Second Edition

Handbook of

FIREARMS AND BALLISTICS

Examining and Interpreting Forensic Evidence

Brian Heard

Developments in Forensic Science

WILEY

The Forensic Science Society

Handbook of Firearms and Ballistics

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Developments in Forensic Science

The world of forensic science is changing at a very fast pace. This is in terms of the provision of forensic science services, the development of technologies and knowledge and the interpretation of analytical and other data as it is applied within forensic practice. Practicing forensic scientists are constantly striving to deliver the very best for the judicial process and as such need a reliable and robust knowledge base within their diverse disciplines. It is hoped that this book series will be a valuable resource for forensic science practitioners in the pursuit of such knowledge.

The Forensic Science Society is the professional body for forensic practitioners in the United Kingdom. The Society was founded in 1959 and gained professional body status in 2006. The Society is committed to the development of the forensic sciences in all of its many facets and in particular to the delivery of highly professional and worthwhile publications within these disciplines through ventures such as this book series.

Dr. Niamh Nic Daéid
Series editor.

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In writing the second edition of this book I have been assisted by more people than I could begin to recount. Of these, a few deserve special mention.

Quenten Ford not only for his invaluable help in formulating the outline of the original book, but also for his assistance in correcting the many typos that crept in.

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And last, but not least Barbara, Edward and Emily, my wife and children, for all their support and understanding without which I could never have written this book.

Foreword

> Medico-legal analysis forms, perhaps beyond all other branches, the most important work undertaken by the Analyst . . . its responsibility and importance lies in the fact that, as the term itself suggests, questions of health, or even of life or death are involved, and secondly, that the work performed will usually result in an action at law, either civil or criminal . . . For these reasons the work demands the greatest skill and experience that can be brought to bear upon it the best instrumental equipment that can be procured, the utmost patience, the most rigidly exact work, and, lastly, a sufficiency of time. . . .

Stirring and eminently appropriate sentiments which would do justice to any modern forensic laboratory administrator. The fact that these words were spoken by E.R. Dovey, Government Analyst of Hong Kong, in an address in 1917, is both a remarkable testament to that scientist and a realization that even 80 years ago, the profession he represented fully appreciated the vital role that forensic science can play in the justice system.

Incredible advances have been made in the sciences over the last few decades, and modern forensic laboratories are now staffed by teams of specialists, all experts in their own particular fields. The days are past when a forensic scientist appeared in the witness box one day as an expert in blood grouping, the next as a questioned document examiner and a third day as a suspicious fire investigator. Such 'generalists' do still present themselves from time to time, but informed courts now afford them a level of credence bordering on ridicule, and rightly so!

Increasing specialization and sophistication of scientific method has, however, widened the gulf of knowledge between the scientist, the lawyer and the jury. With a poor level of scientific literacy in the population at large, frequent criticism of the capacity of scientists to express themselves intelligibly to a lay audience, and a predominance of barristers who are unable or unwilling to help bridge the comprehension gap, that gulf is in danger of widening further.

The Select Committee on Science and Technology (House of Lords 5th Report 1992/3) has constructively, and to some, controversially, pointed the way forward with recommendations for pre-trial conferences between counsel and own experts as a norm rather than an occasion; pre-trial review between experts of both sides to define disagreements; encouragement for concluding statements by experts before leaving the witness box; increasing use of visual aids; and finally, for forensic science to feature more prominently in a lawyer's training.

To satisfy the last recommendation, however, there is a need for instructional and informational textbooks on the specialist areas of the forensic sciences written with the practising criminal lawyer in mind, which bridge the gap between the handbooks for the expert and a 'good read' for the lay reader of scientific bent. It is to be hoped that this book fills that purpose in the ballistics field.

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Government Chemist, Hong Kong, (retired)

1
Firearms

1.1 A Brief History of Firearms

1.1.1 Early hand cannons

The earliest type of handgun was simply a small cannon of wrought iron or bronze, fitted to a frame or stock with metal bands or leather thongs. These weapons were loaded from the muzzle end of the barrel with powder, wad and ball. A small hole at the breech end of the barrel, the *touch hole*, was provided with a pan into which *a priming charge* of powder was placed. On igniting this priming charge, either with a hot iron or lighted match, fire flashed through the touch hole and into the main powder charge to discharge the weapon.

