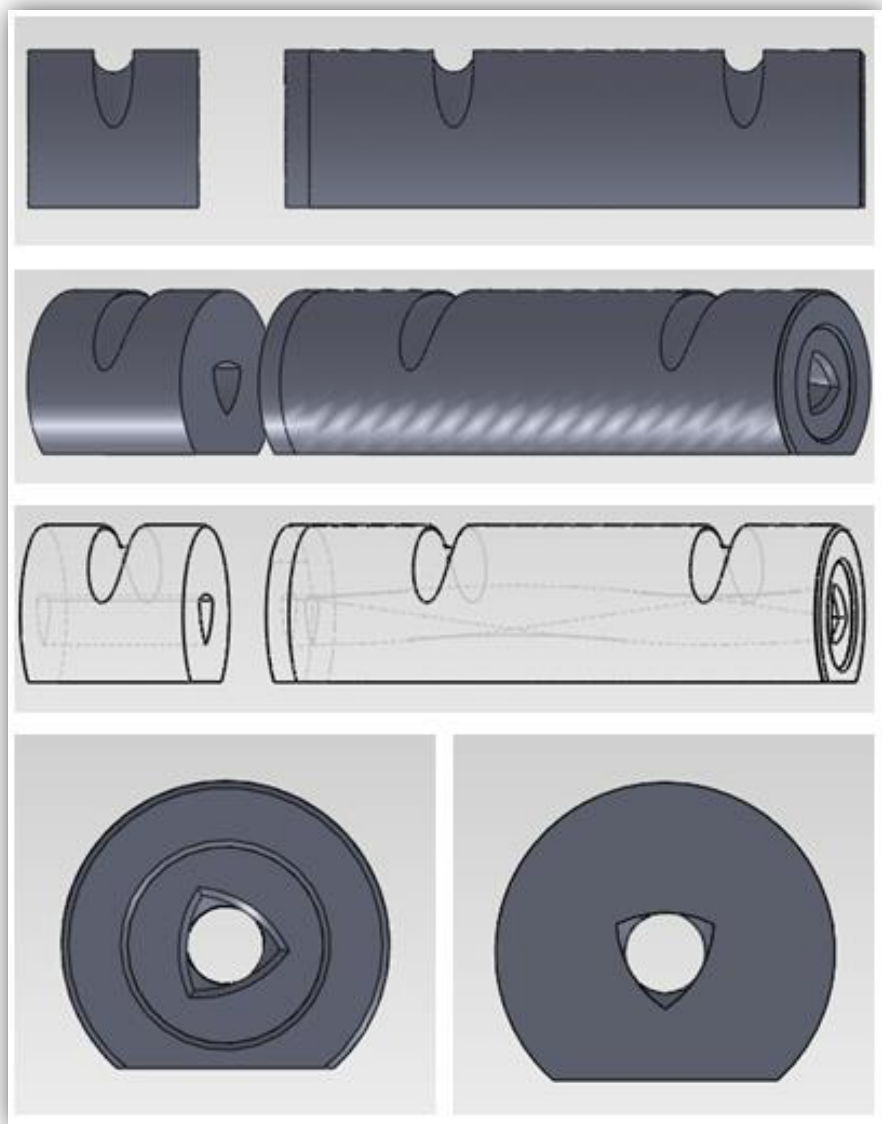


Figure 41: SolidWorks™ Model of the Finalized Barrel and Cylinder Design. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

Figure 42: Recreated Schneeloch Triangular Barrel and Cylinder Manufactured with DMLS. Courtesy of A. Shukitis taken March 2013 in Tampa, FL

6.4 Firing Mechanism Manufacturing

Once the barrel had been created using DMLS, some form of firing mechanism needed to be made to ignite the primer. After brainstorming several unique ideas, the final decision was to create a spring powered firing pin. The idea behind this was to have a firing pin attached to a spring that can be compressed and locked into place. When it came time to physically fire the gun, the spring would be released, allowing the firing pin to indent the primer causing it to ignite.

This firing mechanism was created within a 2x3 inch aluminum block to incase the main components. This aluminum block has a small hole on one side, located centrally with respect to the cylinder's triangular bore. The block has a larger hole that runs throughout the entire block from the opposing side until it reaches the smaller hole. This larger hole creates the cavity where the components are slid into place. The internal components are composed of a hexagonal rod, an eyebolt, and a spring. The hexagonal rod fits snug in the cavity and tapers down to a pin. This pin fits snug in the smaller hole and is long enough to slightly protrude out of the block, meaning the pin is longer than the depth of the hole. The spring is small enough to fit within the cavity but large enough to allow the eyebolt to fit through the center. The eyebolt is fed through a bolt, which has a hole drilled through the center, and the spring then screwed into the hexagonal rod. A photograph of the internal components is located in Figure 43.

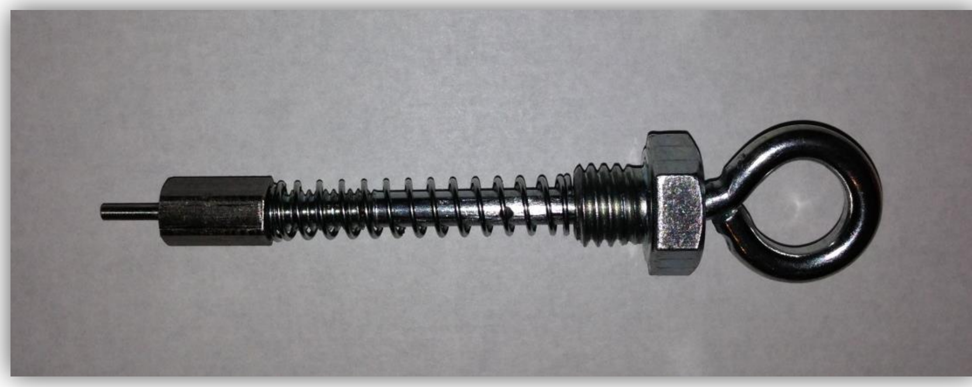


Figure 43: Photograph of the Assembled Firing Mechanism Internal Components. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Once the internal components were assembled, they were then slid into the larger hole of the block and the bolt was screwed into place. The bolt forces the internal components to be contained within the block, without falling out, but allows the eye bolt be pulled outward compressing the spring. There is also a hole located on the side of the eyebolt that allows a hitch pin to be pushed into; this acts as the "lock" causing the spring to lock in the compressed position. Therefore, when shooting the Schneeloch recreated gun, the hitch pin is simply pulled out of place allowing the compressed spring to force the firing pin forward, indenting the primer. A photograph displaying the internals with the hitch pin in place and the spring compressed is located in Figure 44.

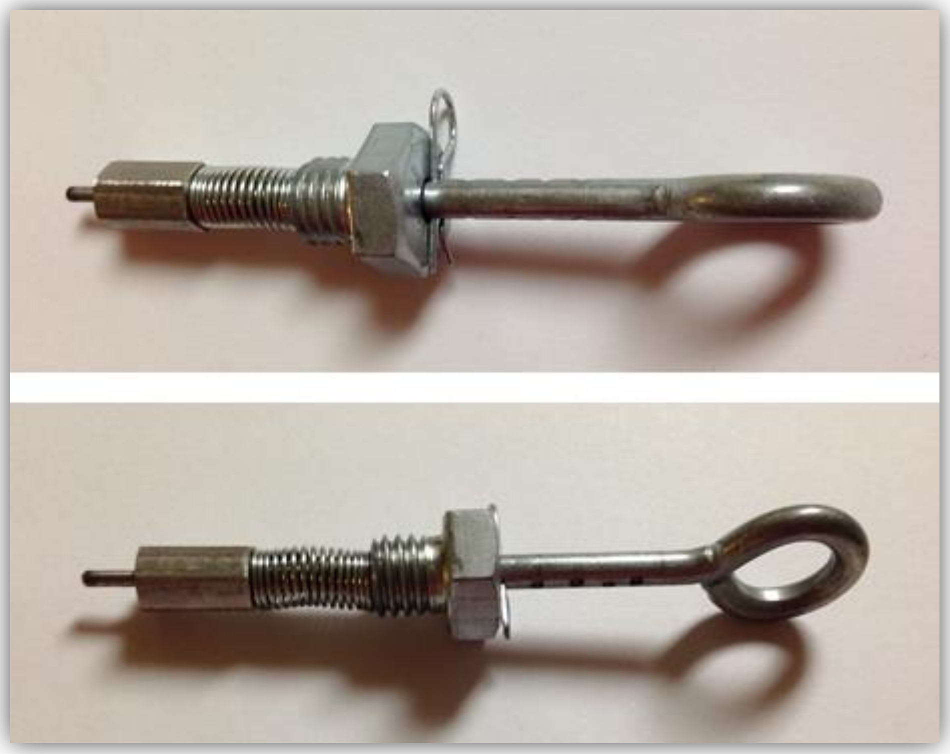


Figure 44: Photograph of the Firing Mechanism Internal Components with the Spring Compressed and Hitch Pin in Place. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Although the internal components of the firing mechanism are the main focus, the encasing aluminum block also has some important and convenient features added. In order to prevent removing the cylinder each time a new cartridge is fired, the block needed to easily lift out of place, providing access to the cylinder. There are two main features that were added to the aluminum block to accomplish this convenient removal. First, there were two holes drilled vertically into the block. These holes allowed the block to be bolted to the flat support, which also holds the barrel and cylinder. In order to avoid having to inconveniently remove the bolts each time and retighten them, the bolts were fed through the bottom of the support and locked into place with nuts. Because of the placement of the nuts, the aluminum block needed to have larger counter bored holes added to the current vertical holes. This allowed the block to be placed down on the two bolts and have an opening that fits over the nuts, permitting the block to sit directly on the support. It is then locked into place with wing nuts for easy removal. Photographs of the block, displaying the vertical attachment holes and counter bored holes, is located in Figure 45.

