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An Introduction to Forensic Firearms Identification

Fundamentals of Firearms ID

Studies have shown that no two firearms, even those of the same make and model, will produce the same unique marks on fired bullets and cartridge cases. Manufacturing processes, use, and abuse leave surface characteristics within the firearm that cannot be exactly reproduced in other firearms.

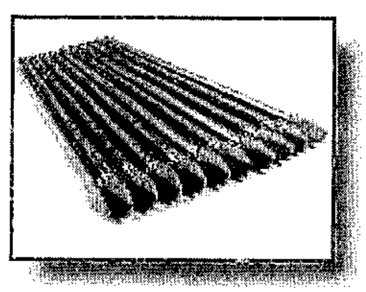
Firearms do not normally change much over time. This allows for firearms recovered months or even years after a shooting to be identified as having fired a specific bullet or cartridge case. Tests have been conducted that found that even after firing several hundred rounds through a firearm the last bullet fired could still be identified to the first.

It should be noted that not all firearms leave consistent reproducible marks. But overall it has been my experience that around eighty percent of the firearms that I examine produce what is sometimes called a "mechanical fingerprint" on the bullets and cartridge cases that pass through them.

All cases that involve firearms identification start with preliminary examinations of the evidence for similar ***class characteristics***. Class characteristics can be defined as:

> ***Intentional or design characteristics that would be common to a particular group or family of items.***

A very basic example would be that several no. 2 pencils in a box are yellow and have pink erasers. The color and eraser type is a common class characteristic to all of the pencils.



When it comes to firearms and ammunition it is not quite so simple.

The class characteristics of firearms that relate to the bullets fired from them includes the ***caliber*** of the firearm and the ***rifling*** pattern contained in the barrel of the firearm.

Cartridges and Cartridge cases on the other hand are examined for class similarities in what are called ***breech marks***, ***firing pin impressions***, ***extractor marks***, ***ejector marks*** and others.

If dissimilarities in class characteristics are found or if a general lack of good class characteristics are present no further comparisons may be necessary.

When similar class characteristics are identified the examinations progress to a final stage where an attempt is made to find a "match" in what are called ***individual characteristics.***

> ***Individual characteristics are those characteristics that are unique to an item. They can also be referred to as accidental characteristics.***

The transfer of individual characteristics from a firearm to the ammunition components passing through it is what makes firearms identification possible.

Click the ***Next*** button below learn more about ***bullet identification***.

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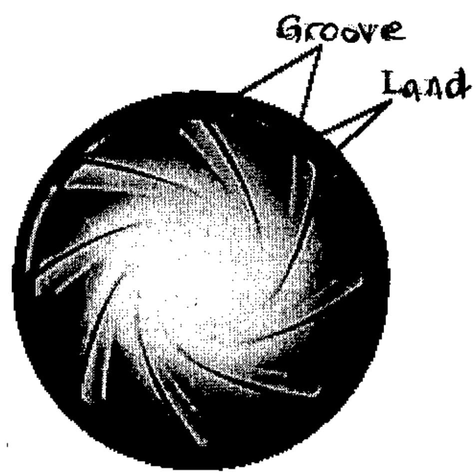
Rifling

Most modern pistols, revolvers, rifles, and some shotgun barrels have what are called ***rifling*** in their barrels.

> ***Rifling consists of grooves cut or formed in a spiral nature, lengthwise down the barrel of a firearm.***



Rifling is placed in the barrels of firearms to impart a spin on the bullets that pass through it. Because bullets are oblong objects, they must spin in their flight, like a thrown football, to be accurate. Looking down the barrel of a firearm you might see rifling like that depicted on the right. This image shows a pattern of rifling containing eight grooves with a right twist.

In firearm examiner lingo we refer to the rifling as ***lands*** & ***grooves***. The lands are the raised areas between two grooves. A rifling pattern of eight grooves with also have eight lands.

Firearms can be manufactured with any number of lands and grooves in their barrels. They can also spiral either left or right. A few of the more common rifling patterns are 4/right, 5/right, 6/right, 6/left, 8/right, and 16/right.

The procedures described below are abbreviated somewhat but I hope that they will provide you a better understanding of basic rifling techniques.

When barrels are manufactured, they start out as a solid rod of steel. A hole is drilled down the center of the rod and the rifling is then placed in the barrel.

There are three ways basic processes that modern firearms manufacturers use to form the rifling in barrels. Rifling can be cut into the inner surface of a barrel using a ***broach***, the rifling can be formed using a hardened steel ***button***, or the rifling will be formed through a process called ***hammer forging***.

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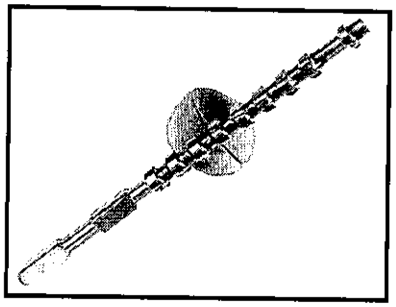
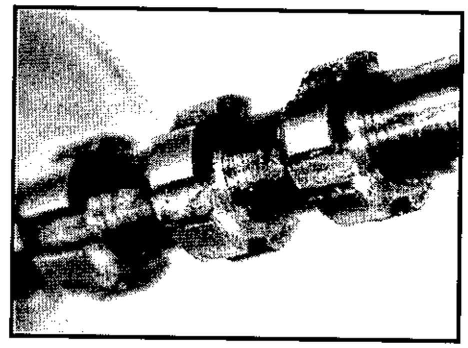
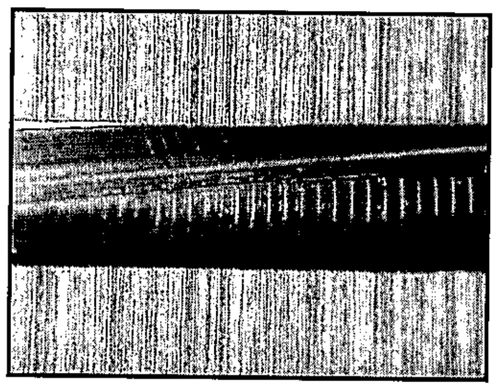
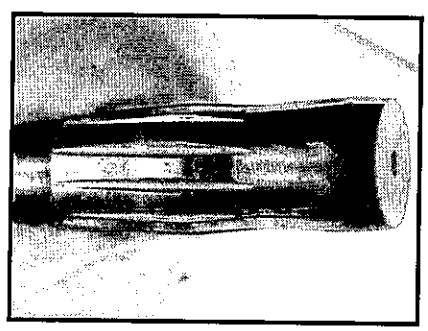
The modern broach method of rifling uses a hardened steel rod with several cutting rings spaced down the rod. Like the one shown below. Broaches can be over 16 inches long and because they have several cutting rings, they are referred to as ***gang broaches***.

Each successive cutting ring is slightly larger in diameter and when the last ring on the broach passes down the barrel the desired depth to the grooves is obtained. The cutting rings have gaps evenly spaced around them to allow for the lands. The rod is twisted as it is pulled through the barrel and this forms the spiral to the rifling pattern. A cut-away of the inside of a barrel below shows the cut grooves and the lands with original drilling marks.



Probably the most common method used today to rifle barrels is ***button rifling***. Button rifling uses a different approach to forming the grooves in the barrel. A button as seen below is a very hard steel plug that is forced down an unrifled barrel.



The grooves are then formed in the barrel under very high pressure.

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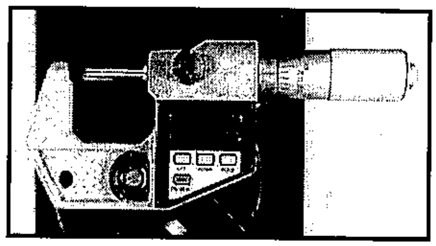
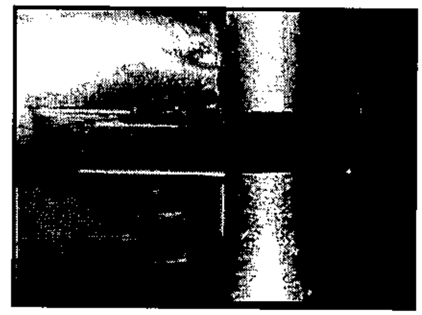
Rifling Impressions

A bullet is slightly larger in diameter than the ***bore diameter*** of the barrel in which it is designed to be fired. The bore diameter is the distance from one land to the opposite land in a barrel. As a result, a rifled barrel will impress a negative impression of itself on the sides of the bullet like those seen below.