These early weapons could have been little more than psychological deterrents being clumsy, slow to fire and difficult to aim. In addition, rain or damp weather had an adverse effect on the priming charge making it impossible to ignite.

Their first reported use is difficult to ascertain with any degree of certainty, but a number of instances are reported in Spain between 1247 and 1311. In the records for the Belgian city of Ghent, there are confirmed sightings of the use of hand cannons in Germany in 1313. One of the earliest illustrations concerning the use of hand cannons appears in the fifteenth century fresco in the Palazzo Publico, Sienna, Italy.

The first recorded use of the hand cannon as a cavalry weapon appeared in 1449 in the manuscripts of Marianus Jacobus. This shows a mounted soldier with such a weapon resting on a fork attached to the pommel of the saddle. It is interesting to note that the use of the saddle pommel to either carry or aim

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Figure 1.1 Early hand cannon.

the hand guns could be the origin of the word ‘pistol’, the early cavalry word for the pommel of the saddle being ‘pistallo’.

Combinations of the battle axe and hand cannon were used in the sixteenth century, and a number of these can be found in the Tower of London. One English development of this consisted of a large mace, the head of which had a number of separate barrels. At the rear of the barrels, a concealed chamber containing priming powder led to all the barrels. When the priming compound was ignited, all the barrels discharged at once.

1.1.2 The matchlock

This was really the first major advance in pistols as it enabled the weapon to be fired in one hand and also gave some opportunity to aim it as well.

The construction of the matchlock was exactly the same as the hand cannon in that it was muzzle loaded and had a touch hole covered with a priming charge. The only difference was that the *match*, a slow-burning piece of cord used to ignite the priming charge, was held in a curved hook screwed to the side of the frame. To fire the gun, the hook was merely pushed forward to drop

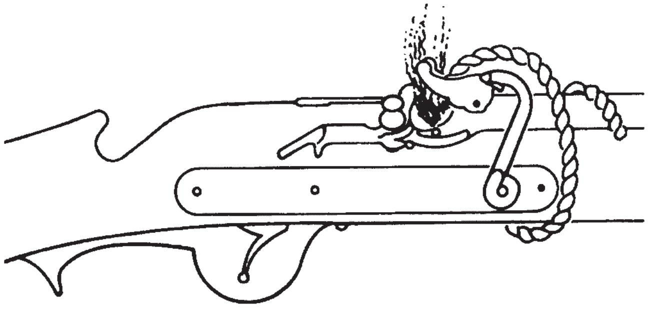

Figure 1.2 Matchlock (by courtesy of the Association of Firearms and Toolmark Examiners).

the burning end of the match into the priming charge. As these weapons became more sophisticated, the curved hook was embellished and took on the form of a snake and became known as the weapon's *serpentine*.

Eventually, the tail of the serpentine was lengthened and became the forerunner of the modern trigger. Further refinements included the use of a spring to hold the head back into a safety position. The final refinement consisted of a system whereby when the tail of the serpentine was pulled, the match rapidly fell into the priming compound under spring pressure. This refinement, a true trigger mechanism, provided better ignition and assisted aiming considerably (Figure 1.2).

It was during the era of the matchlock that reliable English records appeared, and it is recorded that Henry VIII, who reigned from 1509 until 1547, armed many of his cavalry with matchlocks. The first true revolving weapon is also attributed to the period of Henry VIII and is on show in the Tower of London. This weapon consists of a single barrel and four revolving chambers. Each chamber is provided with its own touch hole and priming chamber which has a sliding cover. Although the actual lock is missing from the Tower of London weapon, its construction strongly suggests a single matchlock was used.

The major defect with the matchlock design was that it required a slow-burning 'match' for ignition. As a result, it was of little use for surprise attack or in damp or rainy conditions.

1.1.3 The wheel lock

With the advent of the wheel lock the lighted match used in the matchlock was no longer necessary. This important innovation in the field of firearms design made ambush possible as well as making the firearm a practical weapon for hunting.

