

The Criminal Lawyer[®]

published by SALLY RAMAGE[®]



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GUNCRIME

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<http://www.criminal-lawyer.org.uk/>

Abstract

The study of ballistics is usually divided into three: internal, external and terminal. Internal (or interior) ballistics concerns what happens between the cartridge being fired and the projectile leaving the muzzle. External (or exterior) ballistics is concerned with the flight of the projectile from the muzzle to the target. Terminal ballistics describes what happens when the target is hit. Lawyers need to understand guns as well as relying on expert evidence. This Guncrime paper is concerned mainly with gun use in unlawful Homicides, a subject matter which is considered to be among the most serious of crimes and which generates considerable public, media and political concern.

Caselaw

Bell v State of Indiana (1969).

Dudley v State of Indiana (1985).

R v Charles Peace (1878).

R v Pendleton [2001] UKHL 66.

R v Barry George [2007] EWCA Crim 2722.

Tallahassee v Sigfredo Garcia; Luis Rivera and Catherine Magbanua [2019]

Introduction

Firearms are a contemporary topic and the public needs to understand the state of firearms knowledge today. However, it is a fallacy to think that lawyers did not always grasp such expert knowledge. Caselaw shows that there have been very eloquent and astute cross-examination in courts where the case was won because of the barrister's good grasp of such knowledge and ably transmitting this to the jury.

History of handguns since year 1247

It is believed that handguns have been used since 1247 and the first recorded use of a hand cannon appeared in the year 1449 in the form of an illustration of a mounted soldier with a hand cannon resting on a fork attached to the pommel of the saddle. A literature review

reveals that in modern times, there is a connection between drugs and crime such as burglary.¹

Culture and gun crime today

There is a rising homicide rate in young people. In the classical sub-cultural perspective, lower-class communities generate a distinctive amoral world, which glorifies and legitimizes aggressive behaviour, especially by young men. There are high homicide rates, especially in disadvantaged communities. Scholars are aware of homicides they term ‘retaliatory homicides’, and ‘cultural retaliatory homicides’, due to problematic policing, neighbourhood culture, interpersonal violence, poverty, unemployment and disadvantage.

The power that weaponry confers is another factor in gun crime, which requires expert knowledge to bring about successful convictions. Guns are being used as a symbol of power to achieve goals by inducing compliance with the user’s demands. Firearms and ballistics remain a male past-time.

Prosecutors must understand basics of firearms

To achieve successful conviction, prosecutors need to understand the basics of firearms² and ballistics. Books on ballistics are thus fit for that purpose. It is good that the barrister, police officer, solicitor and layperson understand some of the ways that a guncrime conviction is secured.

Evidence is rapidly lost from the surface of hands and within three or four hours, all gun shot residue (‘GSR’) particles will have been lost from the hands. Brian Heard, in his 2008 book on firearms and ballistics said (on page 259) that:

‘... the GSR vented from the breech end of a pistol is of low velocity. In addition, as such, particles can only be found on the surfaces immediately surrounding the breech of the weapon, that is, the hands. The likelihood of any GSR particles being found on any of these alternative sites, unless a strong wind is blowing towards the firer, is therefore small’.

¹ The offence, under s.9 Theft Act 1968, of entering a building, ship or inhabited vehicle, such as a caravan, as a trespasser with the intention of committing one of three specific crimes in it-burglary with intent; burglary without intent and aggravated burglary [s.10 Theft Act 1968].

² Any weapon from which a projectile is expelled by the action of expanding powder gases. By UK Firearms Act 1968, a firearm is any potentially lethal weapon with a barrel that can fire a shot. Illegal possession of a firearm carries a maximum sentence of ten years imprisonment.

R v Charles Peace (1878)

Remembering the 1878 case of Charles Peace (1832-1879) who was charged with shooting a Blackheath police officer with intent to murder, and who nearly escaped being charged because John and William Hebron were charged with killing police officer Nicholas Cook on 1st August 1878. The Hebron brothers were the original suspects because they had been heard to make threats to kill the police officer Nicholas Cook for causing their arrest in an earlier incident. There was a boot mark at the scene of crime and police said that it matched a boot worn by the older Hebron brothers.

Apart from ballistic expert evidence, this 1878 case must have been the first ever shoeprint case, some 130 years before the established British police shoeprint database. Evidence was called to prove that William Hebron had tried to buy gun cartridges at a local ironmonger's. Evidence was called of someone who claimed to have seen William Hebron near the crime scene some minutes before the police officer's death.

However, there was evidence that the two brothers were working at a nursery at the time when one of them was alleged to be attempting to purchase the cartridges. Many local residents reduced the death sentence to life imprisonment after successful petition.

Confession

However, Charles Peace later confessed to the murder of police officer Nicholas Cook³. On 29th November 1876, Charles Peace had shot and killed Arthur Dyson, an engineer employed by the North-Eastern Railway. Charles Peace was not arrested and went on to live the life of a music-loving man in a respectable neighbourhood. He was arrested one night with housebreaking tools in his possession, after which it was discovered that he was the killer of Arthur Dyson in 1876 and he was so charged.