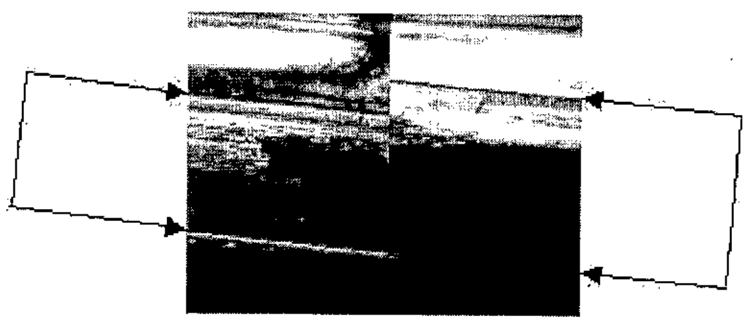
The rifling pattern in the barrel that fired a particular bullet can be determined by counting the number of groove or land impressions around the circumference of the bullet. Then, by holding the nose of the bullet pointing away from you, the direction the impressions run away from you (either to your left or right) determines the direction of twist. If the rifling impression pattern on the bullet matches the rifling pattern in the barrel of the questioned firearm, the next step is to measure the rifling impressions on the bullet.

The lands and grooves on a bullet are measured in thousandths of an inch or in millimeters. One way to measure individual rifling impressions is to use a micrometer like the one below. The right image below shows the micrometer positioned next to a land impression on a bullet.





This is important because even though the rifling pattern may match between the bullet and questioned barrel one 6/right rifled barrel can have lands and grooves of a differing width than another. The image below shows the land impressions on two bullets. Both were fired from 6/right rifled barrels. The land impressions are lined up at the bottom edge but as you can see, the upper edges do not line up because the land impression on the right bullet is wider.



The widths of the lands and grooves on a bullet provide a further class characteristic that can be used as a preliminary means to determine if the submitted bullet could have been fired from the submitted firearm.

Another class characteristic of rifling that is seldom comes into play is the ***rate of twist*** or ***pitch*** of the rifling in the barrel. The rate of twist is the distance the rifling needs to spiral down the barrel for it to complete a single revolution. An example would 1 turn in 12 inches. The term pitch refers to the angle at which the rifling is cut in the barrel. The two images below show the rifling in a 5 inch barrel on the left opposed to a 1 3/4 inch barrel on the right. Note the difference in pitch of the rifling.

You may get a bullet fragment that only has one or two land and groove impressions and the direction of twist may not be obvious.

Therefore, here is where a little math comes in. Let us say you have a fragment with only one land and one groove impression visible (the minimum number for this to work). You measure the land impression width to be .055 inches and the groove impression width to be .130 inches. Divide the diameter of the bullets suspected or measured caliber, in this case .357, by the sum of the width of the one land and groove impression (.185), and then multiply that number by pi (3.14).

$$.357 / .185 * 3.14 = 6.05$$

This will give you the approximate number of lands or grooves that would have been in the barrel that fired the bullet. In this example, the approximate number of lands and grooves would be six.

If a bullet is badly damaged and exhibits poor class characteristics not all is lost. There is still a possibility that some unique microscopic marks from the barrel still exist on the surface of the bullet.

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April 2000 Volume 2 Number 2

Firearms and Toolmarks in the FBI Laboratory

Part 1

Sally A. Schehl
Associate Editor
Forensic Science Communications
Forensic Science Research Unit
Federal Bureau of Investigation
Washington, DC

Read about ...

Introduction

The Firearms-Toolmarks Unit (FTU) is one of many subdivisions of the FBI Laboratory devoted to a specific discipline of forensic science. This unit, comprised of firearms examiners and physical science technicians, receives and examines all incoming evidence related to firearms, firearm components, ammunition, ammunition components, tools, and toolmarks.

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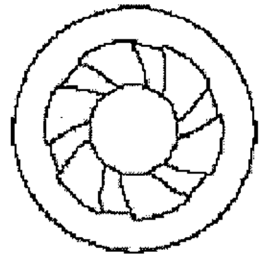
Firearms Identification

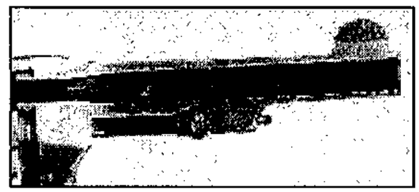
Forensic firearms examinations are based on firearms identification, which involves the identification of a bullet, cartridge case, or other ammunition component as having been fired by or in a particular firearm. The possibility for such singular identification can be attributed to specific machining processes used in the manufacture of firearms.

Rifling

Helical grooves known as rifling are cut into the bore of a barrel of a firearm during production to increase the accuracy of that firearm. When the gun is discharged, these grooves cause the bullet to spin as it travels the length of the barrel and thus stabilize the bullet during flight. At the same time, the expansion of the fired cartridge and the high pressures propelling the bullet through the bore of the barrel press and scrape the bullet against the rifling as it heads toward the muzzle. The fired bullet, as a result, will bear the negative impressions of the grooves in a rifled barrel; these marks are described by firearms examiners as land and groove impressions, or lands and grooves.

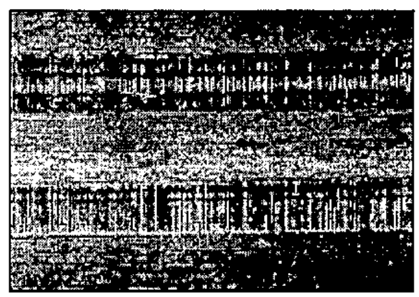


Cross-section of the barrel of a firearm showing lands and grooves



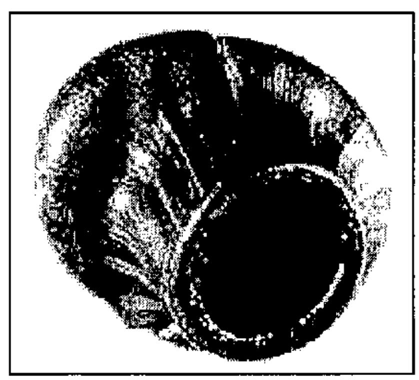
Rifling in the barrel of a firearm

Because the equipment used in the machining and finishing processes of firearms production is inherently imperfect at the microscopic level, a machined, rifled barrel will contain scratches, scrapes, and other minute nicks and flaws. These unique imperfections are exacerbated through the subsequent use and discharge of the firearm, as further abrasion of the barrel occurs, and as a result of natural wearing processes such as rusting and corrosion.



Microscopic view of imperfections in the rifling of a barrel

A lead or jacketed bullet propelled by high pressures at great speed through the barrel of a given firearm, then, will have impressed on its surface not only the general rifling characteristics of that barrel, but also microscopic marks unique to that barrel, marks not found in the barrel or rifling of any other firearm.



Rifling on a fired bullet

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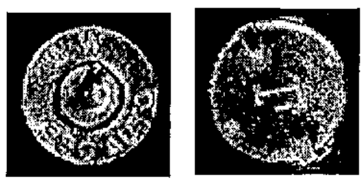
Identifying Features of Fired Ammunition

In addition to the rifling marks produced on a bullet by its passage through a gun barrel, a number of other impressions found on cartridge cases and resulting from machining processes are crucial to firearms identification. Firing pin impressions, breechface marks, extractor marks, ejector marks, and chamber marks, when present and of sufficient quality, are all features used by firearms examiners in their analyses. During the discharge of a firearm, the firing pin strikes the primer of a cartridge, creating microscopic contact marks and unique indentations. As the powder within the cartridge begins burning, the cartridge case is propelled backwards against the breechface with enough force to be impressed with the characteristic microscopic features of that surface.

Extractor and ejector marks are produced when the cartridge case is mechanically extracted from the chamber and ejected and are visible as fine striations and gouged impressions on the rim and head of the case. Chamber marks, parallel striations on the cartridge case caused by contact with the walls of the chamber of the firearm, also occur at this time. All of these potentially identifying features are produced as a result of the machining and finishing processes of firearms manufacture, which inevitably leave microscopically rough areas and edges on the parts of a given gun. During discharge, these imperfections are transferred from the metal parts of the firearm to the bullet and cartridge case.



Firing pin impressions

Breechface and ejector marks

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Firearms Examinations

Using the various microscopic signatures created by a firearm during discharge, a firearms examiner compares submitted bullets and ammunition components to each other as well as to any number of firearms.

Test firing into a water tank

Because a bullet, bullet jacket, or cartridge case cannot be directly compared to the rifling present in the barrel of a firearm or to the firearm's parts, the examiner will test fire an incoming weapon into a water tank to produce known, fired specimen bullets and cartridge cases for use in comparison with questioned (evidence) ammunition components. The large volume of water contained in this tank slows a discharged bullet's flight with no damage or distortion to the projectile and the impressions it carries, thereby generating ideal samples for microscopic examination. Fully automatic firearms, high caliber firearms, and shotguns, which cannot be discharged into the water tank, are tested on the Firearms-Toolmarks Unit's indoor range or on outdoor firearms ranges at the FBI Academy in Quantico, Virginia.