When fired from the shoulder, the wheel lock was often referred to as an *arquebus* from the shape of the butt which was often curved to fit the shoulder.

Another name, strictly only for much heavier calibre weapons, was the *hacquebut*, which literally means 'gun with a hook'. This referred to a hook projecting from the bottom of the barrel. This hook was placed over a wall, or some other object, to help take up the recoil of firing.

In its simplest form, the wheel lock consisted of a serrated steel wheel, mounted on the side of the weapon at the rear of the barrel. The wheel was spring-loaded via a chain round its axle with a small key or spanner similar to a watch drum (Figure 1.3). When the wheel was turned with a spanner, the chain wound round the axle and the spring was tensioned. A simple bar inside the lockwork kept the wheel from unwinding until released with the trigger. Part of the wheel protruded into a small pan, the *flash pan or priming pan*, which contained the priming charge for the touch hole. The serpentine, instead of containing a slow-burning match, had a piece of iron pyrite fixed in its jaws. This was kept in tight contact with the serrated wheel by means of a strong spring. On pressing the trigger, the bar was withdrawn from the grooved wheel which then turned on its axle. Sparks produced from the friction of the pyrite on the serrated wheel ignited the priming charge which in turn ignited the main powder charge and fired the weapon.

The wheel lock was a tremendous advance over the slow and cumbersome matchlock. It could be carried ready to fire and with a small cover over the flash pan, it was relatively impervious to all but the heaviest rain. The mechanism was, however, complicated and expensive, and if the spanner to tension the spring was lost, the gun was useless.

There is some dispute as to who originally invented the wheel lock, but it has been ascribed to Johann Kiefuss of Nuremberg, Germany in 1517.

Whilst the wheel lock reached an advanced stage of development in Germany, France, Belgium and Italy towards the close of the sixteenth century, England showed little interest in this type of weapon.

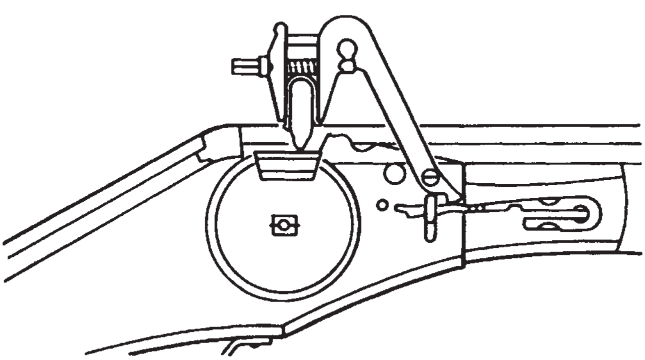

Figure 1.3 Wheel lock (by courtesy of the Association of Firearms and Toolmark Examiners).

Records show that the wheel lock was still being widely manufactured in Europe as late as 1640, but by the turn of the century, it was making way for its successor.

1.1.4 The snaphaunce

The snaphaunce first appeared around 1570, and was really an early form of the flintlock. This mechanism worked by attaching the flint to a spring-loaded arm. When the trigger is pressed, the cover slides off the flash pan, then the arm snaps forward striking the flint against a metal plate over the flash pan producing sparks to ignite the powder.

Whilst this mechanism was much simpler and less expensive than the wheel lock, the German gunsmiths, who tended to ignore the technical advances of other nationalities, continued to produce and improve upon the wheel lock up until the early eighteenth century.

1.1.5 The flintlock

The ignition system which superseded that of the wheel lock was a simple mechanism which provided a spark by striking a piece of flint against a steel plate. The flint was held in the jaws of a small vice on a pivoted arm, called the *cock*. This was where the term to 'cock the hammer' originated.

The steel, which was called the frizzen, was placed on another pivoting arm opposite the cock, and the pan containing the priming compound was placed directly below the frizzen. When the trigger was pulled, a strong spring swung the cock in an arc so that the flint struck the steel a glancing blow. The glancing blow produced a shower of sparks which dropped into the priming pan igniting the priming powder. The flash produced by the ignited priming powder travelled through the touch hole, thus igniting the main charge and discharging the weapon.