Physically disabled murderer

What was unique about Charles Peace was not the murders he committed but the disability he was under when he shot and killed two persons in separate incidents. At an early age, Charles Peace injured his left hand and leg whilst employed in a mill. He coped with his disability by concealing the injured hand under his coat by wearing a false arm in his sleeve, terminating with a hook. Charles Peace killed his victims by strapping his revolver to his wrist.

³ Confession is one of the exceptions against hearsay. Its admissibility in English law is governed by section 76 of the Police and Criminal Evidence Act 1984, which requires the prosecution if called upon to do so, to prove beyond a reasonable doubt that the confession was not obtained by oppression of the person who made it or as a result of anything that was likely to render the confession unreliable.

One thing that the Charles Peace case in 1878 demonstrates is that violence and the possibility of injury make robbery⁴ a serious crime and this is the reason why the Criminal Justice System responds to such violence by punishing such robberies more harshly. Robbery violence is a by-product of robbery encounters.

English caselaw: Jill Dando's murder-*R v Barry George*⁵

Examine the 'Jill Dando' murder case in which Barry George was prosecuted for her murder. The Criminal Cases Review Board had found that Barry George had a right to appeal because his conviction was founded on a single particle residue. The appeal court found that, at his trial, the jury had been misled about the significance of a single microscopic speck of GSR found in the lining of an inside pocket of Barry George's overcoat.

At this trial the prosecution relied primarily on four categories of evidence:

- (1) witnesses who had seen a man who looked like Barry George near the scene of the murder when it occurred and one witness who had identified him as being there four hours earlier;
- (2) repeated lies told by Barry George in police interview;
- (3) an alleged attempt to create a false alibi; and
- (4) a single particle of firearm discharge residue (FDR) found, about a year after the murder, in Barry George's overcoat in his wardrobe at his home.

The prosecution called expert witnesses at this murder trial, whose evidence suggested that it was likely that the particle of FDR came from a gun fired by Barry George rather than from some other source. Those witnesses and other witnesses from the Forensic Science Service told the Court of Appeal that this was not the right conclusion to draw from the discovery of the particle of FDR. It was, in fact, no more likely that the particle had come from a gun fired by Barry George than that it had come from some other source.

Lord Phillips of Worth Matravers

The Court of Appeal decided, and Lord Phillips of Worth Matravers CJ gave the CA decision. He said that if this evidence had been given to the jury at the trial, there is no certainty that they would have found Barry George guilty. For this reason Barry George's

⁴ A robbery is an offence under s.8 of the Theft Act 1968, of using force against any person, or putting them in fear of being subjected to force in order to commit a theft, either before the theft or during the course of it. Robbery and assaults with intent to rob are punishable by a maximum sentence of life imprisonment.

⁵ [2007] EWCA Crim 2722.

conviction had to be quashed. In the Barry George murder prosecution for the murder of Jill Dando (a crime television programme actress) there were 200 fields that should have been examined on the sample stub.

Lord Phillips of Worth Matravers CJ continued:

“The FDR evidence was not the foundation of the prosecution’s case against the appellant. Without pre-judging what might follow, in the absence of the FDR evidence there was circumstantial evidence capable of implicating the appellant; that much is clear from the detailed consideration given to the other aspects of the case by the Court of Appeal hearing the first appeal. Mr Clegg has accepted that proposition by conceding that, if this appeal succeeds, there should be a re-trial. We have to decide whether, had the evidence that we have heard been adduced at the trial, this might reasonably have affected the decision of the jury to convict, for this is a good test of whether, in the light of the fresh evidence, the conviction is unsafe – see R v Pendleton [2001] UKHL 66....”⁶

Basic knowledge about guns

There are four (4) types of guns, four (4) types of bullets, and four (4) types of cartridge markings:

Guns:	Bullets:	Cartridge markings:
1. Semi-automatic	1. Full metal jacket	1. Firing pin
2. Revolver	2. Soft point	2. Breech block
3. Rifle	3. Hollow point	3. Ejector
4. Shotgun	4. Lead alloy	4. Extractor

"Automatic" is common terminology for semiautomatic pistols. There are few fully automatic pistols which continue to fire as long as the trigger is held (with the exception of some old, virtually nonexistent German Mausers, the Glock 18, and the Beretta 93R).

⁶ This appeal concerned the role of the Court of Appeal (Criminal Division) when fresh evidence is received on an appeal against conviction. The legal question raised (although not the legal question certified) is whether in *Stafford v Director of Public Prosecutions* [1974] AC 878 this House correctly defined the test to be applied in deciding whether or not to allow an appeal in such a case.