A rifle deck at Quantico

Known Versus Questioned Specimens

Known, test-fired specimens are compared to questioned evidence specimens using the comparison microscope. Consisting of two separate microscopes joined by an optical bridge, this microscope allows the side-by-side observation and comparison of the microscopic characteristics present on different bullets or cartridge cases. A camera attached to this scope provides photographic documentation of these specimen comparisons, which are conducted with regard to *class characteristics* and *individual characteristics*.

In firearms identification, class characteristics include the number and direction of a barrel's rifling (e.g., four grooves, right twist or six grooves, left twist), caliber or gauge, and the width of lands and grooves. Individual characteristics are distinct, unique marks produced during the manufacturing process and include signatures of damage and wear, such as the impression left by a deformed or broken firing pin or the unusual striations left on a bullet by a spur on a sawn barrel. These features, in combination with the microscopic marks left on bullets and cartridge cases as a product of the discharge of a firearm, enable an examiner to identify and classify ammunition components and firearms in relation to each other.

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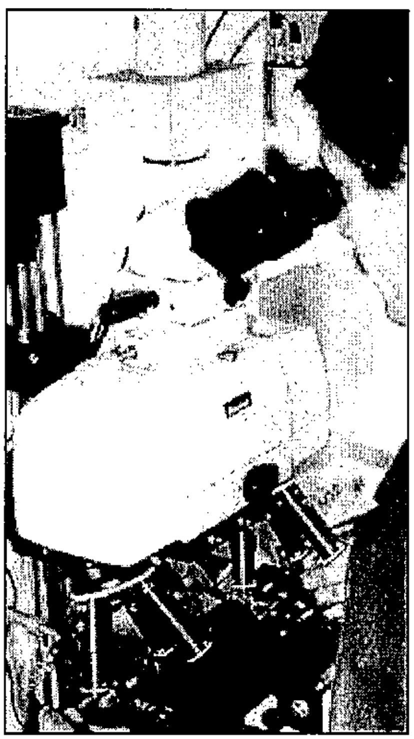

A comparison microscope

Examination Results

Following examination of case material, a firearms examiner will arrive at one of three conclusions: *identification*, *exclusion*, or *no conclusion*. An identification signifies a match between two ammunition components or a match between an ammunition component and a firearm. An exclusion represents a nonmatch between the examined items of evidence—the possibility of an association between the items is excluded. *No conclusion* indicates that the ammunition components could neither be identified nor eliminated as having been fired by a particular weapon based on the quantity and quality of microscopic markings. In this instance the class characteristics of the evidence in question may be in agreement, but the correspondence between individual characteristics or striae is insufficient or absent. This is not to say, however, that a given bullet could not have been fired by a submitted weapon, or from the same firearm as another bullet, but rather that the markings present on the bullet are of insufficient character to draw any conclusion.

In instances of severe leading,

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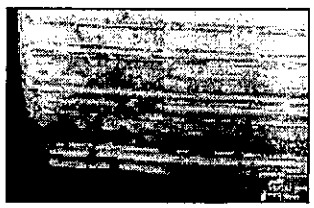
Comparison of the breechface impressions on two cartridge cases showing similarity of microscopic characteristics: a positive identification



A microscopic identification of two bullets showing the agreement of class characteristics

mutilation, or corrosion of a recovered weapon, the unique microscopic markings normally present in the barrel and other portions of the firearm may be obscured or obliterated and thus may preclude identification. Conclusive identifications of bullets or other ammunition components are similarly impossible when the rifling impressions on these components match the rifling type of a given firearm, but no other distinct, unique characteristics are present on the ammunition. In other words, a bullet may bear class characteristics like those produced by the barrel of a particular type of firearm but may not be impressed with individual identifying characteristics that match it with a single specific firearm.

Additional information on the forensic examination and identification of firearms and firearms components is available in the Firearms Examinations and Elemental Analysis Examinations sections of the *Handbook of Forensic Services*.

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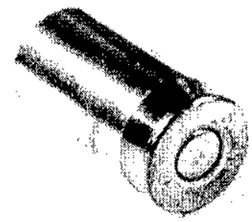
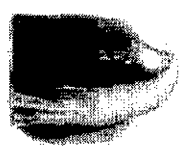
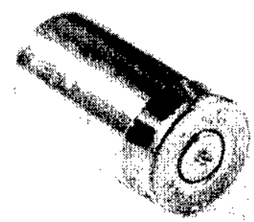
Bullet (unfired)



Casing (unfired)



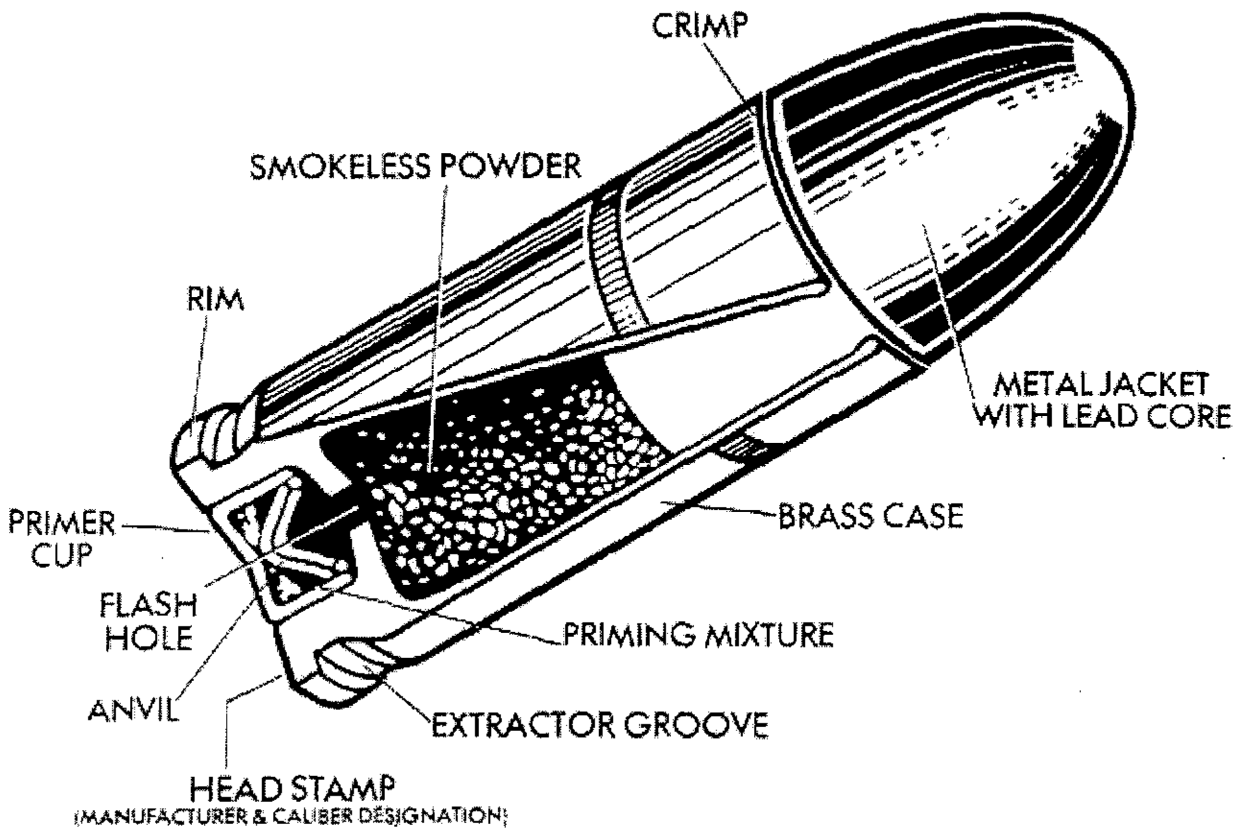
Bullet (fired)