The flintlock represented a great advance in weapon design. It was cheap, reliable and not overly susceptible to damp or rainy conditions. Unlike the complicated and expensive wheel lock, this was a weapon which could be issued in large numbers to foot soldiers and cavalry alike.

As is the case with most weapon systems, it is very difficult to pinpoint an exact date for the introduction of the flintlock ignition system. There are indications of it being used in the middle of the sixteenth century, although its first wide use cannot be established with acceptable proof until the beginning of the seventeenth century (Figure 1.4).

Three basic types of flintlock were made:

- *Snaphaunce* – a weapon with the mainspring inside the lock plate and a priming pan cover which had to be manually pushed back before firing.

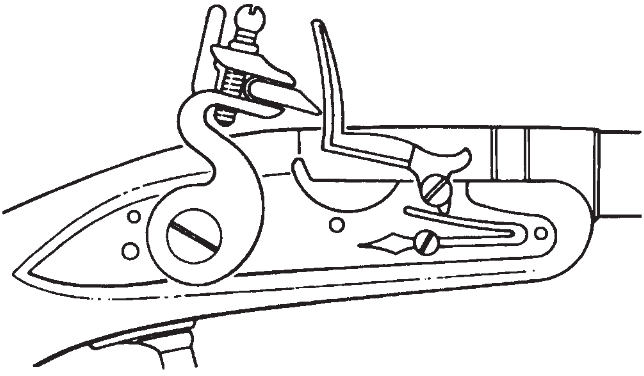

Figure 1.4 Flintlock (by courtesy of the Association of Firearms and Toolmark Examiners).

- *Miquelet* – a weapon with the mainspring outside the lockplate, but with a frizzen and priming pan cover all in one piece. In this lock type, the pan cover was automatically pushed out of the way as the flint struck the frizzen.
- *True flintlock* – a weapon with a mainspring inside the lock plate and with the frizzen and priming pan cover in one piece. This also had a half-cock safety position enabling the weapon to be carried safely with the barrel loaded and the priming pan primed with powder. This system was probably invented by Mann Le Bourgeoys, a gunmaker for Louis XIII of France, in about 1615.

Flintlock pistols, muskets (long-barrelled weapons with a smooth bore) and shotguns were produced with the flintlock mechanism. There was even a patent for flintlock revolvers issued in 1661.

1.1.6 The percussion system

The flintlock continued to be used for almost 200 years and it was not until 1807 that a Scottish minister, Alexander John Forsyth, revolutionized the ignition of gunpowder by using a highly sensitive compound which exploded on being struck. This compound, *mercury fulminate*, when struck by a hammer, produced a flash strong enough to ignite the main charge of powder in the barrel. A separate priming powder and sparking system was now no longer required (Figure 1.5). With this invention, the basis for the self-contained cartridge was laid and a whole new field of possibilities was opened up.

Once this type of ignition, known as *percussion priming*, had been invented, it still took some time to perfect ways of applying it. From 1807 until 1814, a wide range of systems were invented for the application of the percussion

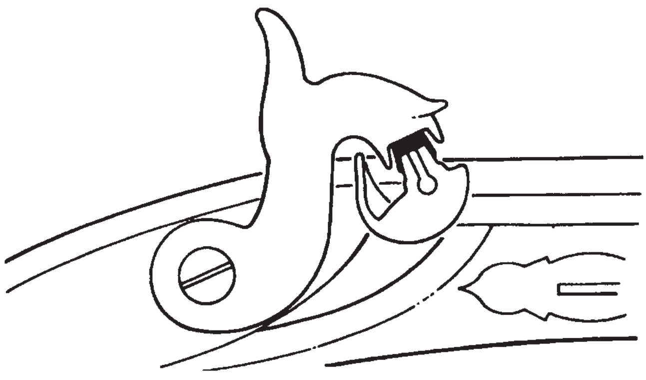

Figure 1.5 Percussion cap system (by courtesy of the Association of Firearms and Toolmark Examiners).

priming system including the Forsyth scent bottle, pill locks, tube locks and the Pauly paper cap.