Converting standard Glock 17's into full auto Glock 18's by street gangs has become popular in some cities. There are fully automatic military weapons, and also "machine guns", but these are types of rifles. A semiautomatic handgun requires a trigger squeeze for each shot, and loads fresh cartridges into itself from a vertical magazine inserted into a hollow handle grip. The firing pin is held in a free-floating position by a spring. Once fired, recoil causes a backward sliding movement of the breech block (slide) where the spent cartridge makes contact with an ejector tab, activating both an extractor pin and the trigger into a cocked position ready for firing the next round.

Revolver

A revolver (or repeating) handgun has a circular cylinder built to hold anywhere from five to twelve cartridges (with six - the most common) which rotates each time the hammer is drawn back.



A double-action revolver draws the hammer back when the trigger is squeezed. A single-action revolver must be cocked by hand. Revolver cylinders are emptied and reloaded in one

of three ways: by folding out sideways; by folding out forward; or by removing a pin so the cylinder falls out completely.

Rifle

The word "rifle" refers to any weapon requiring use of both arms.



There are four ways the "action" on a rifle is supplied: lever action; bolt action, pump, and self-loading. Self- or auto-loading rifles are called semiautomatic or automatic rifles. Pump, lever, and bolt action (repeating) rifles require some kind of action by the shooter. The word "carbine" refers to a short barreled rifle.

Shotgun

A shotgun is a smooth-bored, short-range, shoulder weapon that is either self-loading, pump action, single barrel, or double barrel. It may or may not have a "choke" which narrows the cone-like shot pattern on a target.



They fire small balls of metal (or sometimes a slug of metal). The weight of a lead ball that fits exactly inside the bore determines the "gauge" of the shotgun: 1/10th of a pound equals 10 gauge; 1/12th pound equals 12 gauge; 1/16 pound equals 16 gauge; and 1/20 pound

equals 20 gauge. There are also shotguns, such as .410s, which express millimetres, but these are usually smaller bores than 20 gauges.

Bullets

"Bullets" are the projectile pieces of cartridges, consisting of a lead core hardened with tin, antimony, copper-zinc, other alloy, and/or surrounded in an envelope of hard metal. Bullets generally fragment or mushroom upon impact, depending on their hardness.

Full metal jacket refers to the most common type of non-expanding (non-fragmenting, non-mushrooming) bullet where the outer layer is as hard as the core. They are designed for complete penetration, as in military applications.

Soft point, also called round nose, bullets have a tip of metal softer than the core which usually produces a mushrooming effect, to put a bigger hole inside the target. Hollow point bullets are designed to fragment into little pieces, thus taking out different parts inside the target.

Lead alloy, or so-called "cop killer", bullets use specially-made alloys as hard as or harder than lead to penetrate any body armour. With shotguns, projectiles include "shot", "slug", and "wad".

Shot are composed of lead with a small amount of antimony, and regardless of number, have a muzzle velocity of twelve hundred feet per second.

A *slug* is a hollow, elongated piece of metal, which has longer range and more shock power. A *wad* is a greased piece of felt or plastic sleeve using to keep the cartridge airtight, and wads typically open 24 inches from where the shotgun was fired.

Cartridge

"*Cartridge*" refers to one unit of ammunition, consisting of a case, primer, powder, and bullet. The bullet is made of hardened lead and the cartridge case is made of brass. They are crimped together by compressing the mouth of the cartridge case to hold the bullet in place, making a waterproof seal.

The back end (head) of the cartridge will be rimmed, semi-rimmed, or rimless. In a "rim fire" cartridge, the primer is located around the circumference of the rim, so the firing pin may strike anywhere on the rim.

In a "centre fire" cartridge, the firing pin must strike in the centre of the head to crush the primer.

Rim fire cartridges are mostly found in .22 calibre ammunition, and other ammunition is rimmed only because it fits better into chambers and cartridge cases that way. The sole purpose of primer is to produce a small spark or flame that ignites the powder. Although modern smokeless (nitrocellulose-based) powders now exist, "black powder", consisting of 75% potassium nitrate, 15% charcoal, and 10% sulphur, has been the most common form of gun powder.

Bullet comparisons

All firearms, except smooth-bored shotguns, have "rifled" barrels that are unique to a particular firearms manufacturer. Rifling refers to the drilling process used to hollow out the barrel, and each manufacturer uses a somewhat different process to create small spiral *grooves* inside the barrel. The surfaces or ridges of these grooves are called *lands*. The distance in hundredths of an inch or in millimetres between opposite lands determines the *calibre* of the weapon.

A 38 calibre weapon, for example, has a distance of .38 inches from the top edge of one land to the top edge of a land on the opposite side. It's not the same as diameter for two reasons: one, barrels are deliberately bored out smaller than the size of the ammunition they are made for, making for more explosive force; and two, spiral grooving imparts spin and gyroscopic stability to the bullet. Some manufacturers use spiral grooves that impart a clockwise spin; others a counter clockwise spin.