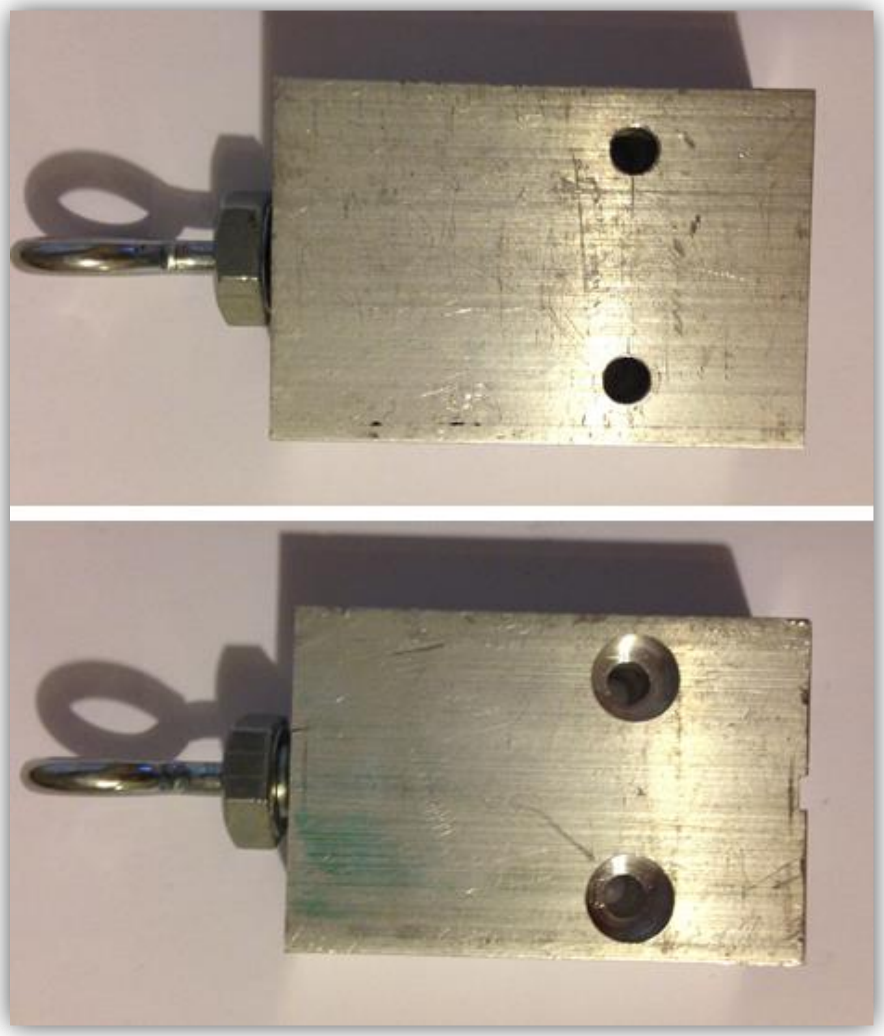


Figure 45: Firing Mechanism: Displaying Vertical Attachment Holes (top) and Larger Counter Bored Holes (bottom). Courtesy of A. Shukitis taken September 2013 in Tampa, FL

The second necessary feature is a groove located on the side where the firing pin hole is located. This is necessary because the Schneeloch cartridges have a protruding primer. If there was no groove, then the firing mechanism would need to be placed a certain distance from the front face of the cylinder. Because it is desired to have the aluminum block sitting flush with the cartridge base and ears, the groove was cut into aluminum block. The groove allowed the block to be slid into place while the cartridge is located in the cylinder, even with the primer protruding out. The primer fits inside the groove and slides through the groove as the block is put into place. In addition to making the block removal process more convenient, it also adds additional support to the back of the cartridge and primer. Because the primer protrudes out of the cartridge, it does not have the same support as it would, being flush with the base. Therefore, the groove causes the cartridge base and primer to have adequate support during the shooting process. Photographs displaying the primer groove and the entire firing mechanism are located in Figure 46.

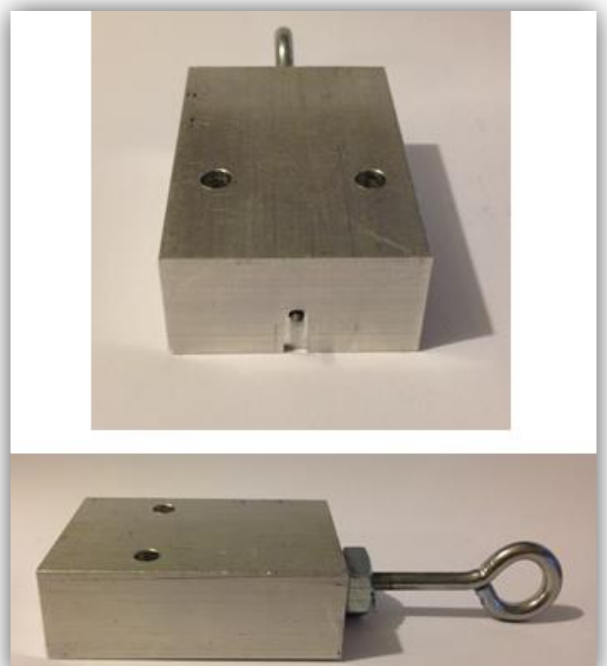


Figure 46: Fully Assembled Firing Mechanism: Front View of Primer Groove (Top), Side View with Hitch Pin in Place . Courtesy of A. Shukitis taken September 2013 in Tampa, FL

6.5 Barrel Shooting Rest

When determining the performance of a gun and its ammunition, the placement of the muzzle is crucial. It must have the exact same placement each time it is shot. If it is moved just slightly, the accuracy measurements would be imprecise. A shooting rest is customarily used for this purpose since it allows for recoil by rotating and absorbs energy via a friction disk. The Ransom rest has become the standard in ballistics testing, and so this was the rest that was purchased for the current research effort. The rest also requires grip pad inserts made of a dense rubber foam material, which holds the firearm securely without causing damage to surfaces. The Random rest and the grip inserts are both displayed in Figure 47.

Figure 47: Ransom Master Series Machine Pistol Shooting Rest with Grip Inserts. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

The ransom rest is designed to hold complete firearms, yet for the current case the barrel, cylinder, and firing mechanism lacked a conventional frame. Therefore, some machining had to be done in order to create a custom frame that would hold all the components together and adapt them to the rest and inserts. First, an aluminum plate was cut using a milling machine. It was cut to a shape that could easily fit inside the rest. Then, three holes in the same orientation as the holes in the grip inserts were drilled into the plate using a vertical drill press. Because the holes were the same size as the holes in the grip inserts and were located in the same placement, the aluminum plate could slide onto the placement rods of the shooting rest.

In addition to the aluminum plate two pieces of aluminum angle were used. These were each one inch wide and six inches long and provided a flat top for attaching components. U-bolts were used to attach the barrel and cylinder to the upper flat surface created by the two angled pieces. A gap of precisely 0.003 inches (measured with a feeler gauge) was left between the barrel and cylinder to simulate the gap normally present in an actual revolver.

In addition to attaching the barrel and cylinder, the firing mechanism needed to be attached as well. This was achieved with thru-bolts and wing nuts. A photograph of the aluminum grip piece with the barrel, cylinder and firing mechanism attached is shown in Figure 48, and shown inserted in the Ransom™ shooting rest in Figure 49.

