Overview of Analyzing Firearm, Tool Mark and Impression Evidence at the Miami-Dade Police Department

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Introduction and Fundamental Principles
(Part 1 of 8)

Firearm and Tool Mark Identification vs. *Forensic Ballistics*

- *Ballistics* deals with the motion of a projectile and the forces which cause and affect this motion.
- *Firearm and Tool Mark Identification* is not concerned with this, but rather the marks imparted from the gun to the bullet and/or casing.
- “Forensic Ballistics” is therefore an improper term that is used, although incorrectly, to describe this discipline of Forensic Science.
- Practitioners prefer the title of “Firearm and Tool Mark Identification” instead of “Forensic Ballistics.”

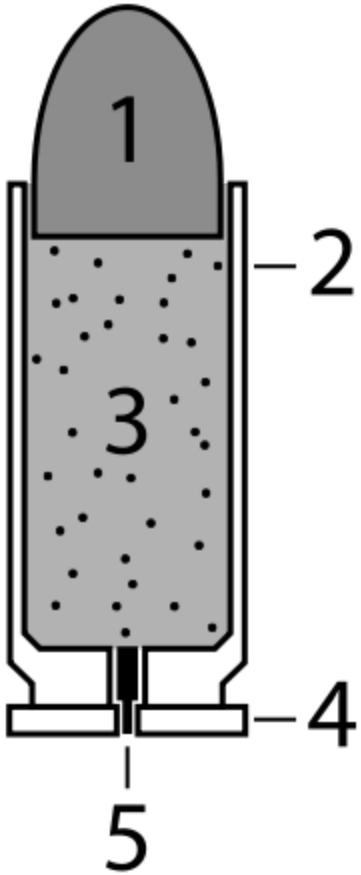
Evidentiary Value

- **A component of ammunition (casing and/or projectile) from the crime scene can be identified to the firearm that fired it to a reasonable degree of scientific certainty.**

- **A firearm leaves it's unique "fingerprint" on components of ammunition fired in that firearm. This "fingerprint" is in the form of unique impressions or striations also known as a tool marks.**

- **Casing or projectile evidence from a crime scene identified to a firearm in the possession of a potential suspect would represent strong evidence against that suspect.**

Components of Ammunition (anatomy of a cartridge)



- 1. bullet/projectile
- 2. casing
- 3. gunpowder
- 4. head of casing
- 5. primer

- After firing, one cartridge becomes two pieces of evidence (a projectile and a casing)

Connection to Interior Ballistics

- Firearm and tool mark examiners are concerned with what happens inside the chamber and bore during the firing sequence.

- While the ballistics industry is interested in optimizing the performance of a load by studying breech pressures and primer efficiency. FA-TM examiners are interested in the impressed or striated markings left on the ammunition components from the interior (breech, chamber, barrel) of the gun.

- These marks are transferred to the surface of ammunition components as a result of the pressures involved with setting off a unit of ammunition

Search for fired evidence

- It is important that the crime scene investigator is thorough in his/her search for fired evidence.
- Ejected casings:
  - Behind, under, and on top of furniture (inside)
  - In grass, under parked cars (outside)
  - If firearm fired in car…between cushions, under seats, down dash board

Search of fired evidence (cont.)

- Projectiles can be found in walls, tree bark, the ground, within a body (medical examiner), within car cushions or furniture cushions, etc., etc.
- Spent projectiles will have land/groove markings.
- Fired casings will have breech face marks, firing pin impressions, extractor marks, ejector marks, chamber marks.

Fundamentals of Firearm & Toolmark Identification

- Definitions
- Fundamental Propositions (1 & 2)
- Examination Method
- Range of Conclusions

Definition:
Firearm & Toolmark Identification

An empirical comparative analysis that can determine if a striated or impressed mark was produced by a particular tool.

Definition: *Tool*

The harder of two objects that comes into forceful contact with one another, resulting in the softer object being marked.