Crime Scene bullets

Visual analysis comparing a bullet found at a crime scene with a test bullet fired from a suspect's gun (into a water tank) can easily tell from these *class characteristics* (lands, grooves, twist) if the manufacturer, model, calibre, and sometimes year of make are the same. It is often said the suspect is then linked to the crime or exculpated. A class characteristic match only matches the same type of gun.

Comparison of striations

To narrow down the suspect and weapon further, the examiner uses a comparison microscope at fairly low magnification to look for fine lines or *striations*. These are very small impressions onto the sides of a bullet made by minute chips of steel that embedded them in the barrel of a gun during the manufacturing process. Striation patterns are always random, irregular, and make up the *individual characteristics* of firearms evidence. No two barrels have identical striation patterns. An individual characteristic matches exactly that particular gun. To ensure chain of custody, all firearms evidence is marked, usually with the

initials of who found the evidence. Sometimes, it is hard for the examiner to find markings on bullets because grit, rust, low calibre, and mutilation upon impact may hinder the examiner's work. A sufficient number of points of comparison are all that is needed to be found, however.

United States guncrime and police ballistic fingerprinting

To assist the examiner, both the FBI (DRUGFIRE) and ATF (BULLETPROOF) formed IBIS (Integrated Ballistic Identification System) in 2000 which provides computerized database systems which contain digitized photographs of markings from many guns. NIBIN (the National Integrated Ballistic Information Network) is the current "ballistic fingerprinting" network operated by the ATF which connects with the IBIS database and contains over 120,000 images from crime scenes throughout the country.⁷ Current databases involve scanning the unique ballistic fingerprints of every gun into the database before it is sold.

Comparison of cartridge cases

The explosion from firing a weapon is so violent that the cartridge case impacts the breech block and other protrusions in the chamber wall with great force. With semiautomatics, there are also the markings of the ejector and extractor mechanisms. Firing pin markings are also present, but their uniqueness is very microscopic. Just as with bullets, cartridge cases pick up individual striation patterns. Shotguns have to be analyzed by their cartridges (shell casings) because there are no striation patterns on shot. The wad of a shotgun blast is important to recover because it has factory markings.

Gunpowder residue analysis

Powder is never totally burned when a gun is fired. Residues are thrown out quite some distance (as well as backwards in a cloud-like formation). By analyzing the presence or absence of powder residue thrown out forward towards the target, the analyst can determine *muzzle to target distance*, not an unimportant consideration with cases of self-defence pleas

⁷ Mechanics article on ballistic fingerprinting. See <http://popularmechanics.com/>

and alleged suicides.⁸ Distances and angles can also be determined by analyzing the halo, tattooing, or spotting around a bullet hole in a target's garments.

Infrared photography will usually reveal even the minutest traces of powder residue. A halo of soot around the hole is usually 12-18 inches; a halo with specks usually 18-25 inches; and specks only 25-36+ inches. With shotguns, the general rule is that a one inch spread equals one yard, so a ten inch patter equals ten yards, for example.

Gunshot holes or wounds usually fall into one of three categories: close range; distant; or contact. Distant shots are the most problematic.

One of the oldest tests (1933) in existence was called the *paraffin test*, or *dermal nitrate test*. It was designed to check for residue on the hands (from the blown-back cloud-like formation). The suspect's hands were coated with paraffin or wax, and then the paraffin was tested with diphenylamine. If the wax turned blue, it indicated nitrates were present. *Nitrates are the most common unburnt part of gunpowder residue.*

Unfortunately, the test fell out of popularity over the years because urine, tobacco, fertilizer, cosmetics, and other substances on the hands also yielded a blue colour. Modern tests for hand residue look for primer substances such as barium on the thumbs and bullet-alloy substances such as antimony on the fingers.

Gunshot distances and angles

Another test for nitrates is called the *Griess test* which is designed to assist with measurement of distances and angles. The examiner presses a photographic paper onto surfaces near the target, and then sprays the paper with sodium rhodizonate and a pink to violet colour appears if nitrates are present.

Yet another test, called the *Harrison-Gilroy test*, does not check for nitrates at all, but for antimony, barium, and lead using the same paper colour change indicator. There is some instability in the colour changes of many of these tests, but they are the best thing to use when the crime scene is covered with bloodstains since the tests will activate only for gunshot residue. Many other tests exist, the most expensive ones involving neutron activation analysis and/or electron microscopes.

⁸ It seems an obvious point, but in the case of suicide the resulting wound must be capable of being self-inflicted. If a body has a bullet hole in the forehead and another at the back of the head, it can only be suicide if the entry wound is at the front. If the entry wound is at the back of the head, it is likely to be homicide. Other determining factors such as trajectory must be investigated at post-mortem. Post mortem can even reveal if there is no likelihood of suicide if the angle at which a bullet entered the victim is inconsistent with self-infliction.