Figure 48: Barrel, Cylinder, and Firing Mechanism Attached to Aluminum Plate for the Ransom Shooting Rest. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

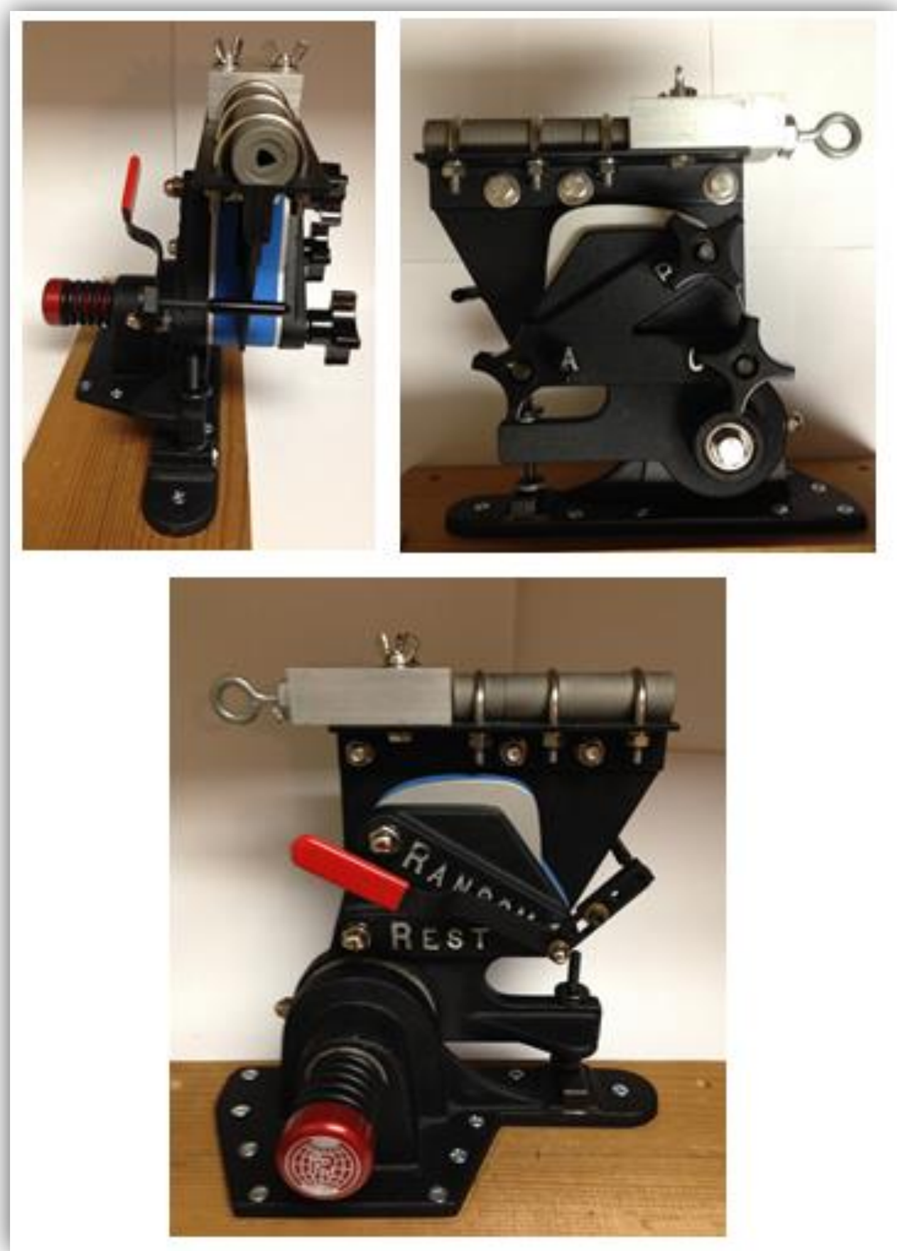


Figure 49: Barrel, Cylinder and Firing Mechanism Attached to the Aluminum Plate Inserted into the Ransom Shooting Rest. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

CHAPTER 7: CARTRIDGE PRODUCTION PROCESS

7.1 Bullet Production Process

Several options were considered for how to produce the uniquely shaped Schneeloch bullets but the best method eventually chosen was investment casting, with rapid prototyping used to create the molds for wax patterns. The pattern mold was designed using SolidWorks™ which is shown in Figure 50. Investment casting is a form of casting that utilizes wax to create the finalized mold. The rapid prototyped plastic mold is used to produce wax patterns by pouring molten wax into the cavity. Once the wax hardens it is then removed. Plaster of Paris is then poured over the wax pattern in a container. The Plaster of Paris hardens around the wax piece. When it is hardened, it is baked to remove the wax and to remove any unwanted moisture. Then molten lead is poured into the new Plaster of Paris mold. Once the lead has solidified, the mold is broken exposing the desired lead bullet. This process works well but took several trial and error attempts before it was perfected.

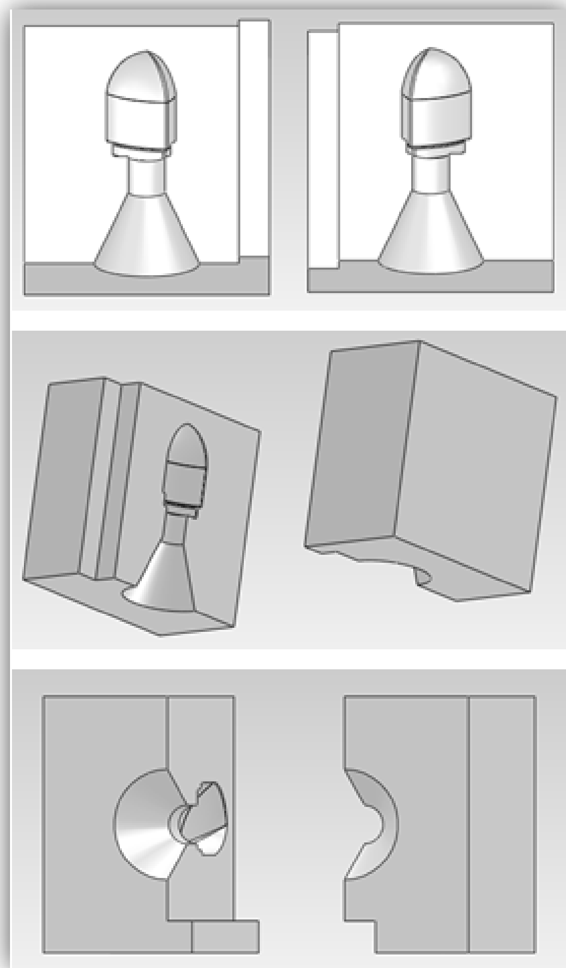


Figure 50: SolidWorks™ Model of Plastic Bullet Mold. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

7.1.1 Production of Bullet Mold

Once the bullet mold was designed using SolidWorks™, the file could then be used to rapid prototype the mold. The SolidWorks™ file was uploaded to the Dimension Elite, rapid prototyping machine. It breaks down the file by layers and creates each layer at a time using ABS plastic, while using another dissolvable material as a support for the open cavities during the printing process. Once the machine had finalized the mold, it then needed to sit in a chemical bath in order to remove all the unnecessary support material. The finalized plastic mold is displayed in Figure 51.

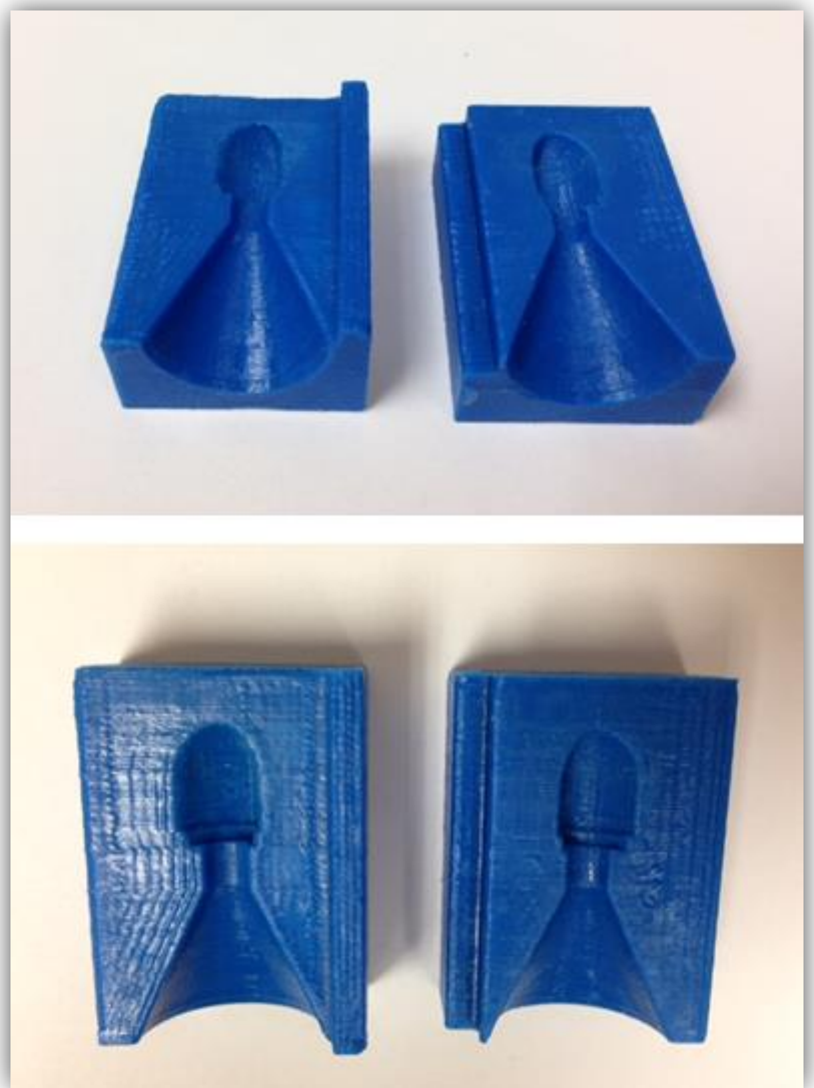


Figure 51: Rapid Prototyped Plastic Bullet Mold. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Once the plastic mold was created, it was then used to make the wax bullets. The first several attempts utilized melted wax, which was poured into the funneled portion until it reached the top face of the mold. Once the wax hardened it was then removed. The wax flowed well into the mold and took on the shape nicely. Unfortunately, the wax bullets inevitably became stuck inside the mold. A releasing agent was then used in order to remove the wax piece. The releasing agent made it possible to remove the piece but the small stem between the funneled portion and the bullet was too weak to withstand the removal process. Therefore, a solution was necessary in order to continue this process.