The final form, the percussion cup, was claimed by a large number of inventors. It is probably attributable to Joshua Shaw, an Anglo-American living in Philadelphia in 1814. Shaw employed a small iron cup into which was placed a small quantity of mercury fulminate. This was placed over a small tube, called *a nipple*, projecting from the rear of the barrel. The hammer striking the mercury fulminate in the cup caused it to detonate and so send a flame down the nipple tube igniting the main charge in the barrel.

1.1.7 The pinfire system

Introduced to the United Kingdom at the Great Exhibition in London in 1851 by Lefaucheux, the pinfire weapon was one of the earliest true breech-loading weapons using a self-contained cartridge in which the propellant, missile and primer were all held together in a brass case.

In this system, the percussion cup was inside the cartridge case whilst a pin, which rested on the percussion cup, protruded through the side of the cartridge case. Striking the pin with the weapon's hammer drove the pin into the priming compound causing it to detonate and so ignite the main propellant charge (Figure 1.6).

The pin, which protruded through the weapon's chamber, not only served to locate the round in its correct position, but also aided extraction of the fired cartridge case.

The pinfire was at its most popular between 1890 and 1910 and was still readily available in Europe until 1940. It had, however, fallen out of favour in England by 1914 and was virtually unobtainable by 1935.

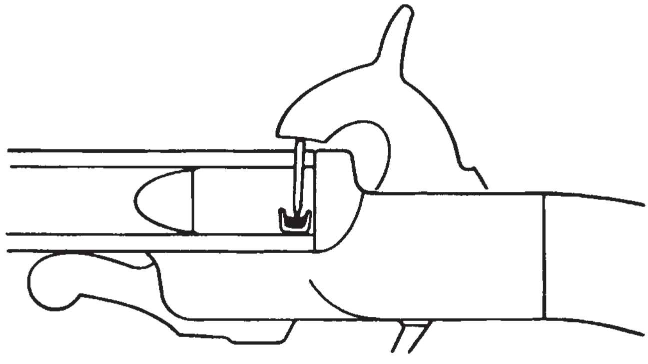

Figure 1.6 Pinfire system (by courtesy of the Association of Firearms and Toolmark Examiners).

Calibres available in the pinfire revolvers were 5, 7, 9, 12 and 15 mm, whilst shotgun and rifle ammunition in 9 mm, 12 bore and various other calibres was also available.

The really great advance of the pinfire system was, however, not just the concept of a self-contained cartridge, but obturation, the ability of the cartridge case under pressure to swell and so seal the chamber preventing the rearward escape of gases.

1.1.8 The rimfire system

Whilst the pinfire system was a significant step forward, it did have a number of drawbacks, not least of which was the propensity of the cartridge to discharge if dropped onto its pin. This problem was all but eliminated by the rimfire which, like the pinfire, was exhibited at the Great Exhibition in 1851.

The rimfire cartridge is a thin-walled cartridge with a hollow flanged rim. Into this rim is spun a small quantity of a priming compound. Crushing the rim with the firing pin causes the priming compound to explode, thus igniting the propellant inside the case.

The initial development of this system was made by a Paris gunsmith, Flobert, who had working examples of it as early as 1847 (Figure 1.7).

It was, however, some time before it gained acceptance, and it was not until 1855 that Smith and Wesson manufactured the first revolver to fire rimfire cartridges. This was a hinged-frame 0.22″ calibre weapon in which the barrel tipped up by means of a hinge on the top of the frame. This enabled the cylinder to be removed when loading and unloading the weapon.

Although a great step forward, the rimfire was only suitable for high-pressure weapons in small calibre. Anything above 0.22″ and the soft rim necessary for the ignition system resulted in cartridge case failures.