Case study: Tallahassee v Sigfredo Garcia, Luis Revera and Catherine Magbanua (murder trial for the murder of Criminal Law Professor Dan Markel in 2014- case heard in 2019-against hire-for-murder offenders, not the principal killers)

Criminal Law Professor of Florida State University, Dan Markel, age 45, was shot at point-blank range in his car in his garage at home. Dan Markel's car keys were found in his own unlocked black Honda, which was in the garage where his body was found. Due to a confession in 2016, the case came to court in 2019. It concerned a murder-for-hire by the ex-wife's family in a murky divorce highly involved with Child Custody, Perjury in financial mis-declarations to the Family Court and possibly insurance claims⁹ and which culminated in the cold-blooded murder of Criminal Law Professor Dan Markel who –in fighting for equal custody for his two young sons, then ages 2 and 3 years old, realised that he had stumbled upon financial crimes of hidden monies not declared by his ex-wife (also a lawyer) to the Court, much to his detriment and very tragic demise.

The hired gunmen travelled from Florida (where his ex-wife's family live) to Tallahassee, and shot Dan Markel as Markel drove into his garage one sunny morning after taking his boys to nursery class.



⁹ We are reminded of Anthony Riggs, a Persian Gulf war veteran who was shot to death in front of his in-laws' home shortly after returning from the war, when it was assumed that the soldier was another tragic victim of a Detroit street robbery. Police soon learned that the victim's wife and brother-in-law conspired to murder Anthony Riggs in order to collect the \$175,000.00 life insurance policy. See Mizell, L.R. (1997) *Masters of Deception*, New York: John Wiley & Sons, pp 147-148. Markel's life insurance remains in trust where the ex-wife cannot have access to it.

Dan Markel was shot in his home garage by hired killers

The two hired criminals were waiting for him; they knew his movements; they shot him in the head and face; left him for dead, and drove back to Florida to collect their loot, paid in

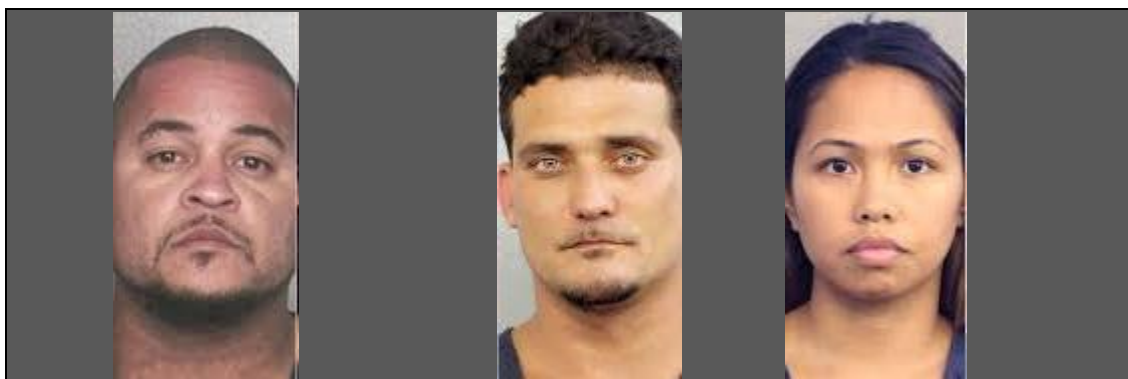


cash (\$50,000.00).

After two years police arrested and charged them and the woman who is believed to be the liaison between the killers and the wife's family who paid for Dan Markel's murder. At present there is one retrial (of Defendant number three) and one appeal (by Sigfredo Garcia) pending, unhappily obstructed by the Covid-19 Pandemic which began in December 2019.

Ballistics identified the shooter

Tallahassee Police did not find the gun which killed Dan Markel. However they were able, using ballistics, to identify the shooter from the projectile direction, his height and his proximity to Dan Markel's driver's side window. This made clear that it was Sigfreda Garcia who shot Criminal Law Professor Dan Markel, rather than the much shorter defendant Luis Rivera.



Luis Rivera

Sigfredo Garcia

Catherine Magbanoa

This reminds one of the 1944 case of *U.S. v Karl Hulten and Elizabeth Jones*.

Firearms Identification and Ballistics

"Guns don't kill people - unless you practice real hard" (Bill Maher)

Experts in the general area of firearms identification are usually called firearms examiners, and their duties or specialties often encompass the identification, comparison, and testing of bullets, cartridges, gunshot residue, the science of ballistics, serial number restoration, toolmark examination and other impressions, trace metal detection, as well as collection and preservation of firearm evidence.

Variety of firearms

There is an enormous variety of firearms and quite an extensive literature in this field, so it is difficult (but not impossible) to become an all-purpose practitioner. In fact, anyone professing to be a "ballistics" expert will probably be held to a higher standard of qualifications, most likely involving college courses in mathematics or physics.

Expertise in analytical chemistry, biology and general science

However, there are exceptions for self-educated persons, but specialty areas like gunshot residue expertise ought to involve competency in matters of analytical chemistry. Other experts may be qualified on the basis of biology or general science courses (involving the use of microscopes and/or special equipment, etc).