Something needed to be done in order to add strength to the stem. Therefore, a metal piece was machined from brass using a lathe. It included the small stem that stepped into a funnel shape, at the same angle as the mold, which then transitions to a straight portion of same diameter as the top of the funnel. A small hole was drilled through the stem and funneled portion, then a larger blind hole was drilled into the larger diameter portion. The larger hole was created in order to act as a funnel for pouring wax. Another hole was drilled perpendicular to the side of the larger diameter straight portion; this was done to insert a thin metal rod to support the wax piece in the plaster mold creating process. A picture of the brass stem piece is located in Figure 51 with the wax bullet.

Once the brass piece was completed, it was used with the same process of pouring melted wax into the rapid prototyped bullet mold. The brass piece successfully added strength to the stem, allowing it to be easily removed. Unfortunately, it also caused the melted wax to cool too quickly, preventing it from flowing into all the necessary grooves in order to provide the correct bullet shape. Therefore, another adjustment was necessary to make this process successful. Instead of pouring melted wax into the mold, a warm piece of wax was used. The wax was melted and allowed to cool, while consistently stirring. When it cooled to a slightly warm temperature, it was an extremely pliable piece of solidifying wax. This warm piece was pushed into each of the sides of the mold, forcing it to fill every void in the mold. The two halves of the mold were then forced together and the brass piece was forced into the top of the mold. All of these steps, made the warm pliable wax take on every detail of the bullet in the mold. Once it was completely cooled, the wax bullet was then removed, keeping the stem connected.

This process created a bullet that took on the exact shape of the mold and was easily removed, which proves to be the perfected method. One of the wax bullets including the attached brass piece is displayed in Figure 52.

Figure 52: Wax Bullets with Brass Stem Support. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

This perfected process was repeated several times until ten pristine wax bullets were created. These bullets were then used to create the Plaster of Paris mold needed to make the actual lead bullets. The Plaster of Paris was then mixed to the correct consistency and poured into a small paper cup. The ten wax bullets with the attached stems were placed pointing downward into the plaster and held into place using the small rod in the perpendicular hole of the brass piece. Once the mold had hardened the brass piece was removed, the paper cup was peeled off, and the molds were placed into an oven. They were baked at 175 degrees for two hours and the temperature was increased by 25 degrees for five minute intervals until 500 degrees was reached. This was done in order to pour the melted wax out leaving an open cavity and to eliminate the unwanted moisture within the mold. This produced the final molds needed for creating the actual lead bullets. A picture of one of the plaster molds created is located in Figure 53.

Figure 53: Plaster of Paris Bullet Mold: Top View of Mold with Pouring Funnel (top), Internal View of Cavity (center and bottom). Courtesy of A. Shukitis taken September 2013 in Tampa, FL

7.1.2 Bullet Production

Now that the mold had been completed, the bullets could then be created. In order to recreate bullets as genuine as possible, lead from the correct era was used (battle field relics circa 1860). Three American Civil War bullets, specifically three ringed .58 caliber with a hollow base, were carefully sanded and melted to use in making the Schneeloch bullets. The .58 caliber bullets were used because they were predominately used by the union army, therefore this lead would be the closest to the form of lead Schneeloch would have used. Since he lived in New York and was armorer to a union regiment. Photographs of the three bullets used are displayed in Figure 54.

Figure 54: Three Ringed .58 Caliber Civil War Bullets. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

The Civil War era molten lead was then poured into the Plaster of Paris bullet molds. Once the lead had cooled and hardened, the mold was carefully broken until the bullets were freed. Because lead is a very soft metal, this process was done extremely carefully in order to avoid damage to the bullets. If they became damaged in any way, the entire process would have to have been redone. Each of the bullets had a funnel shaped stem attached, just as the wax bullets did, along with a striated surface from the roughness of the rapid prototyped mold. Nine bullets were created using this process. The roughness of all nine bullets was filed down until they correctly fit the barrel and had a smooth finish. Once this was completed, the stem was carefully cut off and detached from the bullet. Photographs of some of the recreated Schneeloch triangular bullets with and without the stem are displayed in Figure 55.

Figure 55: Recreated Schneeloch Bullets: with Funnel Stem (top), without Stem (bottom). Courtesy of A. Shukitis taken September 2013 in Tampa, FL

7.2 Cartridge Casing Production Process

After creating the barrel, cylinder, and bullets, the only other component that needed to be made in order to complete the recreation was the cartridge casing. Although producing a cartridge may seem to be a simple task, because of its unique geometry it proved to be extremely complex. The main reasons for difficulties were the lack of triangular shaped brass tubing and the lack of a brass triangular base with a priming pocket. Because these products were not available, they needed to be created.

7.2.1 Production of Cartridge Mandrel

Since there is no triangular shaped brass tubing, it needed to be made. Specifically it needed to have the correct triangular shape with the outward curvature of the sides. In order to do this, circular brass tubing with a cross section of the same circumference as the triangular shape's perimeter was needed. Unfortunately there is no brass tubing of the exact diameter; therefore tubing with a slightly larger diameter was utilized. The plan to create the triangular brass tubing needed for the cartridge casings required a mandrel. The mandrel needed was to be a solid piece of steel with the same triangular cross section as the inside of the cartridge casing. Once this was made, it could be used to create the casings from circular tube by swaging.

In order to first create the mandrel, the inner perimeter and shape of the cartridge must be determined. This was found using SolidWorks™, as displayed in Figure 24. The figure shows the diameter of the circle that fits the curvature inside the cartridge casing. After determining the equivalent diameter of the curvature, the centers of the three circles that slightly overlap every 120 degrees were found. These centers, along with the diameter were used to program a CNC milling machine. This machine cut a piece of steel into the correct shape, creating the necessary mandrel. A photograph of the triangular steel mandrel is located in Figure 56.

Figure 56: Triangular Steel Mandrel. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

7.2.2 Production of Cartridge Bases

Now that the mandrel had been created, the cartridge bases still needed to be made. The same programing for the CNC milling machine was used in order to create a brass version of the mandrel. Although it looked exactly the same but made from brass, the brass version was not used as a mandrel. It was used to create the cartridge bases. A photograph of this triangular brass rod is displayed in Figure 57.

Figure 57: Triangular Brass Rod for Cartridge Bases. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Once this solid brass rod with a triangular cross section was made, it was used to create the bases. First the triangular brass rod was placed in the three jaw chuck of a lathe, clamping it on the large circular portion. Using the lathe, a #17 drill was used to drill a hole with a depth of 0.08 inches into the center of the triangular portion. This is the primer pocket where the primer will be pressed into. This depth was chosen because it will allow the primer to sit nicely in the base while also letting it protrude out the correct length to that of the original Schneeloch primer. Then a #46 drill was used to drill a flash hole, which allows the flames created by the primer to reach and ignite the black powder in the cartridge. The triangular brass piece was then removed from the lathe and placed in the three jaw chuck of a three axis milling machine. Using a thin slitting saw, the triangular brass piece was cut to separate the base with a priming pocket and flash hole from the rest of the piece. It was cut to provide a base thickness of 0.12 inches. This process was repeated until nine bases were created. A photograph of six of these bases is displayed in Figure 58.