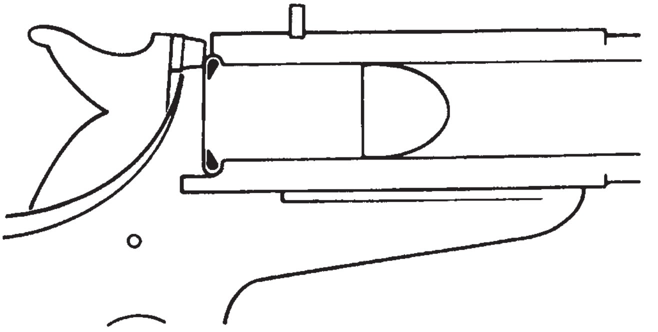

Figure 1.7 Rimfire system.

1.1.9 The Dreyse needle fire rifle

The Dreyse needle gun was a military breech-loading rifle, famous as the main infantry weapon of the Prussians, who adopted it for service in 1848 as the Dreyse Prussian Model 1848.

Its name, the needle gun, comes from its needle-like firing pin, which passed through the cartridge case to impact a percussion cap glued to the base of the bullet.

The Dreyse rifle was the first breech-loading rifle to use the bolt action to open and close the chamber, executed by turning and pulling a bolt handle.

The Dreyse rifle was invented by the gunsmith Johann Nikolaus von Dreyse (1787–1867) and was first produced as a fully working rifle in 1836. From 1848 onwards, the new weapon was gradually introduced into the Prussian service, then later into the military forces of many other German states. The employment of the needle gun radically changed military tactics in the nineteenth century.

The cartridge used with this rifle was a self-contained paper case containing the bullet, priming cap and black powder charge. The bullet, which was glued into the paper case, had the primer attached to its base. The upper end of the paper case was rolled up and tied together. Before the needle could strike the primer, its point had to pass through the powder and hit the primer ahead. The theory behind this placement of the primer is that it would give more complete combustion of the charge. Unfortunately, this led to severe corrosion of the needle which then either stuck in the bolt or broke off rendering the rifle useless. It was, however, a major step forward in the production of the modern rifle (Figure 1.8).

1.1.10 The centre fire system

This was the great milestone in weapon and ammunition development. In centre fire ammunition, only the primer cup needed to be soft enough to be crushed

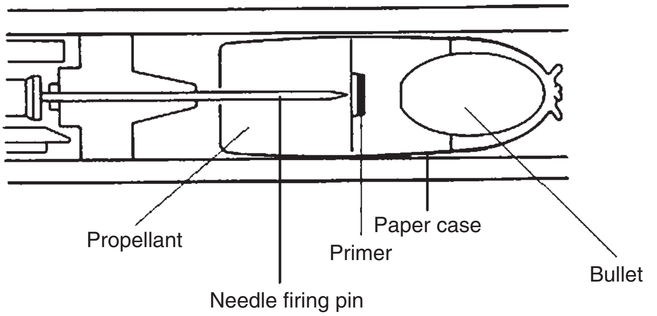

Figure 1.8 Dreyse needle fire system.

by the firing pin. The cartridge case could thus be made of a more substantial material which would act as a gas seal for much higher pressures than could be obtained with rimfire ammunition.

Once again the precise date for the invention of the first centre fire weapon is difficult to ascertain, although there is a patent issued in 1861 for a Daws centre fire system (Figure 1.9).

Probably no invention connected with firearms has had as much effect on the principles of firearms development as the obturating centre fire cartridge case. Although invented around 1860, the principles are still the same and are utilized in every type of weapon from the smallest handgun up to some of the largest artillery pieces.

Rocket-propelled bullets (the Gyrojet), caseless ammunition, hot air ignition and many other esoterica have come and gone. However, for simplicity, reliability and ease of manufacture, the centre fire ignition system in an obturating cartridge case has not been excelled.

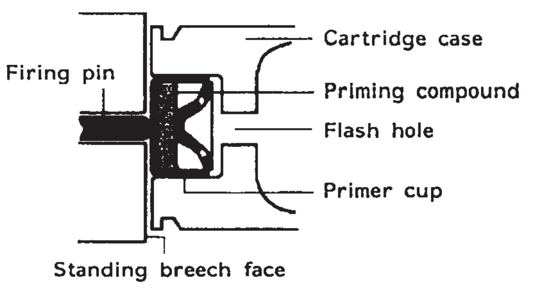

Figure 1.9 Centre fire system.