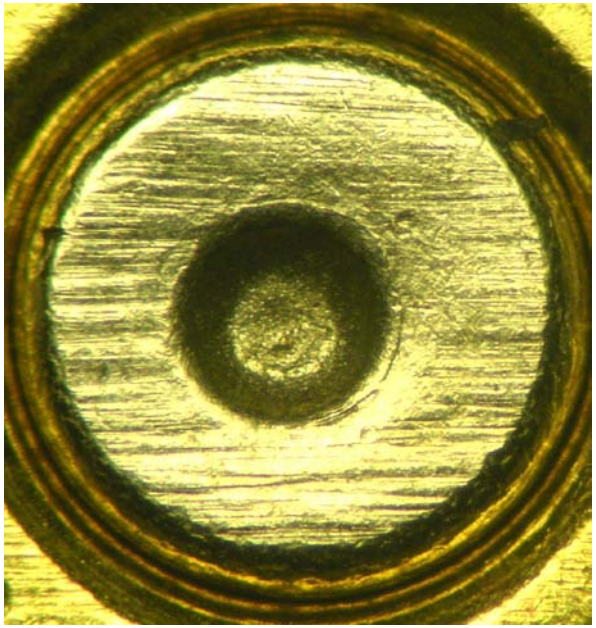
Definition: *Toolmark*

Features imparted on an object by the contact and force exerted from a tool.

- *Two Types:*
  - Impressed Toolmarks
  - Striated Toolmarks

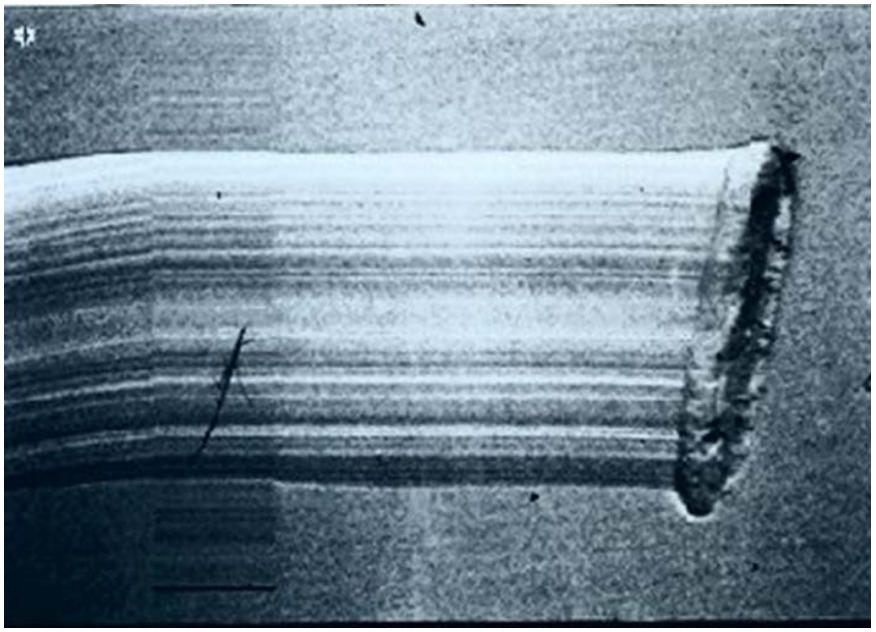
Definition: *Impressed Toolmark*

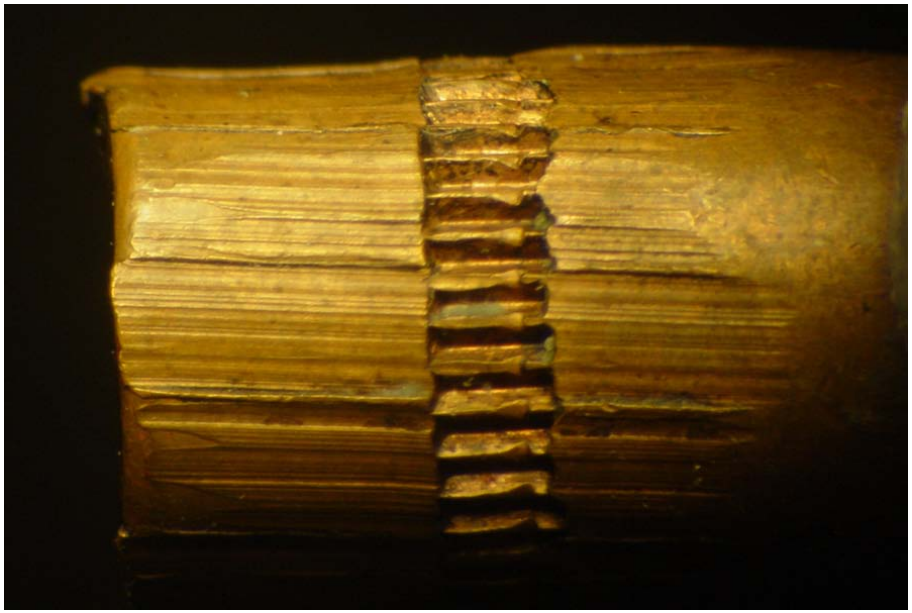
Features produced when a tool contacts an object with enough compressive force that it leaves an impression.