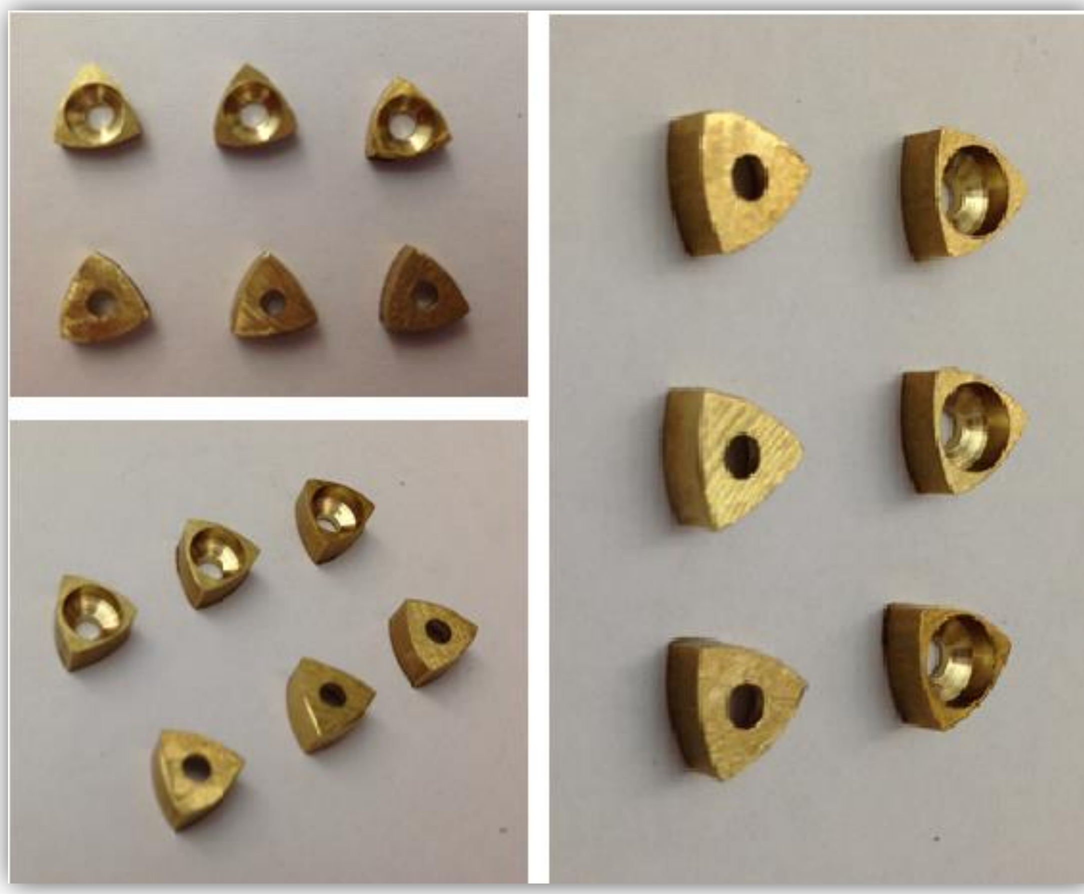


Figure 58: Triangular Cartridge Bases. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

7.2.3 Cartridge Casing Assembly Process

After the steel mandrel was manufactured and all the cartridge bases were made, the casings could then be created and assembled. Before the brass tubing was formed into the triangular shape, the tubing needed to be cut to the correct diameter. A lathe was used to cut the outside of the tubing until the wall thickness became 0.01 inch, which is equivalent to most modern pistol cartridge casings' thickness. Once the correct thickness had been machined and the piece was cut to a length of 0.51 inches, the triangular cross sectioned walls needed to be made from the circular brass tubing. The brass tubing was placed inside a large three jaw chuck and it was tightened until the tubing was forced into a slightly triangular shape. Once it had deformed sufficiently the steel mandrel was slipped inside and the chuck was tightened further until the brass hugged the mandrel tightly. This swaging process was repeated several times in order to ensure the correct shape was made. The entire cartridge cutting and shaping process was repeated until nine cartridges were made.

Now that the cartridges were the correct length and triangular shape, the three protruding “ears” needed to be formed. The tubing was chosen to be 0.51 inches long because this is the combined length of cartridge at 0.45 inches plus the length of the side protrusions at 0.06 inches. A fixture was used to hold each triangular cartridge tube vertically in the milling machine. A small milling cutter then cut away the three upper corners of the tube to leave a castellated top consisting of three rectangular extensions. Figure 59 displays a SolidWorks™ model of the cartridge with the three corners cut away, leaving only the three extensions. These three extensions were then bent perpendicular to the side of the triangular tubing, becoming the three protruding “ears" near the base of the cartridge casing.

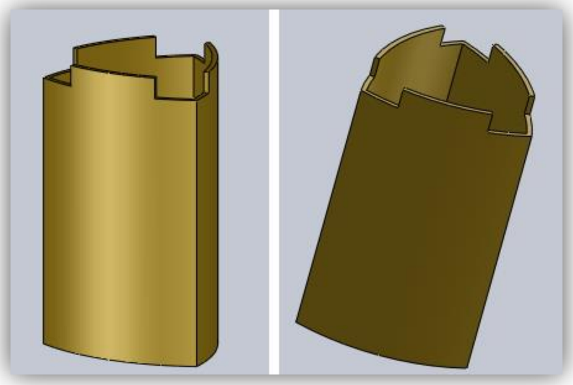


Figure 59: SolidWorks™ Model of the Cartridge Case with the Three Corners Cut Away. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Once the wings were created, the bases with the priming pockets were inserted into the base. Once inserted, the bases were then epoxied into place. They were epoxied in order to keep a tight airlock seal to prevent any gases from escaping when the gun is fired. Figure 60 displays a photograph of some of the completed cartridge casings. Now that the wings were bent into place and the bases were epoxied, the cartridge casings were now completed and ready for cartridge assembly.

Figure 60: Recreated Schneeloch Triangular Cartridge Casings. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

7.2.4 Cartridge Loading Process

The cartridges needed to be assembled before any testing could be performed. When the bases were correctly placed and the epoxy had cured, modern day centerfire magnum primers (Winchester brand small pistol magnum primers) were then carefully pushed into the priming pockets of the bases. The cartridge is made up of the casing with primer, FFFF grain black powder, and a lubed bullet. Each of the nine cartridge cases were filled with 3 grains of FFFF black powder. When loading smokeless powder, it is common for a plastic funnel to be used along with a plastic measuring device. When using black powder, glass or metal is the material desired for the measuring cup and paper for the funnel. This is because plastic can cause a spark when the black powder rubs against it, which can cause ignition of the black powder. When using black powder it is necessary to fill any unused space within the cartridge casing. This is because any excess space can cause high pressures which in turn can cause the cylinder to explode. In this case, there was no excess space between the powder and base of the bullet; therefore there was no need for any type of wad such as cardboard or wax.

The bullet's heel dimensions were designed in order for the bullet to fit snug inside the casing. This means that the bullet was difficult to fit into the cartridge casing. Although it was difficult, it was desired to have that tight fit in order to allow gases to build up behind the bullet which would provide effective propulsion. Before the bullet could be pushed into the cartridge casing, it needed to be lubed. Lubrication is essential when using soft lead bullets as it reduces lead fowling in the barrel. The lube consisted of an eight to one ratio by weight of beeswax and beef tallow. This recipe was the same as that detailed in the US Army manual of 1861-1873 covering the year of the 1872 patent. A photograph of the beeswax and beef tallow used is located in Figure 61. The beeswax and tallow were carefully weighed on a scale and combined in a metal cup. They were heated and stirred until they were completely integrated and it was at a liquid state. With the assistance of a heat gun and paintbrush a thin layer of lube was applied over the outside of each bullet.

Figure 61: Beeswax and Beef Tallow Used for Bullet Lube. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Now that eight of the bullets were lubed, three grains of black powder was put into each of the cartridge casings and the bullet was then pushed into place. Once the black powder and bullets were assembled with the casing, the cartridges were now complete and ready for firing. Photographs of the completed and assembled cartridges are displayed in Figure 62. Note that one of the nine bullets in Figure 62 is shiny in comparison to the other eight. This is because that bullet was excluded from the lubing process, therefore it has a shiny metallic finish instead of the mate finish of the lubed bullets. Comparative photographs of the original Schneeloch cartridges and the recreated Schneeloch cartridges are displayed in Figure 63.

Figure 62: Recreated Schneeloch Triangular Cartridges. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Figure 63: Comparative View of Schneeloch Cartridges [13] (left) and Recreated Cartridges (right). Courtesy of A. Shukitis taken September 2013 in Tampa, FL

CHAPTER 8: BALLISTICS

8.1 Interior Ballistics

In order to fully understand Schneeloch's design, there must be some knowledge in ballistics. Ballistics is a form of science that evaluates the driving force, flight, and impact of projectiles. It can be broken down into three branches: interior, exterior, and terminal. Each of these three branches is extremely important for firearms and ammunition. This is because they are an essential part in determining the effectiveness of any complete firearm system.

Interior ballistics is the branch that deals with what happens within the firearm from the time the firing pin hits the primer up until the bullet exits the muzzle. This includes the combustion of the propellant, the pressure caused by the combustion, and the motion of the projectile within the bore [16]. Factors affecting the interior ballistics includes the cartridge case, the primer, type and quantity of propellant, material and weight of the bullet, any gaps between the barrel and cylinder, barrel length, and the twist rate. Each of these factors can alter the interior ballistics.