1.1.11 Rifling

Rifling is the term given to the spiral grooves cut into the bore of a barrel which impart a stabilizing spin to the bullet. This spin keeps the bullet travelling in a point-first direction and lessens any tendency for it to depart from its straight line of flight. As such, this was a very significant event in the evolution of firearms.

Some writers assign the invention of spiral-grooved barrels to Gaspard Kollner, a gunmaker of Vienna, in the fifteenth century. Others fix the date at 1520 and attribute it to Augustus Kotter of Nuremberg.

German weapons bearing the coat of arms of the Emperor Maximilian I and made between 1450 and 1500 have spiral-grooved barrels and are in fact the earliest identifiable rifled guns.

Both straight and spiral forms of rifling are encountered in early weapons, although it is generally accepted that the straight form of rifling was to accommodate the fouling produced in these early black powder weapons.

The number of grooves encountered can be anything from a single deeply cut rifling right up to 12 in number. The form of the groove also varies with square, round, triangular, ratchet and even comma shapes being encountered. The actual number of grooves appears to have little effect on the stabilizing effect of the rifling.

One of the problems encountered with the muzzle-loading rifle was the difficulty experienced in loading the projectile. If it was of sufficient diameter to take up the rifling, a large mallet was required to force it down the bore. If, on the other hand, it was of reduced diameter to assist in its insertion, the gases produced on firing would escape past the bullet leading to reduced velocity. In addition, the bullet took up little of the rifling and thus became unstable in flight. The Brunswick rifle overcame this problem by having a belted bullet and a barrel with two grooves to exactly match the rib on the bullet.

Several other designs were tried in which the bullet was rammed down onto various projections inside the breech end of the barrel. These projections deformed the bullet, thus filling out the bore. Unfortunately, the deformation was irregular and led to erratic behaviour of the bullet.

Greener in 1835 produced the first expansive bullet, the rear of which contained a steel plug. On firing, this was forced up into the bullet expanding it uniformly.

In 1852, Minie, a Frenchman, was awarded a British government contract for the production of an expanding bullet using a steel plug in the base very similar to the Greener design. This resulted in some acrimonious legal action by Mr Greener who was awarded a sum of money recognizing his as the earliest form of expanding bullet.

Lancaster, at about the same time as Minie invented his expanding bullet, produced a rifle with a spiral oval bore. This permitted easy loading of the bullet, did not require any mechanism to expand the base and, as there were no sharp corners to the rifling, it did not suffer the problems with fouling as encountered with conventional rifling.

In 1854, Whitworth patented the first polygonal bore rifling system which overcame most of the problems and was extremely accurate as well. Unfortunately, Whitworth did not have the experience in the practical manufacture of weapons and was unable to produce guns with the consistency required. As a result, his invention was soon overtaken by others.

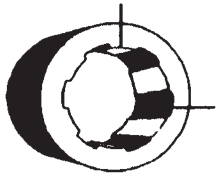

Figure 1.10 Rifling in the bore of a barrel.

The invention of the breech-loading weapon eliminated the problems of having to expand the bullet and fill the bore. The bullet could be made of the correct diameter and could simply be inserted into the rifling at the breech end of the barrel (Figure 1.10). In addition, instead of the deep grooving and a long soft bullet necessary for easy loading and expansion at the breech of a muzzle loader, shallow grooves and hard bullets could be used. This configuration resulted in more uniform bullets, higher velocities, better accuracy and improved trajectory.

1.1.12 Rifling twist rate calculation

One of the first persons to try to develop a formula for calculating the correct rate of twist for firearms was George Greenhill, a mathematics lecturer at Emmanual College in Cambridge, England.

His formula is based on the rule that the twist required in calibres equals 150 divided by the length of the bullet in calibres. This can be simplified to

$$\text{Twist} = 150 \times D^2/L$$

where D = bullet diameter in inches and L = bullet length in inches.

This formula had limitations, but worked well up to and in the vicinity of about 1800 fps. For higher velocities, most ballistic experts suggest substituting 180 for 150 in the formula.