Definition: *Striated Toolmark*

Features produced when a tool contacts an object with lateral force and motion.





The Science of Firearm & Toolmark Identification is based on two fundamental propositions:

Proposition #1

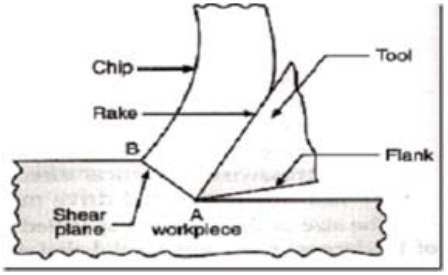
Toolmarks imparted to objects by different tools will rarely if ever display agreement sufficient to lead a qualified examiner to conclude the objects were marked by the same tool. That is, a qualified examiner will rarely if ever commit a false positive error (misidentification).

Pattern Matching

- FA-TM examiners use pattern matching.
- Pattern matching: A visual comparative examination of the topographical features of two different toolmarks.
  - The relative height or depth, width, curvature, and spatial relationship of the features are defined for one toolmark and are then compared to the corresponding topographical features in the other toolmark.

Proposition #2

Most manufacturing processes involve the transfer of rapidly changing or random marks onto work pieces such as barrel bores, breech faces, firing pins, screwdriver blades, and the working surfaces of other common tools. This is caused principally by the phenomena of chip formation and tool wear, or by electrical/chemical erosion. Microscopic marks on tools may then continue to change from further wear, corrosion, or abuse.



- Manufacturing operations create microscopic random imperfections on/in work pieces that give rise to the individual characteristics on bullets and cartridge casings.
- This is even true with firearm components manufactured in consecutively.

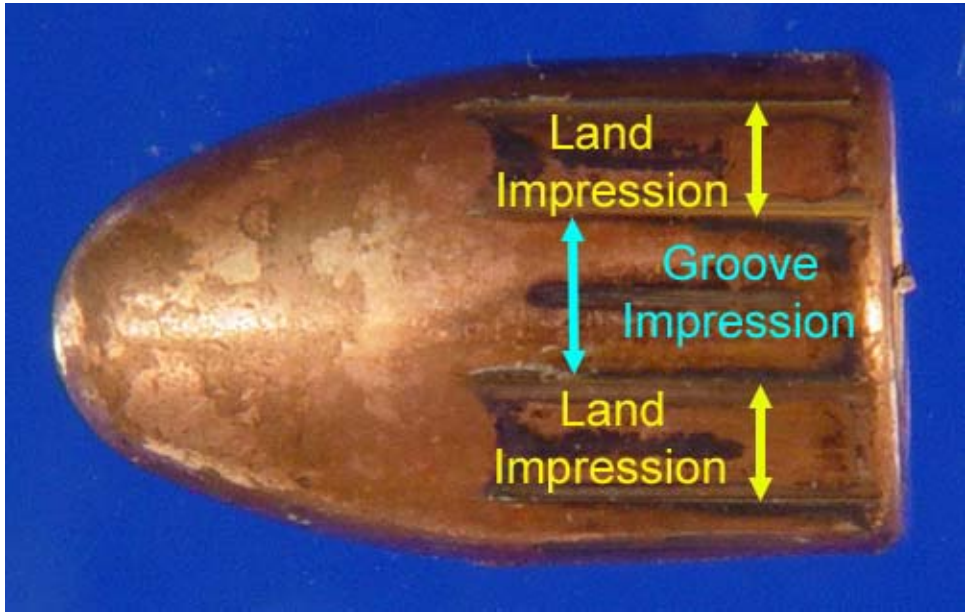
Definition: *Class Characteristics*

General and/or measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture.