8.2 Exterior Ballistics

Exterior Ballistics is the branch that deals with the projectile during its flight. Specifically, it entails when the projectile leaves the muzzle up until it enters the media it is shot into. The interior ballistics of a bullet has an effect on the exterior ballistics. For example, the amount of gun powder used to propel the bullet will determine its velocity during flight. The velocity during flight will have an impact on the effectiveness of the bullet when it enters the media. In addition to the velocity, the twist rate is also important in exterior ballistics. This is because the spin of the bullet, along with the velocity, and shape, will allow it to cut through the air more easily and maintain stability (no tumbling). Being able to cut through the air, or being more aerodynamic, is important because it will result in a more accurate projectile. Therefore, it is desired for all the factors to correspond well with one another. In addition to these factors, there are also several outside elements, such as gravity and wind, which must also be taken into consideration during the flight. Therefore, when looking at the exterior ballistics on an outdoor range the weather conditions have to be considered as well.

8.2.1 Ballistics Coefficient

The ballistics coefficient is a calculated value that determines the bullet's ability to overcome air resistance during flight. As stated before, wind and gravity affect the performance of a bullet's exterior ballistics, but the bullet's weight, cross sectional area, and its shape can positively or negatively affect the outcome. The ballistics coefficient uses these measurements in order to predict its ability to overcome air resistance and be accurate. While these values are provided by the bullet's manufacturer, the Schneeloch triangular bullet's ballistic coefficient must be calculated. This will prove to be a difficult challenge given the uniquely shaped cross section.

8.2.2 Gyroscopic Stability

Gyroscopic stability is the calculated value that measures how stabilized a bullet is and whether or not it will tumble during flight. Theoretically, a value greater than one is considered ideal. However, since this is not a "perfect" world, it is generally accepted to have a value greater than 1.4. The gyroscopic stability utilizes several different factors in determining the value. These factors are muzzle velocity, bullet weight, twist rate, and different atmospheric conditions such as air pressure and density. The idea behind this calculation is that the greater the twist rate, the more stable the bullet becomes in flight. However, if the twist rate is too high the bullet will “strip” and not “hold” the rifling in the barrel. This results in a poor gas seal and reduced muzzle velocity. It would be desirable to determine the gyroscopic stability for the Schneeloch bullet but unfortunately its unusual shape introduces complexity into the equation which was developed for circular bullets, thereby making the solution difficult to calculate.

8.3 Terminal Ballistics

The final branch, terminal ballistics, considers what happens when the bullet enters the media it is shot into. The terminal ballistics are dependent upon the interior and exterior ballistics, along with the shape of the bullet. A faster velocity mixed with a sharper pointed bullet will increase the penetration into the media; while a different configuration at the tip of the bullet, such as a hollow point, will cause more damage to the media due to its expansion. Terminal ballistics is focused on the outcome of the projectile, which is typically the main focus of ballistics. Although it is typically the main focus, if the other two branches are not taken into consideration then the outcome is useless because the interior and exterior outcomes will affect results of the terminal ballistics.

8.3.1 Sectional Density

Sectional Density is an important term when looking at terminal ballistics. It is the ratio of the bullets weight and its cross sectional area. It is a calculated value found using a simple equation of weight, in pounds, divided by the cross sectional area, in squared inches. This value represents the ability for a specific bullet to penetrate into a given media. Unlike the ballistics coefficient, sectional density is a term that is completely independent from the bullet’s shape because it only utilizes the weight and diameter measurements. The sectional density calculations of the Schneeloch triangular bullets will be performed in order to estimate the possibly penetration effectiveness.

8.3.2 Ballistics Gelatin Options

One of the most important tools used in experimental terminal ballistics is Ballistics Gelatin (gel) this media is used as a target and provides a means of simulating a bullet fired into a living body (human or animal). The gelatin has the consistency of flesh, but is transparent. Ballistics Gelatin therefore provides observational data relating to penetration depth, expansion, fragmentation, wound path, and tissue damage, etc. When determining what type of ballistics gel to use, this type of shooting media needed to be researched. There are several different types of ballistics gel, these types are: Vyse ordnance gelatin, Clear Ballistics gelatin, Perma-gel, Bullet test tube, and Knox unflavored gelatin.

In order to determine which shooting media is the best choice for testing the Schneeloch triangular revolver, details of the material, along with their accuracy compared to human tissue, needed to be known. Vyse ordnance gelatin is the ballistics gel utilized by the FBI when they perform ballistics testing. This gelatin is mixed using a standard ten percent powder with ninety percent water. Vyse ordnance gelatin is an organic product that must be mixed and formed at specific temperatures. After the mixing process and the gelatin has cured, the testing must be performed in a controlled area within only twenty minutes of being removed from the refrigerator. Given the length of the testing and that the area will be outside in the summer Florida weather, FBI ordnance gelatin may prove to be difficult.

Clear Ballistics gelatin is a 100 percent clear synthetic gelatin. It can be used as a complete replacement of the traditional organic ballistics gelatin. It has also been used in many medical testing due to its likeness to human tissue. Unlike the organic gelatin, the Clear Ballistics gelatin can be reused if correctly calibrated. Clear Ballistics sells their own version of the FBI standard blocks, which are the exact same dimensions as the FBI gelatin blocks. In addition to being the correct size, their FBI blocks are shipped calibrated. Clear Ballistics uses the same calibration testing as the FBI and base the performance on the same measurements. Therefore, it will perform exactly like that of the FBI ordnance gelatin. Along with having the same performance in ballistics testing, the Clear Ballistics gelatin is stable up to 130 degrees Fahrenheit. Because of the high temperature stability, this gelatin would be able to be used for a long period of time in the Florida weather.

Similar to the Clear Ballistics, Perma-gel is also a synthetic ballistics gelatin. Perma-gel is a transparent gelatin. This synthetic gelatin is also a substitute for the organic gelatin but proves to be only similar and not an identical match to human soft tissue. Perma-gel is also a reusable gelatin product that can be stored at room temperature. Because both of the synthetic gelatins are reusable, they are both more cost effective than the organic Vyse ordnance gelatin. On top of being more cost effective, the ballistics testing would be easier to perform in the Florida heat because the storage temperature of the synthetic Perma-gel is much higher than that of the organic gelatin. The main problem with choosing this form of synthetic gelatin is the slight difference in performance from human soft tissue, while Vyse ordnance gelatin is a suitable match.

If cost was the main concern for which ballistics media to choose there are two options that are slightly more economical. The first option is the bullet test tube. It is a newer form of ballistics media made from wax. The main concern with this is that it is not transparent and would need to be cut in order to be studied. If the shot isn't perfectly straight and the cut is in the wrong place, then accurate measurements cannot be made. The other economical option is a common homemade gelatin. This gelatin is Knox unflavored gelatin, which would most commonly be used in the kitchen. This is also an organic product and would behave similarly to the other ballistics gelatin but not exactly the same behavior. In order to form this gelatin into a block, a mixture of Knox gelatin powder and water would be mixed together and it would eventually solidify into a gelatin block. Because the cost difference is not substantial, the Knox unflavored gelatin would be the last choice for the ballistics testing of the Schneeloch triangular revolver.

CHAPTER 9: EXPERIMENTAL TESTING PROGRAM

9.1 Apparatus

In order to perform ballistics testing on a gun and its ammunition, specific materials are necessary. These materials include the shooting rest, ballistics gelatin, and different types of measuring devices. Before any testing can be completed, all these materials need to be collected and adjusted to be ready for the performance analysis.

9.1.1 Ballistics Gelatin

The ballistics media chosen was the Clear Ballistics Gelatin. This is because it performs exactly like the FBI ordnance gelatin, without all the temperature issues. In addition to avoiding temperature problems with the Clear Ballistics gelatin, it is also shipped calibrated and the correct size.

9.1.2 Chronograph

Bullet velocity is another important ballistics measurement. A ballistics chronograph is the device used for measuring the velocity of a bullet. This device utilizes two optical t sensors. These sensors are located in the front and in the back of the chronograph. When the bullet passes above the first sensor it starts the clock, and as it passes above the second sensor the clock is stopped. The chronograph then calculates the velocity using the distance between sensors and the time it took to travel from one to the other. The chronograph used for testing was a ProChrono™ Digital Chronograph, displayed in Figure 64.

Figure 64: ProChrono™ Digital Chronograph. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

9.1.3 Paper Targets

In order to determine the accuracy and precision of the Schneeloch triangular bullets, paper targets were necessary for the testing program. The targets used were Champion® VisiShot™ paper targets, shown in Figure 65. These targets have an eight inch black circle that inludes five concentric circles outlined in orange. These targets were chosen primarily because of the easy shot placement detection. When these targets are shot, the black coating flakes off at the location of the bullet entry, meaning, the shot placement is easily seen from a distance away.

Figure 65: Champion® VisiShot™ Paper Target. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

9.2 Procedures

In order for the testing to be done quickly and successfully with no error, a specific procedure was devised. Everything was planned out before it was performed in order to prevent any possible mistakes. The steps involved include forming of the ballistics gelatin, determining the placement of the muzzle, gelatin, chronograph, and paper targets, and determining what tests will actually be performed.