The Greenhill formula is simple and easy to apply and gives a useful approximation to the desired twist. It was based on a bullet with a specific gravity of 10.9, which is approximately correct for a jacketed lead-cored bullet.

In this equation, bullet weight does not directly enter into the equation. For a given calibre, the heavier the bullet, the longer it will be. So bullet weight affects bullet length, which is used in the formula.

For bullets with a specific gravity other than 10.9, then the formula becomes

$$\text{Rifling Twist Rate Required} = CD^2/L \times \sqrt{SG/10.9}$$

If an insufficient twist rate is used, the bullet will begin to yaw and then tumble; this is usually seen as 'keyholing', where bullets leave elongated holes in the target as they strike at an angle.

Once the bullet starts to yaw, any hope of accuracy is lost, as the bullet will begin to veer off in random directions as it processes.

A too-high rate of twist can also cause problems. The excessive twist can cause accelerated barrel wear, and in high-velocity bullets, an excessive twist can cause bullets to literally tear themselves apart under the centrifugal force.

A higher twist than needed can also cause more subtle problems with accuracy. Any inconsistency in the bullet, such as a void that causes an unequal distribution of mass, may be magnified by the spin.

Undersized bullets also have problems, as they may not enter the rifling exactly concentric and coaxial to the bore, and excess twist will exacerbate the accuracy problems this causes.

The twist necessary to stabilize various calibres follows (Table 1.1):

Table 1.1 Rifling twist necessary to stabilize various calibres.

Calibre	Twist rate required
0.22 Short	1 in 24″
0.22 Long rifle	1 in 16″
0.223 Remington	1 in 12″
0.22–250 Remington	1 in 14″
0.243 Winchester	1 in 10″
6 mm Remington	1 in 9″
0.25–0.6 Remington	1 in 10″
0.257 Weatherby Magnum	1 in 10″
6.5 × 55 Swedish Mauser	1 in 7.5″
0.260 Remington	1 in 9″
0.270 Winchester	1 in 10″
7 mm–0.8 Remington	1 in 9.25″
7 mm Remington Magnum	1 in 9.25″
0.30 Carbine	1 in 16″
0.30–30 Winchester	1 in 12″
0.308 Winchester	1 in 12″
0.30–0.6 Springfield	1 in 10″
0.300 Winchester Magnum	1 in 10″
0.303 British	1 in 10″
0.357 Magnum	1 in 16″
0.357 Sig Saner	1 in 16″
0.380 Automatic Colt Pistol	1 in 10″
9 mm Parabellum	1 in 10″
0.40 Smith & Wesson	1 in 15″
0.45 Automatic Colt Pistol	1 in 16″
0.444 Marlin	1 in 38″
0.45–70 Government (US)	1 in 20″

Whilst it is of little circumstance, the question as to the revolutions made per minute by the bullet has been asked on several occasions. The formula for calculating this is as follows:

$$\frac{MV \times 720}{\text{Twist rate in inches}} = RPM$$

For example:

9 mm PB bullet at 1200 fps fired in a barrel with a 1 in 10 twist rate will have a rotational speed of 1200 × 720/10 = 86 400 rpm

0.223″ bullet at 3000 fps fired in a barrel with a 1 in 12 twist rate will have a rotational speed of 3000 × 720/12 = 180 000 rpm

Once again, whilst it has little relevance in everyday case examination, the question as to the rotational speed (revolutions per minute, rpm) and the number of times that a bullet will make a full rotation whilst passing through an object can be asked.

This question was posed in relation to a murder case where one of several bullets which had hit the deceased had cut a trough (often called a 'gutter wound') across the victim's arm. The bullet wound was black and the defence counsel were of the opinion that this was caused 'by the bullet rotating so fast that it had burnt the flesh to carbon'.

This was extremely easy to refute as the barrel of the weapon concerned had a 1 in 10″ rate of twist, which means that the bullet rotated once in every 10 in. of travel. As the wound on the arm was barely 2 in. in length, the bullet would not have made more than $\frac{1}{5}$ of a rotation during that distance.

The blackening, as can be seen from the following photograph, was simply old congealed blood (Figure 1.11).

Figure 1.11 Gutter wound to forearm.