Toolmark examiners

Toolmark examiners are ordinarily qualified on the same basis as general firearms examiners. Firearms identification and toolmark examination tend to be two kinds of skills that go hand-in-hand, both having a long history.

Internal ballistics

As soon as the primer ignites the propellant, gas is generated which rapidly builds up a considerable pressure. This pushes the projectile out of the case and up the barrel. The characteristics of propellant powders are such that the peak gas pressures are generated almost immediately, as the projectile begins its trip up the barrel. That is why the gun steel is thickest at this point. As the projectile accelerates up the barrel, it makes space for the gas to expand so gas pressure declines. It is still significant when the projectile leaves the muzzle, resulting in a rapid expansion into the open air causing the characteristic 'report' of a

gun firing. This final expansion, coupled with the end of the friction between the projectile and the barrel, results in a final boost to the projectile so its maximum velocity is attained just beyond the muzzle ("muzzle velocity" is usually measured at several metres past the muzzle).

Gas pressures

Different weapons operate at different gas pressures; pistols and shotguns generally work at much lower pressures than rifles and automatic cannon. Magnum pistol ammunition, plus some military pistol ammunition intended for sub-machine guns, is loaded to higher pressures than normal in order to generate higher velocities. It can be dangerous to use ammunition in guns not designed for it, unless they are very strong. Rifle and cannon ammunition is generally loaded up to the highest practical pressure level, taking into account barrel wear, the risk of a case being stuck to the chamber and other potential problems.

Ballistics or projectiles in motion

The science of projectiles in motion is called ballistics, and firearms ballistics is divided into three fields:

1. Internal Ballistics - the study of what happens inside of the firearm.
2. External Ballistics - the study of what happens during the bullet's flight.
3. Terminal Ballistics - the study of what happens when the projectile strikes the target.

Most of (1) internal and (3) terminal ballistics is covered in the bullet comparison and residue analysis sections of the study of ballistics.

Bullet travel- no straight line

Focussing on the dynamics of external ballistics is not so difficult for a layperson with Advanced Level Applied Mathematics and Physics. This author passed such "A" level subjects years ago and the saying comes to mind that "love of learning is never unrequited". Bullets do not fly in a straight line. It is true that they fall towards the earth at the same rate as dropped from the hand, but they travel in a parabolic trajectory as range increases and velocity drops off ¹⁰.

¹⁰ "How Do Bullets Fly?" See www.povn.com/

The centreline of a firearm's bore is angled slightly upward so that the projectile crosses the line of sight on its way up (usually at about 25 yards or so) and again on its way down at what is called the zero or point blank range. The *aerodynamic drag* that a bullet experiences depends mostly on its velocity, although weather conditions and weapon cleanliness make a difference. If the drag is graphed against *velocity*, the curve will have a similar shape for all similarly shaped bullets. Since the shape of drag curves is similar, curves can be related to one another by multiplying or dividing by a single number.

The ballistic coefficient

The *ballistic coefficient* is that number relating to the drag of bullets that have similar shapes to one another. The Ballistic Coefficient refers to the effect of air drag on a bullet's flight and can be used to predict any particular bullet's trajectory under any circumstances through what are called "*drag tables*" which apply only to a particular bullet and are published by bullet manufacturers. Ballistics experts use these standard tables and often calculate formulae themselves through test firing and mathematics:

*The Coefficient of Drag is an aerodynamic factor that relates velocity erosion to air density, area, velocity and mass. It is calculated by multiplying the weight of a bullet by its frontal area. A one inch diameter, one pound bullet would have a Coefficient of Drag (CD) of one, the standard for all drag tables.

The bullet's Form Factor

Another important term is a bullet's Form Factor (FF). The Form Factor is simply the CD divided by the CD from a bullet manufacturer's pre-defined drag table.

Ballistic Coefficients are then just the CD divided by the FF:

Ballistic Coefficient = (Bullet Coefficient of Drag) / (Bullet Form Factor)/

Tool marks and other impressions

A toolmark is any impression, cut, gouge, or abrasion caused by an object (typically a burglar tool) coming into contact with another object. Tools generally fall into one of three categories: scraping, shearing, or pinching.

Impressions (such as shoeprints or tire tracks) are any indentations caused by a heavier object coming into contact with a softer object. Generally (but not always) toolmark

expertise falls under the domain of firearms examination. Tools often have random nicks from wear and tear which leave individual characteristics (striations) at the crime scene. Tools often contain minute amounts of *trace evidence*, such as paint, wood, fibre, or glass. Impressions in woodwork, metal, or similar material can be lifted by applying a casting material like dental stone (gypsum powder). Impressions in softer material, like carpeting, can be lifted using Mylar film pressed against the floor where the impression becomes evident through applying dye colour and electrostatic charges to the Mylar. Lots of other related specialties exist in this field, like forensic locksmithing, types of forensic engineering, and trace metal analysis, for examples.