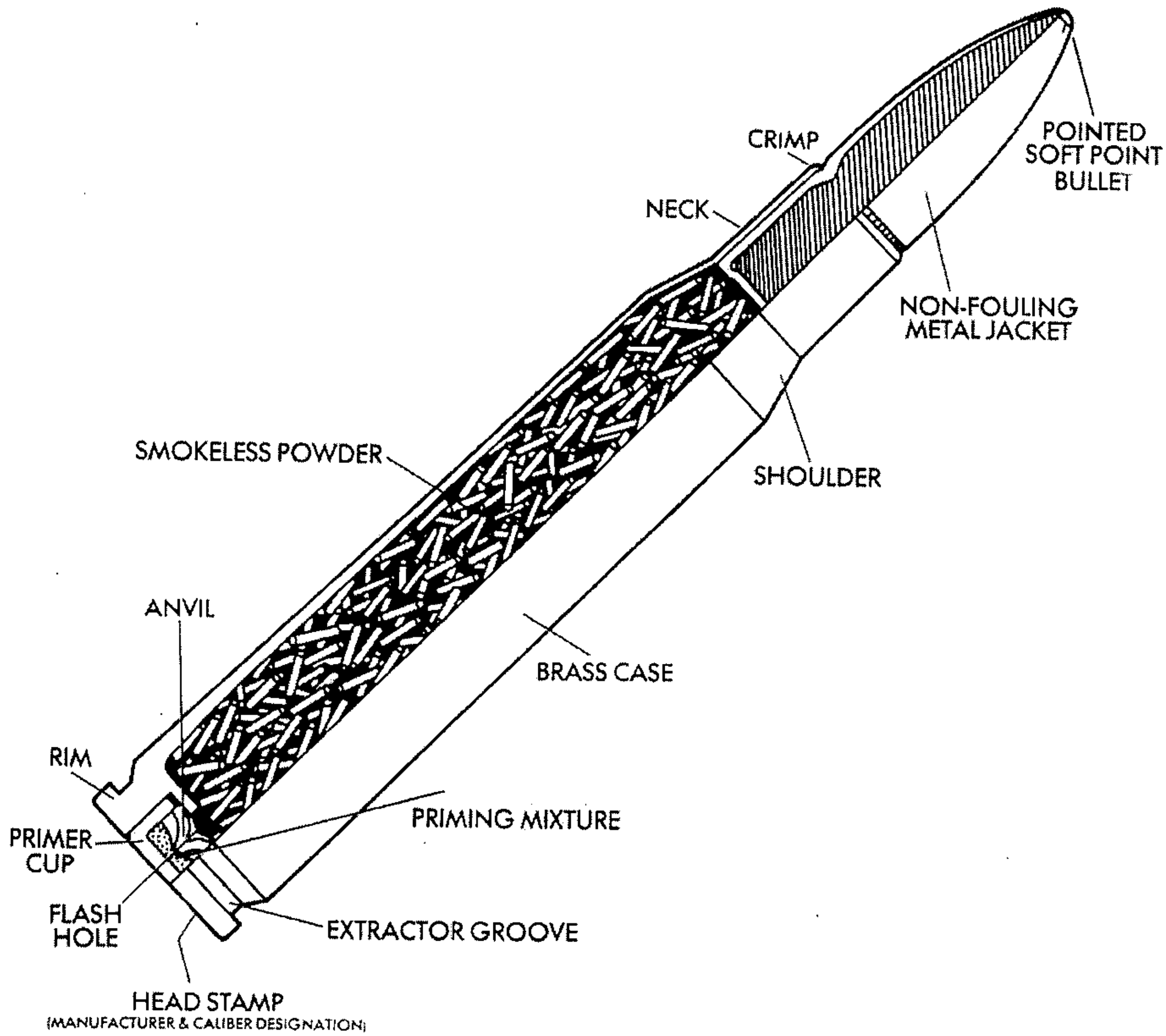
Casing (fired)

The pictures above illustrate identical bullets and cartridge casings, the top never fired, the bottom after firing. The marks made on bullets and casings during the firing process are visible in the bottom pictures.

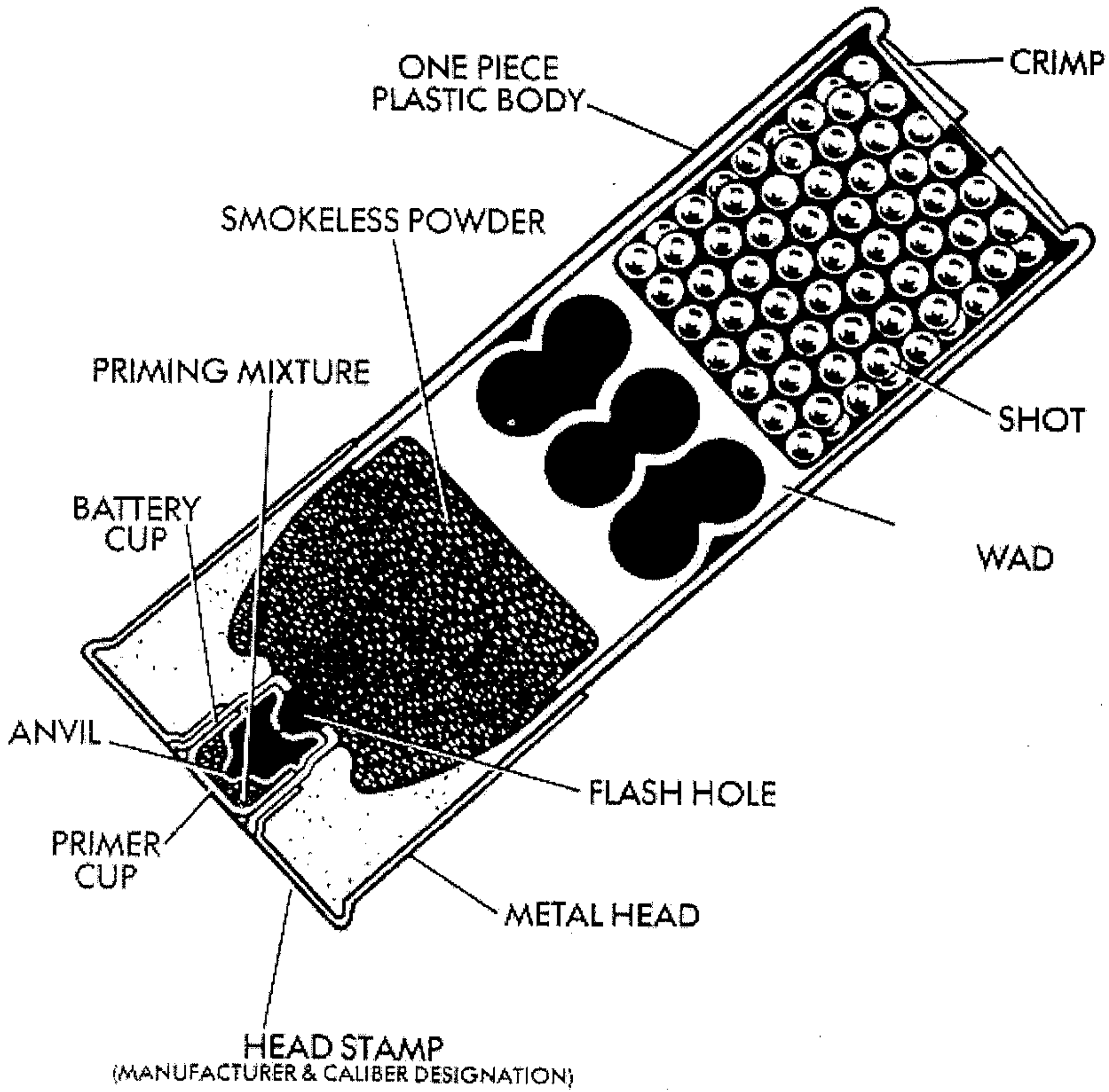
Pistol Cartridge/Full Metal Jacketed Bullet (Back)



Rifle Cartridge/Jacketed Soft Point Bullet (Back)



Shotgun Shotshell/Pellet Load (Back)



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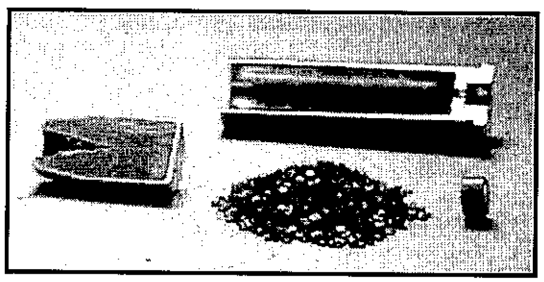
Caliber

W**hen a bullet is submitted for comparison to a firearm, one of the first examinations conducted will be to determine the bullet's ***caliber.

Caliber is a term used to indicate the diameter of a bullet in hundredths of an inch. A bullet that is 32 hundredths of an inch (.32) in diameter is called a 32 *caliber* bullet. The term caliber is of English origin and is used by ammunition and firearm manufacturers in the United States. Firearms and ammunition of European origin use the metric system and would refer to a 32 caliber bullet as an 7.65mm bullet.

The caliber of the bullet is just the first class characteristic that must agree with the questioned firearm. The bullet must also be of the type found in ***cartridges*** that the firearm will fire. A cartridge is a single unit of ammunition consisting of the cartridge case, primer, and propellant with or without one or more projectiles. The image below shows these various components.