9.2.1 Range

The range used for the testing process is located in Zephyrhills, Florida. It is an open field surrounded by foliage. Although it was surrounded by foliage, there was backstop located behind the ballistics gelatin and paper target. This backstop is made of sandbags and railway ties, and would stop the bullet from projecting further into the field past the range area. The range location needed to be outside due to the chronograph. The ProChono™ Digital chronograph needs sunlight for the photo sensors to correctly "see" the bullet. Using the chronograph indoors may cause problems reading the bullet velocity due to either not enough light or the wrong type of light. This is the main reason why the testing process was performed outside.

The placement of the measuring devices, ballistics gelatin, target, and the barrel was a key factor in the testing process. The Ransom™ shooting rest was bolted to a wooden table. The machined aluminum piece that is attached to the barrel, cylinder, and firing mechanism had already been slid into place between the grip inserts of the Ransom rest. Once it was bolted into place, the ballistics gelatin was placed in a position in which the front face was located ten feet away from the muzzle. It was located in the line of fire, and some adjustments were made to the Ransom rest in order to correctly aim the barrel using a laser. Finally, the paper target was held in place with a wooden frame which was attached to a stand. It was located in the same position as the face of the ballistics gelatin. The frame was easily removable from the stand, which meant that it could be removed from its position when it was time to use the gelatin block.

Once the barrel and ballistics gelatin are appropriately placed, the measuring devices were then put into position. The center of the chronograph was located five feet from the muzzle and five feet from the face of the gelatin. This distance was chosen because according to the ProChrono™ Digital operating instructions, the chronograph must be placed five to ten feet away from the muzzle, specifically for pistols, to avoid the muzzle blast falsely triggering the photo sensors. The chronograph was used for each of the rounds fired. The range, along with the apparatus placement, is displayed in Figure 66.

Figure 66: Outside Range with the Correctly Located Apparatus. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

9.2.2 FBI Standard Ballistics Testing

Although there is no common ballistics testing protocol, the FBI has developed their own ballistics testing methods. The FBI's standard ballistics testing protocol is made up of eight different tests. Each of these tests utilizes a new block of Vyse ordnance gelatin. The block used must have the dimensions of 6x6x16 inches, with one of the square sides as the front face.

The first six tests performed are shot at a distance of ten feet from the front face of the gelatin. Test one consists of shooting a bare block of gelatin. Test two consists of shooting a block that is covered with four layers of different clothing materials. The four materials are cotton t-shirt material, cotton dress shirt material, down comforter with a cambric shell, and denim. Test three through six are all shot into a gelatin block that is covered in a layer of cotton t-shirt material and a layer of cotton dress shirt material. Test three has two pieces of 20 gauge hot rolled, galvanized steel placed between the gelatin block target and the gun. The steel is set three inches apart from one another and the rear piece of steel is located 18 inches from the front face of the clothing covered block of gelatin. Test four has two pieces of wallboard that is ½ inch thick placed in front of the gelatin block. These wallboards are set 3.5 inches apart from one another and the rear board is placed 18 inches from the clothing covered gelatin. Test five has one piece of plywood that is ¾ inch thick located 18 inches from the front face of the clothing covered gelatin block. Test six has one piece laminated automobile safety glass that is ¼ inch thick located 18 inches in front of the clothing covered gelatin block. The glass is also set at an angle of 45 degrees from the horizontal and 15 degrees to the side. Test seven has the same four layers of clothing as test two but is shot from a distance of twenty yards. Test eight has the same automobile glass set up as test six with the same distance and angle from the gel but is shot at a distance of twenty yards.

The FBI uses this eight step ballistics testing in order to assess the performance of specific guns or ammunition that they use. Obviously they want to have a weapon that will successfully protect them in whatever situation necessary. In order for ammunition to pass the FBI testing, it must penetrate the ordnance gelatin at least twelve inches.

9.2.3 Testing

When determining what tests to implement in assessing the performance of the Schneeloch triangular barrel and bullets, the FBI standard testing was taken into consideration. Originally, each of the FBI standard tests was going to be performed. Then the reality of the eight tests became clear. Those tests are all designed for strong self-defense ammunition that is made to penetrate through all the different layers. When Schneeloch created his triangular revolver and bullets, he did not intend to be shooting through steel, walls, glass or thick clothing. Yes, it was meant to be a self-defense weapon that could easily be carried; it was never intended to be as powerful as the FBI ammunition of today. The ammunition during the time of Schneeloch's patent was not even as powerful as the FBI ammunition of today either. Therefore, Schneeloch's ammunition should not be expected to be that strong. Because of this, the testing performed was simplified.

The main focus of the ballistics testing was to determine the velocity of the bullets, accuracy, precision, and penetration depth. The ballistics gelatin will be bare, with no layers of clothing covering it. It will also be located ten feet away from the muzzle. Unlike the FBI testing, only one Schneeloch bullet will be shot into the gelatin. The reasoning behind this is because there is a limited number of bullets and there only needs to be one bullet to provide penetration depth. There will be five rounds of the Schneeloch triangular bullets fired, one will be shot into the gelatin while the others into the target. The chronograph will be set up between the muzzle and target for each shot fired in order to get velocity recordings for each one. With this testing method, the performance should be assessed easily in order to determine whether or not triangular bullets are a viable projectile option.

9.2.4 Safety Procedures

During the testing process, a few safety procedures were strictly followed in order to prevent any possible injuries. When the recreated Schneeloch triangular bullets were fired, eye and ear protection were worn at all times. In addition to the safety gear, the bullets were fired from a distance of about ten yards. This was accomplished by tying a long string to the hitch pin. Therefore, the long string was simply pulled to fire the bullets. When the string was pulled, it caused the hitch pin to be removed from the firing mechanism, which allowed the spring to expand from its current compressive state forcing the firing pin into the primer which caused the ignition.

CHAPTER 10: RESULTS

10.1 Calculations

As mentioned in chapter 8, there are two parameters that can be calculated in order to provide important ballistics information. These values are the sectional density and the ballistics coefficient of the projectile.

10.1.1 Sectional Density

Sectional density is a calculation that is independent of the bullet's shape. It is the weight of the bullet divided by the cross sectional area. The cross sectional shape, triangle with outward curved sides, which was created in SolidWorks™ easily provides the cross sectional area of the Schneeloch bullets. The cross sectional area is 0.0565 square inches. Using the SolidWorks™ and the model of the bullet made of pure lead, the weight is calculated to be 0.0081 pounds. The conversion between pounds and grains is one pound equals 7000 grains. Using this conversion, 0.0081 pounds is equivalent to 56.7 grains. This weight is closely related to the weight of 57 grains provided by Alvin Olsen. Given that sectional density has a unit of pounds per square inch, the weight of the bullet in pounds will be divided by the cross sectional area in square inches. Therefore, 0.0081 pounds divided by 0.0565 square inches will provide the sectional density.

Table 1: Sectional Density of the Schneeloch Triangular Bullet

Sectional Density of the Schneeloch Triangular Bullet
0.1434 lb/in^2

Unfortunately, this sectional density value is relatively low. There is a scale that can be used in order to determine how effective a given sectional density is. The lower end of this scale shows that a value of 0.180 is useful for small animals, while a range of 0.200 to 0.230 is better for medium sized animals [17]. The calculated sectional density for the Schneeloch triangular bullets does not even reach the value necessary for smaller animals. This result was expected since defense ammunition of the late 1800s used relatively small charges of black powder and are considered “puny” by today’s standards.

10.1.2 Ballistics Coefficient

In order to determine the ballistics coefficient, the sectional density is one of the values used in the calculation. The ballistics coefficient is found by dividing the sectional density by a form factor. Although the sectional density was easily calculated, the form factor was difficult to determine. The form factor is a ratio between the drag coefficient of the bullet in question and drag coefficient of the standard “G1” model bullet. Because of the unique cross sectional shape of the Schneeloch bullets, the form factor proved too difficult to find. Therefore, the ballistics coefficient was not calculated for the Schneeloch triangular bullets.

10.2 Geographic and Atmospheric Conditions

The experimental testing was performed on November 25, 2013 in Zephyrhills, Florida. Testing was performed under the following conditions displayed in Table 2.

Table 2: Testing Day Atmospheric Conditions

Ambient Temperature	72 °F
Relative Humidity	53%
Wind	18 mph SE
Barometric Pressure	30.2 inHg

Testing was performed mid-day and there was a slight overcast, providing adequate diffused light. This diffused light created ideal conditions for the use of the chronograph. The18 mph wind was coming from the southeast. The weather conditions were not typical for Florida but were suitable for the testing to be performed because it created more realistic conditions for other regions. A photograph of the shooting range set up is displayed in Figure 67. Before the Schneeloch triangular bullets could be tested, some data needed to be acquired for the 22 short caliber bullets. These bullets were the caliber Schneeloch was trying to outperform by creating larger heavier bullets, which the same amount could be packed into the same sized cylinder.