Wound Ballistics

Wound Ballistics is the study of effects on the body produced by penetrating projectiles.¹¹ To fully understand the qualities a bullet must have in order to be reliably effective in stopping a determined homicidal attacker is the police ballistics aim. The basics of terminal performance, wounding effects and wounding effectiveness are easy for ordinary people to understand. Wound Ballistics is a specialty field that does not receive much exposure outside the few professional disciplines that have a need for valid, scientifically verifiable information about ballistic injury.

Maximum velocity a projectile can be pushed to

This is ultimately limited by the expansion rate of the gas from the burning propellant. In rifles, the practical limit is around 1,200 m/s (nearly 4,000 fps) achieved in small-calibre guns which only need light bullets (plus a couple of WW2 7.92mm anti-tank rifles). This is also about the maximum velocity for cannon firing conventional full-calibre HE shells. The highest velocities currently achieved are in tank guns firing APFSDS shot, which is extremely light for the calibre and allows velocities to be pushed up to 1,800 m/s (nearly 6,000 fps), which is close to the theoretical limit for conventional powder propellants. To go much faster would require a different technology. The barrel length in comparison with the calibre is obviously an important factor in muzzle velocity. In cannon calibres, this is expressed as the "calibre length", which is simply the length of the barrel divided by the calibre.

¹¹ Note that a projectile is a bullet or any other object projected by force and continuing in motion by its own inertia. So, a bullet is not a projectile until it is in motion.

Recoil

Two factors determine recoil: the cartridge ballistics and the characteristics of the gun (most especially, its weight). The recoil impulse generated by firing a cartridge has two components; the momentum of the projectile, and the "rocket effect" of the escaping gas. The simple formula for calculating this is as follows : (bullet weight x muzzle velocity) + (propellant weight x 1,200 m/s / 4,000 fps)

Therefore a cartridge firing a 10g bullet at 1,000 m/s should have the same bullet momentum as one firing a 20g bullet at 500 m/s. Note that this is a different calculation from muzzle energy, as bullet weight and muzzle velocity are of equal value. This explains why in different bullet-weight loadings of the same cartridge which generate the same muzzle energy, the heavy bullet loading will produce heavier recoil.

The recoil caused by the escaping gas is much more difficult to calculate because it depends on the relationship between the burning characteristics of the propellant and the length of the barrel. The only way of reducing the recoil force generated by a cartridge while maintaining the muzzle energy, is to reduce the effect of the escaping gas by diverting some of it, either to one side or (preferably) to the rear. A device to achieve this is known as a muzzle brake. The extent to which a muzzle brake can reduce recoil obviously depends upon the proportion of the recoil impulse generated by the propellant gas - it gives the greatest benefit in very powerful, high-velocity weapons. A disadvantage of a muzzle brake is that the rearwards-deflected gas greatly increases the muzzle blast and noise perceived by the firer, and may also kick up dust, revealing the weapon's position and affecting the user's visibility. A recoil-less gun deflects most of the gas directly behind the weapon, so in this case the "rocket effect" more or less balances the projectile momentum. This requires the use of several times as much propellant as with a conventional gun of the same muzzle energy, so the ammunition is bulky and expensive.

External Ballistics

Just two key factors determine the external ballistics of a projectile; *the muzzle velocity* and *the ballistic coefficient*. The ballistic coefficient is significant because it determines the rate at which the projectile slows down, and in conjunction with the muzzle velocity this decides the maximum range and the time of flight to any particular distance

Trajectory

The curved path of the projectile which results from the muzzle velocity, the ballistic coefficient and gravity drop is called the trajectory.

In most types of long-range shooting (whether by rifles or large cannon) a short time of flight is considered desirable because it maximizes the hit probability by reducing the time of flight and flattening the trajectory. It also results in the projectile striking the target at a high velocity and therefore with greater effect. The main exception is when artillery fires in the "upper register" (above 45 degrees elevation) to achieve plunging fire.

There is a practical limit to how high the velocity of any given projectile can be pushed. To make the most of the muzzle velocity, we need to achieve a high ballistic coefficient.

Shells and Bullet Behaviour

Initially, bullets and shells were provided with studs to fit into the rifling but these were slow to load. An alternative approach was to make a polygonal-section barrel with shells manufactured to fit. Subsequently, rifles were provided with Minié type bullets which had a hollow base, designed to expand under the pressure of firing and "take" the rifling. Modern rifle, pistol and heavy machine gun (HMG) bullets are given a metal jacket (usually cupro-nickel) which has a slightly larger diameter than the bore of the gun. It is therefore squeezed into the rifling grooves on firing, which leaves characteristic angled grooves engraved into the bullet.

Terminal Ballistics

There are two different aspects to this; the effect of projectile strike against soft targets (animals or people) and the effect against armour. A military (i.e. fully jacketed, pointed, non-expanding) rifle bullet will be destabilised when hitting a soft target and will tumble. This is because its shape means that the centre of gravity of the bullet is towards the rear so it naturally prefers to fly base-first.