Cartridges are usually given a name or ***cartridge designation*** by their developer, who is more often than not the manufacturer of a firearm (It doesn't make much sense to develop a cartridge if you don't have a firearm to fire it in). The cartridge designation typically includes a numerical value to indicate the approximate diameter of the bullet and will often include the manufacturer's name.

It never fails that when a cartridge is developed the manufacturer or others will immediately try to improve on the design. Variations to the original cartridge are usually inevitable and may be in the form of a longer or shorter case, differences in gunpowder, or differences with the weight and type of bullet contained in the cartridge.

When a variation in the cartridge case length occurs the cartridge's

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Striated Action Marks
Impressed Action Marks

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Striated Action Marks

Striated action marks are common to cartridge cases that have passed through the action of an auto loading or repeating firearm. Striated action marks can be produced on cartridge cases by contact with a number of different areas within the firearm. Some of the more common striated action marks include chamber marks; shear marks, firing pin drag marks, extractor marks, and ejector marks.

Chamber Marks

One of the most common striated action marks are called ***chamber marks***. Roughness in the chamber of a firearm can scratch the outer walls of a cartridge case when loaded and removed from the chamber. Most chamber marks occur after the cartridge is fired. Cartridge cases expand when fired pressing out against the walls of the chamber. When they are pulled out of the chamber, the sides of the cartridge case can be scratched. The comparison image below shows chamber marks on 22 caliber, rimfire cartridge cases.

Shear Marks

Another common striated action mark are ***shear marks*** produced by GLOCK pistols on cartridge case primers. GLOCK pistols have a

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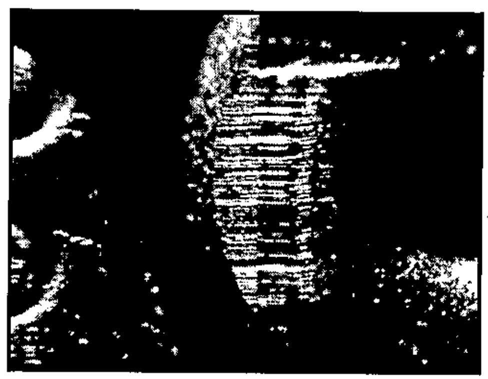
rectangular firing pin hole (below) in their breech face.

When a cartridge case is forced backwards from recoil the primer imbeds itself in the firing pin hole. As the slide of the pistol starts to recoil, the barrel will drop slightly as the action opens. The dropping barrel forces the cartridge case to move down slightly and when this happens the lower edge of the imbedded primer is sheared downward and out of the firing pin hole. The resulting striated marks can be seen in the comparison image below.

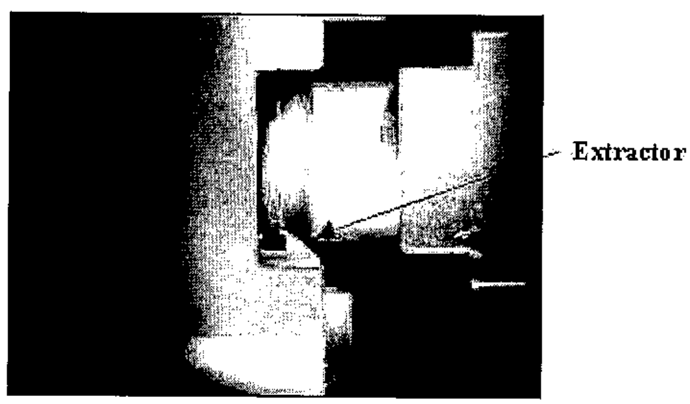


Firing Pin Drag Marks

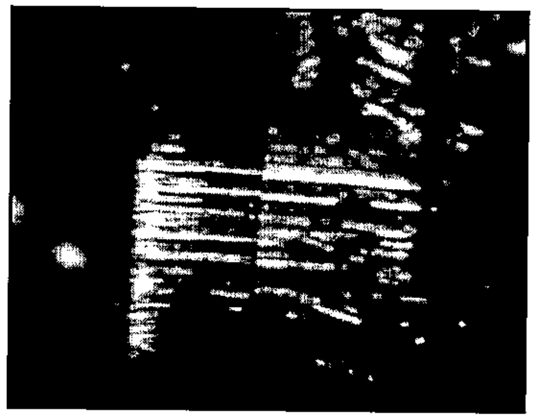
In a similar process, striated marks called ***firing pin drag marks*** can be produced. When the firing pin springs forward to strike the primer of a cartridge, it may remain slightly forward and imbedded in the primer. Certain barrels (like in the GLOCK) drop down slightly as recoil is forcing the action open. The cartridge case drops with the barrel causing the nose of the protruding firing pin to drag across the primer as it leaves the firing pin impression. The below comparison image shows firing pin drag marks produced by a Colt 45 AUTO pistol.

Extractor Marks

Another action mark, usually found in a striated form, are those created by the ***extractor*** of most auto-loading or repeating firearms. The extractor is a small part sometimes resembling a hook that is used to remove a cartridge or cartridge case from the chamber of a firearm. The image below shows the extractor of a 9mm GLOCK pistol hooked into the extractor groove of a cartridge. As the slide of the pistol moves to the rear, the extractor pulls the cartridge case along with it until it is ejected from the pistol.

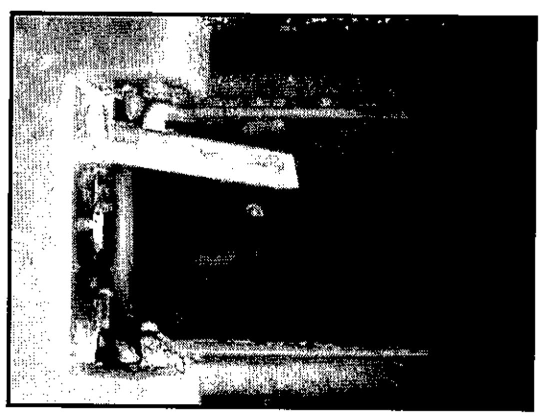


The extractor may or may not leave an identifiable mark on the cartridge case. This is true if the cartridge is fired or simply hand chambered and extracted without firing. Extractor marks may look like those seen in the comparison image below.



Ejector Marks

As described above, the extractor pulls the cartridge case out of firearm's chamber. As the cartridge case is pulled to the rear it will be struck somewhere on an opposing edge by a part as seen below called the ***ejector***.



The ejector is designed to expel the cartridge case from the action of the firearm. The resulting impact of the cartridge case with the ejector will cause another action mark that can be used as a means of identification.

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Ejector marks can be striated in nature but a lot of the time they are ***impressed action marks***. Click the next button below to learn more about impressed action marks.

Additional examples of cartridge case comparisons can be seen in the image galleries.

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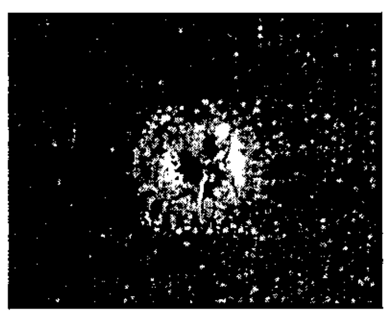
Bullet Hole Characteristics

There are cases that occur all the time where an examination of the victim's body can't determine which bullet hole is the entrance and which is the exit. Pretty critical when witnesses are saying something like, "The police officer came up behind my cousin and shot him in the back!" When the body offers no evidence of bullet entrance and bullet exit, firearm examiners will be called upon to examine the victim's clothing.

When a bullet strikes an object, such as clothing, a bullet entrance hole is created and in a lot of cases the bullet will pass through the object and produce an exit hole on the backside.

Bullet Entrance Holes

Bullet entrance holes typically have very even margins. Almost all non-contact bullet entrance holes will be smaller in diameter than the bullet due to the elasticity of the fabric. Some firmer materials and larger caliber bullets with large hollow point cavities may cause bullet entrance holes to be closer to the actual bullet's diameter but in most cases the diameter of the bullet entrance hole will be of little help in determining the caliber of the bullet.

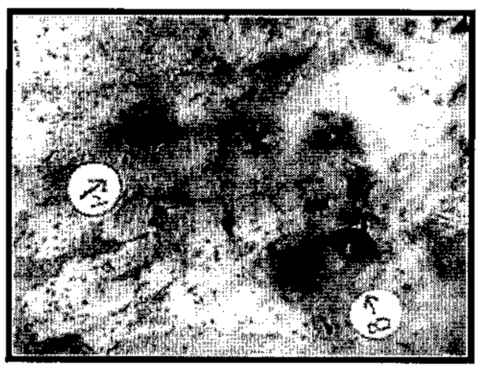


Typical bullet entrance hole in a holster.