Figure 67: Shooting Range Set Up. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

10.3 Measurements

10.3.1 Bullet Velocity and Muzzle Energy

Using the same shooting range set up as stated previously for the Schneeloch Triangular bullets testing, five .22 short caliber bullets were shot. The velocities of each of the five bullets were found using the chronograph and recorded in order to compare with the Schneeloch bullets. After shooting and recording the .22 short caliber bullets, five Schneeloch bullets were then fired. Of the five Schneeloch bullets fired, four of them were shot into a paper target and one was shot into ballistics gelatin. Once the velocities were recorded, these values along with the mass of the bullets were used to calculate the muzzle energy. The muzzle energy is an important calculation because the bullets muzzle energy is transferred to the media it is shot into and this is what causes most damage. The muzzle energy is simply calculated using the equation for kinetic energy, $E = \frac{1}{2}mv^2$. The mass, velocity, and muzzle energy of the ten bullets are displayed in table 3.

Table 3: .22 Short and Schneeloch Triangular Ammunition Testing Results

.22 Short					
Bullet Number	1	2	3	4	5
Mass (grains)	30	30	30	30	30
Velocity (ft/s)	739	774	744	754	819
Energy (ft-lbf)	36.39	39.92	36.88	37.88	44.69
Schneeloch Triangular Bullets					
Bullet Number	1	2	3	4	5
Mass (grains)	54.0	52.3	54.9	53.8	54.25
Velocity (ft/s)	514	505	502	461	533
Energy (ft-lbf)	31.69	29.62	30.73	25.39	34.23

According to the recorded velocities of the .22 short caliber and the Schneeloch triangular bullets in Table 1, it appears as though the Schneeloch bullets traveled about 200 feet per second slower than that of the .22 short caliber bullets, although their energy calculations were not significantly lower. This difference in muzzle energy is attributed to the difference in weight and velocity. Because the Schneeloch triangular bullets weigh almost twice of.22short bullets and yet their velocities were significantly less, the Schneeloch bullets had a muzzle velocity only slightly less than the .22 short. In order to be more precise on the differences in velocity, specific statistical data needed to be calculated. The significant velocity difference can be attributed to the triangular shape, mainly because the triangular shaped cartridge casings. The triangular casings would not be able to expand as uniformly as a circular case, therefore causing possible gas leakage. Gas leakage would prevent the correct energy build up behind the bullet, causing the bullet to propel at a slower speed. The high, low and average velocities along with the standard deviation of the data are displayed in Table 4.

Table 4: Statistical Values for the Ammunition Testing Velocities

Type of Statistic / Type of Ammunition	High	Low	Average	Standard Deviation
.22 Short	819 fps	739 fps	766 fps	32
Schneeloch Triangular	533 fps	461 fps	503 fps	26

The statistical data displayed in Table 3 provides important information about the performance of the Schneeloch bullets compared to the .22 short caliber bullets. According to the high and low velocities, the .22 short caliber bullets had an extreme spread of 80 fps, while the Schneeloch bullets had an extreme spread of 72 fps. This simply means that the highest and lowest recorded velocities of the .22 short caliber bullets had a slightly greater difference than that of the Schneeloch bullets. The average velocities show that the .22 short caliber bullets had a velocity greater than that of the Schneeloch bullets by over 250 fps. When looking at ballistics, speed of travel is extremely important, along with the mass, because it can affect the performance, such as its penetration depth accuracy, and muzzle energy. The Schneeloch bullets also had a standard deviation of 26 compared to the 32 that the .22 short had. This has a similar meaning to that of the extreme spread in that the lower value of standard deviation confirms that the velocities are closer in value. This data proves that the velocities of each of the Schneeloch bullets stayed more consistent with one another than the .22 short bullets.

10.3.2 Penetration Depth

The third Schneeloch bullet shot was fired into the ballistics gelatin. The bullet entered relatively near the center of the front face of the gelatin. It appears to have travelled moderately straight with respect to the sides of the gelatin and it had a slight downward curve through it. It penetrated about 5.5 inches into the ballistics gelatin and stayed intact with no sign of fragmentation. Penetration of 5.5 inches is about two to three inches less than what would be expected of ammunition of similar weight used today. The one unique feature of the bullet's track is the spiraled triangular cut through the gel. When looking at the bullet's track, it I obvious that it was still spinning as it traveled. The three corners of the triangular cross section caused the twisted cut to be seen from when the bullet traveled through the gelatin. This indicates that the bullet continued to spin as it exited the muzzle and did not tumble through the air. Photographs of the ballistics gelatin from different angles are displayed in Figure 68.

Figure 68: Ballistics Gelatin with Schneeloch Bullet. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

10.3.3 Accuracy and Precision

The recreated Schneeloch triangular barrel was not created with any type of sights in order to easily aim. Therefore, accuracy is a measurement that is difficult to determine. It was aimed at the target by looking through the cylinder and barrel to see if it lined up with the center of the target. In addition to aiming the gun by sight, a laser was also shinned through the cylinder and barrel in order to verify if it was correctly lined up with the center of the target. None of the Schneeloch bullets fired actually hit the center of the target, but they all hit the target in the same region as one another which was relatively close to the center. This would imply that the gun is relatively accurate and precise. The four bullets that were shot through the target were all contained within a circle of 1.67 inch diameter. The two bullets that hit the target furthest away from one another only had a distance of about an inch and a half. This proves that the Schneeloch triangular gun is very precise and is more reliable when shot than what was to be expected. Photographs of the target after each bullet was fired are located in Figure 69.

Figure 69: Target Throughout Testing Process (left), Zoomed in View of Four Triangular Bullet Holes Circumscribed Within a Circle. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

CHAPTER 11: CONCLUSION

Although the calculations indicated that the Schneeloch triangular bullets would perform extremely poorly, the testing results provide a very different outcome. The unusual triangular shape of the bullets suggests that it may tumble through the air. The target that was shot four times during testing displayed that the bullets were all precise and accurate when being compared to one another. In addition to being relatively accurate, the punched holes in the target had the triangular shape of the cross section, implying that they did not tumble. Along with the target markings, one of the bullets was also found imbedded in the wooden back stop. This bullet made a perfectly triangular-shaped hole, which again implies that the bullet traveled straight with no tumbling. A photograph of the triangular cut out in the wooden back stop is displayed in Figure 70.

Figure 70: Triangular Hole from Recreated Schneeloch Bullet in the Wooden Back Stop. Courtesy of A. Shukitis taken November 2013 in Zephyrhills, FL

Otto Schneeloch created the triangular revolver in attempt to create a bullet that has a larger weight closer to that of the .32 caliber bullets, while having a larger packing density in the chamber like that of the .22 caliber guns of the time. He created a triangular bullet that had a weight of 56 grains, which was heavier than the .22 caliber bullets but lighter than the .32 caliber bullets. He managed to fit seven triangular bullets in the same sized chamber as the .22 caliber guns, which also had a seven bullet capacity, while the .32 caliber bullets could only fit five in a comparable sized chamber. Visually, the Schneeloch bullets look to be as large as the .32 caliber bullets. It also appears to be more intimidating than that of the .22 caliber bullets. This visual can be displayed in Figure 71.

Figure 71: Visual Comparison of .22 Caliber, Schneeloch Triangular, and .32 Caliber Bullets. Courtesy of A. Shukitis taken September 2013 in Tampa, FL

Unfortunately, the Schneeloch triangular bullets did not travel as fast as the .22 short cartridges that were shot during testing to compare velocities. The .22 short cartridges were modern day cartridges with smokeless powder, which most likely traveled faster than the old.22 short RF cartridge of the late 1800's. Even though the Schneeloch triangular bullet was a slower projectile, it penetrated about 5.5 inches into the ballistics gelatin. This penetration proves that the Schneeloch triangular bullets could penetrate adequately to stop an assailant. This means that it could have been used for self-defense purposes during its era like Otto Schneeloch had planned.

CHAPTER 12: RECOMMENDATIONS FOR FURTHER EXPERIMENTATION

While the measurements taken throughout the testing process are important in determining the performance of the bullet, there is another measuring device that is not necessary but if accessible, can provide information about the bullet during its travel. This device is a high speed camera; all it does is takes pictures at extremely high speeds. These pictures give a frame by frame depiction of how the bullet traveled. If the camera is located near the muzzle, it shows if the bullet exited the muzzle with a constant rotation or if it tumbled as it entered the air. This location also provides information about whether the gases behind the bullet leaked out before the bullet exited the muzzle or if there was a tight seal. Another location that is ideal to have different frames taken would be near the ballistics gelatin. This is because although it may have initially traveled aerodynamically when exiting the muzzle, it may have slowed down and began to tumble, traveling inconsistently as it nears the target. This device would provide more information about the bullet's performance. This is why only five of the nine bullets were shot during testing; the other four were saved to be used for further research with high speed photography.

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APPENDICES

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