Bullets designed for penetrating heavy game animals like elephant - which need to penetrate very deeply in a straight line and must therefore not yaw or tumble - have long, parallel sides and blunt round noses, just like early military rifle bullets.

Tumble of bullet

Not all bullets tumble at the same rate. Other things being equal, small bullets will tumble more quickly than large ones, but the design of the bullet is also important; some visually identical bullets will tumble at different speeds, generally depending on the internal construction. For example, the Yugoslavian bullet for the 7.62x39 has a lead core and has been found in tests to tumble much more quickly than the Russian steel-cored bullet in the same cartridge. Various tricks have been used to increase the probability of a bullet tumbling; the British .303 Mk VII bullet had a lightweight tip filler with the weight concentrated towards the rear of the bullet, and the current Russian 5.45mm rifle bullet has a hollow tip.

Bullet placement

Bullet placement is vital to achieving effective stopping power; it is much more effective to hit an immediately vital area with a low-powered weapon than to inflict a minor wound with a high-powered one. Also, the psychological state of the target has a considerable effect. Someone who is relaxed, or frightened, may be put out of the fight by a minor wound, someone who is highly charged with aggression will require far more power to stop them, and yet another person high on drugs may continue fighting despite suffering the most appalling wounds.

Stopping power

Stopping power is simplest to define pistols which have too low a velocity for hydrostatic shock to be a factor. The classic formula, named after the American Julius Hatcher, is calculated by multiplying the bullet weight by the muzzle velocity and then by the square of the calibre. The result is then multiplied by a form factor, similar in principle to that used for calculating the BC, except that in this case, the blunter the bullet shape the more effective it is. It will immediately be seen that calibre is the most important factor, and indeed large calibre pistols such as the .45" have always had a good reputation for stopping power. It should be noted that even the most powerful handgun or rifle will not physically knock someone down.

Newton's law would require the firer to be thrown backwards with equal force. The recent spread of body armour has changed the perceptions of desirable pistol ballistics to some

extent, as a high-velocity small-calibre bullet will punch through body armour which will easily stop a large-calibre, low-velocity bullet.

Forensic Law

Forensic law holds that you do not have to go to college to become a firearms examiner. There is also no requirement for formal training, certification, or licensing. This is an area where the *Frye test* for admissibility is commonly used, and all that matters is if the expert can offer something to the court beyond the opinion of an average layman and is based upon standard criteria in the field. Most experts testify for the prosecution (and try to balance this by testifying for the defence once in awhile), and courts commonly defer to the word of any crime laboratory employee over the word of a gunsmith. If a person is vouched for in being proficient (by having worked in a crime lab, for example, or knowing someone who works in a crime lab), the court considers that person competent. Practical experience in law enforcement (or the military and with certain manufacturers) also counts toward expert qualification (*Dudley v State of Indiana* 1985) as well as being self-taught, having worked under supervision, and having over three years of experience (*Bell v State Indiana* 1969).

Conclusion

According to scholars such as Ligertwood (2012)¹² and Murphy (2006),¹³ assertions that the new generation of forensic sciences is capable of investigating and inculcating suspects on an order of power far greater than that afforded by traditional forensic techniques, is true. Yet we should not ‘throw out the baby with the bathwater’ and value our older investigators for their long experience.

Forensic science evidence must be presented in a form that can be accommodated within the process of proof employed by judges and juries, as Ligertwood asserts. The challenge is to present forensic science evidence in a form that can be accommodated within this non-mathematical inductive standard of proof.¹⁴

¹² Ligertwood, A. (2012) “Expressing evaluative forensic science opinions in a court of law”, School of Law, New South Wales, Australia.

¹³ Murphy, E., (2006), “The new forensics: criminal justice, false certainty, and the second generation of scientific evidence”, SSRN.

Ligertwood, A. (2012) “Expressing evaluative forensic science opinions in a court of law”, School of Law, New South Wales, Australia. See also, Murphy, E., (2006), “The new forensics: criminal justice, false certainty, and the second generation of scientific evidence”, SSRN. Murphy asserts that this new generation of forensic sciences is capable of investigating and inculcating suspects on an order of power far greater than that afforded by traditional forensic techniques.

All criminal lawyers ought to make themselves familiar with the essentials of firearms and ballistics because gun crime will not disappear sometime soon. As with terrorism, there are whole sub-industries which thrive on gun purchase, fear of guns, and criminal fraternities which rely on loopholes in gun consumption; bribery, corruption and dishonesty. Their way of life depends on the gun culture and only sharp awareness of rule of law will keep them in check. The United States surpasses deaths by gunshot as compared to the United Kingdom and in the U.S. shooting is by far the most common method of homicide, with shooting being the fifth most common method of homicide in the UK, after knifing, bludgeoning, etc. in the UK.

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Appendix one-Professor Dan mMrkel's legal scholarship

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