Contact or near contact entrance holes and entrance holes caused by a bullet that has struck an intermediate object will typically have very uneven margins. Contact entrance holes will typically show extreme damage to the material of a garment. Generally speaking, the higher the velocity of the cartridge the greater the damage to the garment in a contact gunshot.

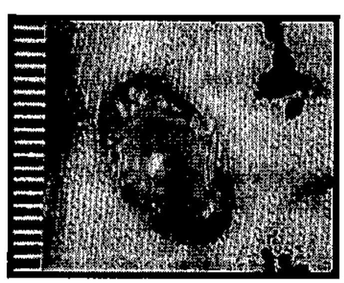
Typical contact entrance hole.

When a bullet strikes an intermediate target (for example the victim's arm) before entering the victim's shirt it may cause the bullet to fragment, expand, or even tumble. The resulting secondary bullet entrance hole can be very irregular in shape and hard to visibly distinguish from an exit hole. Subsequent testing for gunshot residues usually help in making this type of determination.



**Two bullet 7.62X39mm entrance holes where the bullets struck a windshield prior to entering the garment.
Very irregular holes with fragmentation and lead spray (pink).**

Bullets that strike a target at an extreme angle will usually leave an elongated hole. These holes typically will still have fairly even margins.



Angled bullet entrance hole.

It's not too uncommon for a grazing bullet to cause several holes in a wrinkled or folded garment.

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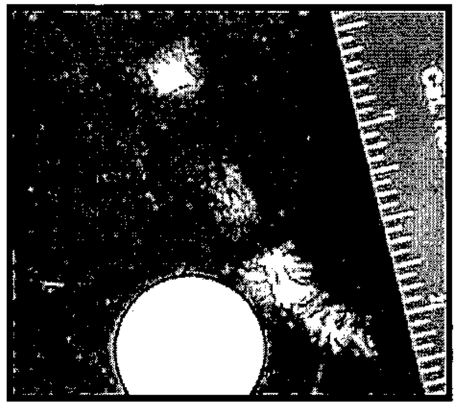
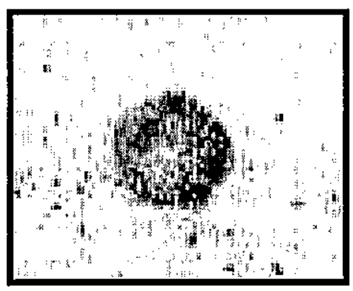


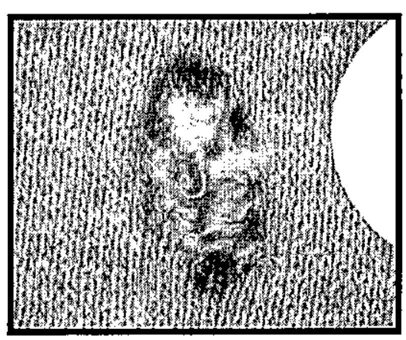
Angled grazing bullet holes made by a single bullet.

A common characteristic of bullet entrance holes is the presence of bullet wipe residue. Not always apparent on darker colored materials, bullet wipe residue is a darkened ring around the immediate margins of the hole. This ring of residue is caused by lead being wiped from the surface of the bullet as it passes through the material. Lead bullets normally leave the heaviest deposits of bullet wipe residue but it is not unusual for jacketed bullets to also deposit bullet wipe residue. Lead fouling in the barrel and lead primer residues can be on the surface of a jacketed bullet.



Bullet wipe residue around the margins of a lead bullet entrance hole.

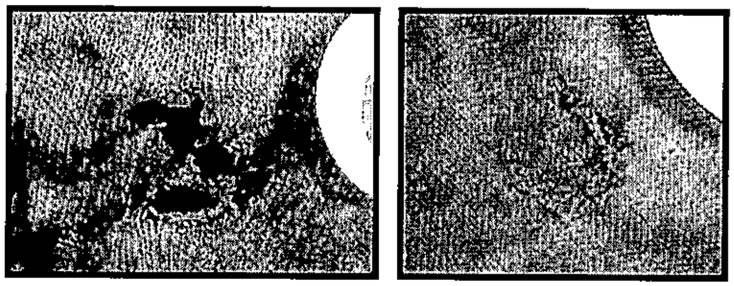
Chemically processing a garment for lead residues will cause a pink reaction around the hole.



Bullet wipe residue after chemical processing.

Bullet Exit Holes

Bullet exit holes are really not much to talk about. Full-metal-jacketed or round nosed bullets may leave holes that are similar to bullet entrance holes but most will be absent of bullet wipe residue. If bullet wipe residue is present it will normally be very light and on the inside of the exit hole. Bullet exit holes caused by fragmented or expanded bullets usually have irregular margins and it's not too uncommon for the bullet exit holes to be larger in diameter than the original diameter of the bullet. Fragmented bullets will typically grab the material of an object as it passes through causing the material to be frayed outward.



Typical Bullet Exit Holes

Once the bullet holes have been examined and fully documented, it's time to start looking for evidence that may allow for a distance determination to be made.

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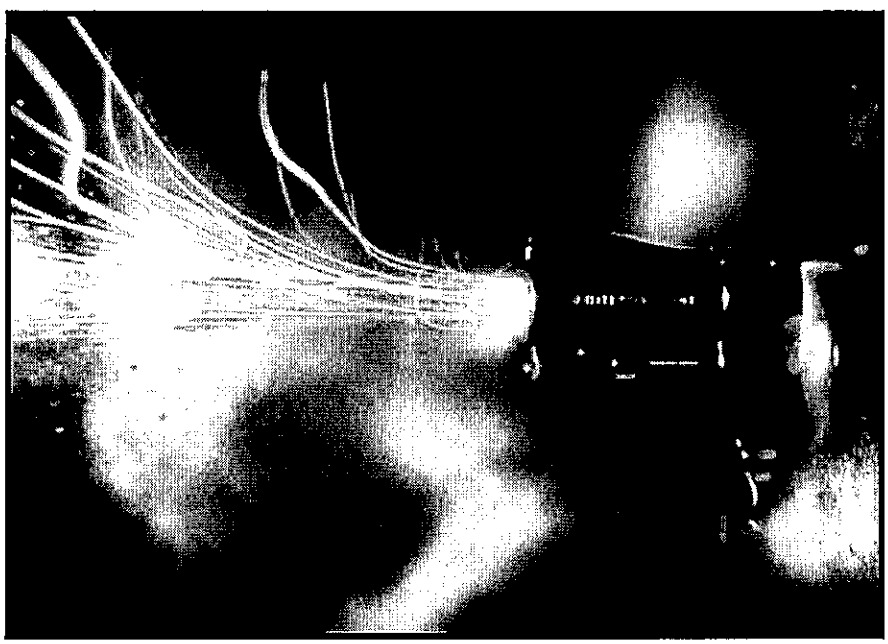
Gunshot Residue

When the firing pin of a firearm strikes the primer of a cartridge the ***primer compound*** ignites sending a flame into the cartridge case. ***Gunpowder*** in the cartridge case starts to burn, causing it to change from a solid material to a gas. This change creates pressure within the cartridge, which in turn forces the bullet down the barrel and down range. Pressure building behind the bullet is released when the bullet exits the muzzle of the firearm.

The bullet acts like the cork in a shook up Champagne bottle. When the bullet exits the muzzle, pressure behind it blows the gunshot residues out of the firearm's barrel under high velocity. The residues are expelled from the barrel in a smoky cone shaped pattern.



Time-lapsed image showing a bullet exiting from the barrel. Streaks of burning gunpowder, smoke, and unburned particulate can be seen exiting the barrel as well.

The further gunshot residues travel from the muzzle, the broader and less concentrated the pattern becomes. Because the various elements included in gunshot residues are very small and lack mass they lose their energy rapidly.

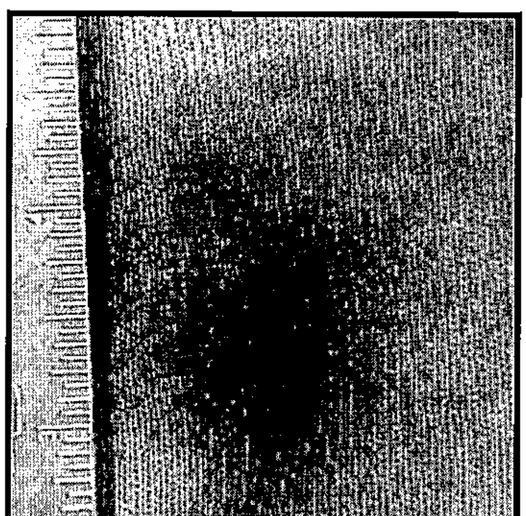
Gunshot residues can also be emitted from other areas of a firearm. As you can see in the above image, gunshot residue is escaping from the barrel/cylinder gap of the revolver.

The muzzle-to-garment distance can vary considerably depending on the firearm and type of ammunition being used. Short-barreled firearms and lower velocity cartridges will not normally expel residues as far as a high velocity rifle. At shorter distances however, they may deposit greater concentrations of gunshot residues. Also, gunpowder can come in several forms such as ball, flake, disc, and others. Ball powder being spherical in shape is more aerodynamic than say a particle of flake gunpowder and as a result will travel farther. A number of other variables can influence the amount of gunshot residues that may reach a target; therefore, it is essential that the firearm and ammunition used in the shooting incident be recovered.

Gunshot residues emitted from the muzzle will travel out to distances of approximately 3 and 5 feet in most firearms but in some cases can travel even greater distances. At the 3-5 foot range the gunshot residues may only consist of a few trace particles and make determining the firing distance difficult if not impossible.

As the firearm gets closer to its target the residue concentrations increase and the actual size or diameter to the pattern gets smaller. At around 18-24 inches most firearms will start to deposit considerable concentrations of gunshot residues that may or may not be visible to the eye.

At distances of less than around 12 inches heavy concentrations of visible gunshot residues will normally be deposited.



Visible gunshot residues around bullet entrance hole.

When the muzzle of the firearm gets next to or is in contact with the target, hot gases escaping from the muzzle at high velocity will typically rip, tear, shred, and/or melt the material of the target. A

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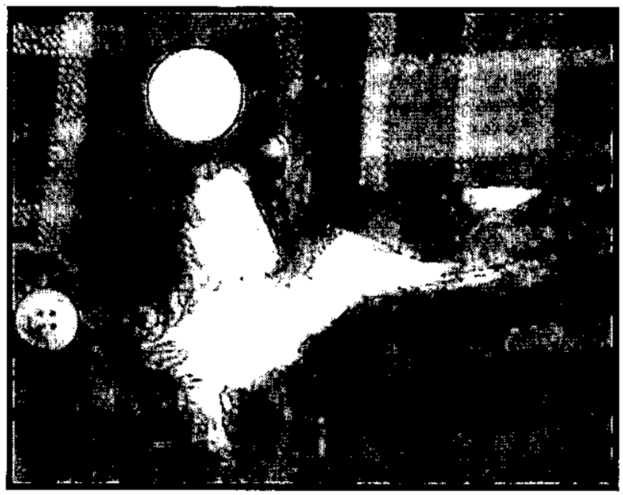
very intense deposit of gunshot residues will be found around the margins of a contact or near contact entrance hole.

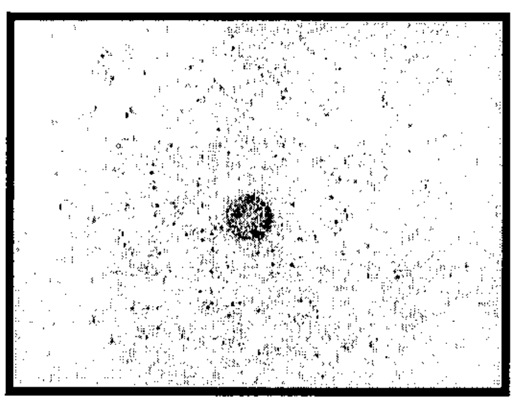


Contact gunshot entrance hole.

There have actually been cases where a hard contact gunshot (muzzle pressed hard against the victim) caused the residues to blow through the wound tract in the victim and be deposited around the inside of the exit hole of the victim's clothing.

Gunshot residue is normally a combination of ***gunpowder residues*** and ***lead residues***. I say normally because some newer ammunition is virtually lead-free. More and more ammunition manufacturers are using lead free or low lead propellants because of the toxicity of lead.

Gunpowder residue can contain unburned gunpowder particles, partially burned gunpowder particles or the carbonaceous soot from completely burned gunpowder. The image below show a bullet hole surrounded by gunpowder particulate residue.



Gunpowder particulate residue around bullet entrance hole.

Modern smokeless gunpowder, and black powder, contains ***nitrate*** compounds. Black powder normally contains a combination of potassium nitrate (75%), charcoal (15%), and sulfur (10%). Smokeless powders can either be ***single based*** or ***double based***.

Single based gunpowder will contain ***nitrocellulose*** (cellulose hexanitrate) as its main ingredient. Double based gunpowder contains nitrocellulose and ***nitroglycerin*** (glyceral trinitrate) as its base.

When either of these types of gunpowder burns the residue left behind will be in the form of a ***nitrite***-based compound. Nitrite particles when emitted from the muzzle of a firearm will strike a nearby target and either be imbedded in the target's surface or leave a deposit of nitrite residue.

Lead residues will be in a vaporous or particulate form and can come from a couple sources within a discharged cartridge. The most common source is the ***primer.*** Primers are used to start the ignition process in cartridges and commonly contain ***lead styphnate, barium nitrate, and antimony sulfide*** compounds. However, some newer primer compounds are being used that are lead and/or barium free.

Cartridges containing lead based primers, when ignited, produce a vaporous cloud of residue that is expelled from the muzzle of the firearm. Additional vaporous lead residues can be produced when the hot gases pushing a lead bullet down a barrel melt lead from the base of the bullet.

A third form of lead residue will be in a particulate form. Particulate lead residue comes from minute lead particles that are shaved from the sides of a lead bullet as it travels down the barrel. Lead particulate has more mass than vaporous lead and travels greater distances. Also, gunpowder particles can be coated by the lead residues and leave what appears to be a lead particulate deposit upon striking the target.

The amount of lead residue emitted from a gun can vary slightly from shot to shot. Fouling in the barrel from previous shots can slightly increase the amount of lead residue emitted from one shot to the next.

As described above, gunshot residue can be deposited on articles of clothing when in close proximity to a discharged firearm. *But will it stay there?* In most cases the answer is yes.

The various elements contained in gunshot residue are not readily water soluble and clothing left exposed to the elements will not usually diminish the residue deposits. Other factors such as heavy bleeding and rough handling of the garment can cover up or dislodge some residues. This has to be taken into consideration when conducting all such examinations. The garments must be promptly collected, allowed to air dry, and packaged in a way that will minimize contamination.

The clothing submitted to the laboratory will be examined to determine if a pattern of gunshot residue is present and there are a

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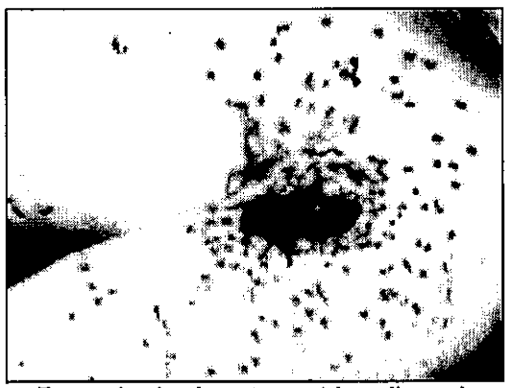
Shotgun Pattern Testing

Another test conducted by firearm examiners is known as ***Shotgun Pattern Testing***. This test involves shotguns and allows for a muzzle-to-target distance to be determined.

Shotgun pattern testing involves examining evidence for a pattern of holes created by the pellets fired from a shotgun. The "unknown" pattern is then compared to "test" patterns created with the suspect shotgun fired at known distances. This will allow for an approximate muzzle-to-target distance to be determined.



Two overlapping shot patterns. A large dispersed pattern overlaps a small close-range shot pattern.

When a shotgun is fired using a multiple pellet shotshell, the pellets exit the barrel of the shotgun and begin to spread out into a pattern that increases in diameter as the distance increases between the pellets and the shotgun.

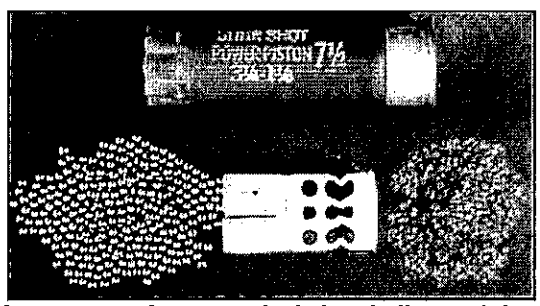
To better understand the principles involved in shotgun pattern testing it's important to first learn a little about shotguns and the shotshells they fire.

Shotguns are firearms typically fired from the shoulder that are designed to fire shotshells containing anywhere from one large projectile to as many as several hundred small pellets. Shotguns aren't classified by caliber but come in different ***gauges***. *The gauge of a shotgun is determined by the number of round lead balls of bore diameter that it takes to equal one pound.* Shotguns can come in 10, 12, 16, 20, 28, and .410 gauge. The .410 is interchangeable or adjustable choke tubes. Shotguns that have had their barrels sawed off have had their choke removed. This creates a shotgun with a cylinder-bore barrel.

The whole point to this "choke thing" is that the choke plays an important role in the rate at which the shot pellets spread as they travel away from the shotgun. A full-choke barrel will tend to shoot smaller shot patterns at a given distance than a barrel with a modified-choke.

Shotshells are cartridges designed to be fired in shotguns and can contain a single large projectile - a slug - or as many as several hundred small spherical pellets called ***shot***. Shot used in shotshells has traditionally been made of lead but because of it's toxicity, other materials are being used as a substitute, with the most common alternative being steel.

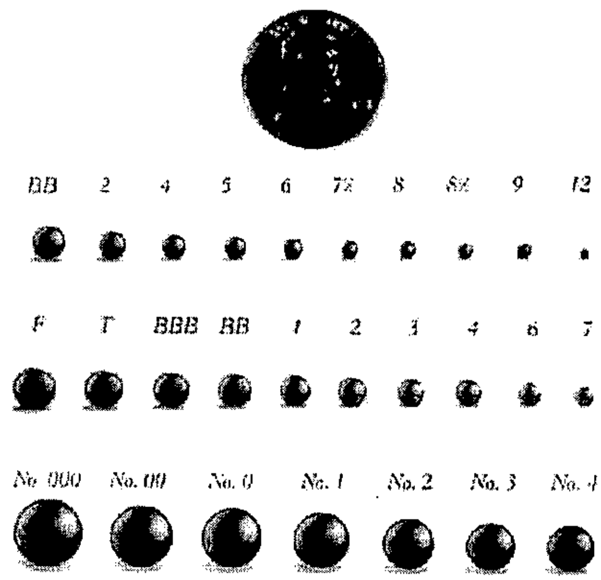
The size of the shot can vary as can the total weight of the shot loaded into a shotshell. Shot comes in two basic varieties, small pellets commonly referred to as ***birdshot*** and larger pellets called ***buckshot***.



Components from a typical shotshell containing birdshot and a one-piece plastic wad.

Components from a typical shotshell containing buckshot and a fiber/plastic wad combination.

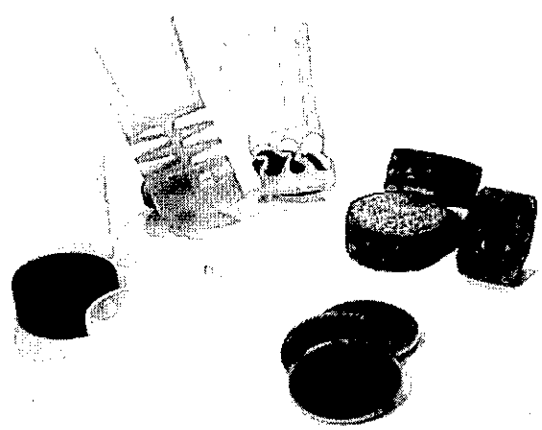
Lead birdshot comes in 12, 11, 9, 8 1/2, 8, 7 1/2, 6, 5, 4, 2, and BB sizes. As the numbers get smaller the diameter of the shot gets larger. Buckshot on the other had comes in 4, 3, 2, 1, 0, 00, and 000. Again, as the number decreases the diameter increases. See the chart below.



Shot size table: lead shot (top), steel shot (middle) and buckshot (bottom).

As you can see from the above chart, steel shot comes in slightly larger sizes than lead shot. Steel doesn't have the density of lead and larger shot is needed to achieve a range comparable to that of lead shot.

Shotshells contain a variety of different ***wads*** - plastic, paper, or fiber material designed to separate the shot from the gunpowder and/or protect the shot as it is pushed down the barrel - that are expelled from the shotshell, along with the shot, when fired.



Various plastic and fiber shotshell wads.

Shotshells come in a variety of loads. The amount of gunpowder in a shotshell can vary and the measurement is referred to by as the ***dram equivalent.*** The dram equivalent is the amount of smokeless powder that produces a velocity comparable to that of black powder.

All of these variables are important in determining a given shot pattern distance.

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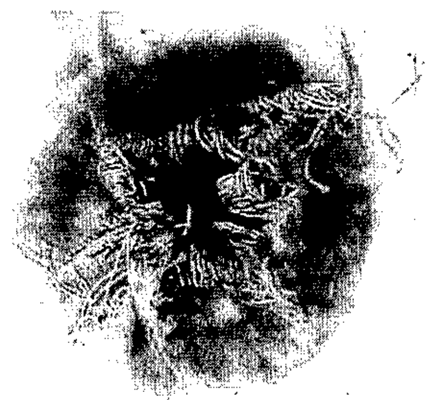
When a shotgun is fired the shot and wadding travel down the barrel and exit the muzzle in a concentrated mass.

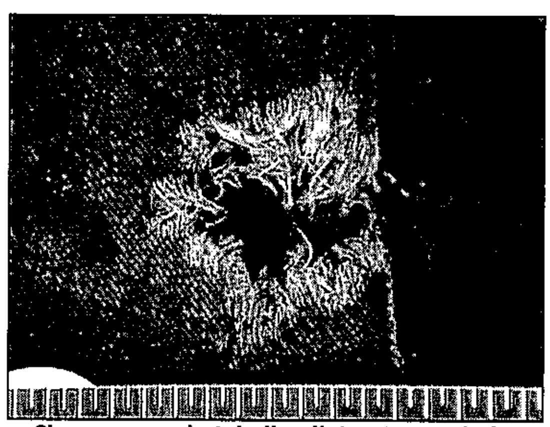
As a result a contact entrance hole will produce a large hole with significant damage to the margins of the hole, but can vary greatly depending on the material being fired into. The same thing also applies to gunshot residue deposits. Most contact entrance holes will have a significant deposit of gunshot residues like the one seen below, but this is not always the case. Some may display very little visible gunshot residue.



Contact shotgun entrance hole.

A hole like the one above will be processed chemically like that previously described on the Distance Determination/Gunshot Residue pages.

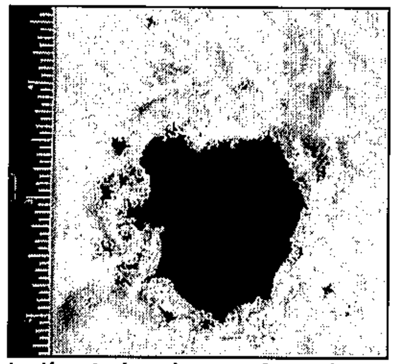
At ranges of around 5-10 feet* the shot and wadding mass will produce a single large hole in a target. If the target happens to be a person, the wadding material will be blown into the wound tract with the pellets.



Close-range shotshell pellet entrance hole.

The close-range entrance (less than 5 feet*)hole seen above is almost square, and is a common shape for this range. You might notice a pinkish color (lead residue) to the material around the hole.

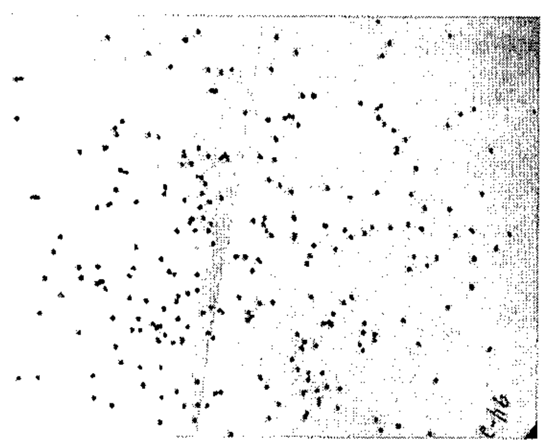
At distances greater than 5-10 feet* the shot mass starts to break up. Fliers (individual pellet holes) will start to appear around the edge of an entrance hole and the wadding may or may not enter the victim.



Individual pellets starting to break apart from the main mass of pellets.

As the wadding slows down it will start to take a separate trajectory from that of the shot and can actually leave abrasions or bruises to the area around an entrance wound. Wadding will lose its energy and fall harmlessly to the ground at distances of around 20 feet*.

As the pellets get further and further away from the shotgun the pattern will eventually become dispersed to the point that only individual pellet holes are present in a target.



Witness panel fired into at a distance of 28 feet.

Firearm examiners will try to reproduce the pattern by firing into witness panels at known distances. Shot patterns can be affected by the load, pellet size, wad type, and choke of the shotgun. That is why it is essential that the shotgun is recovered and the type of shotshells used is known. Hopefully some shotshells will be recovered at the scene that can later be used in firing the distance standards. Also, patterns produced by a shotgun at any given distance can vary slightly. Multiple tests patterns will be fired at known distances and compared directly to the pattern in question.