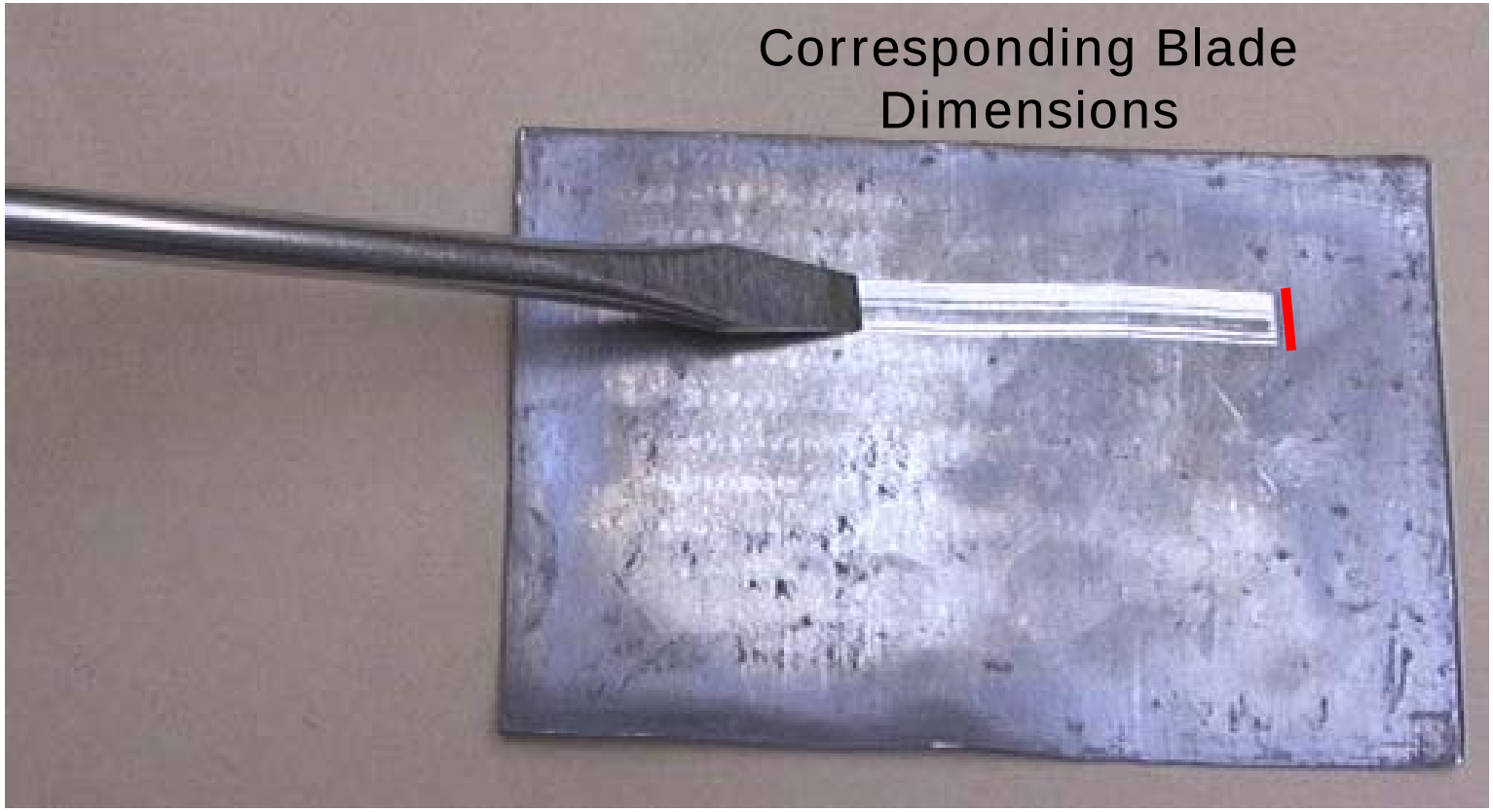
Examples of Class Characteristics

Known Source:
Rifling

Questioned Item:
Bullet



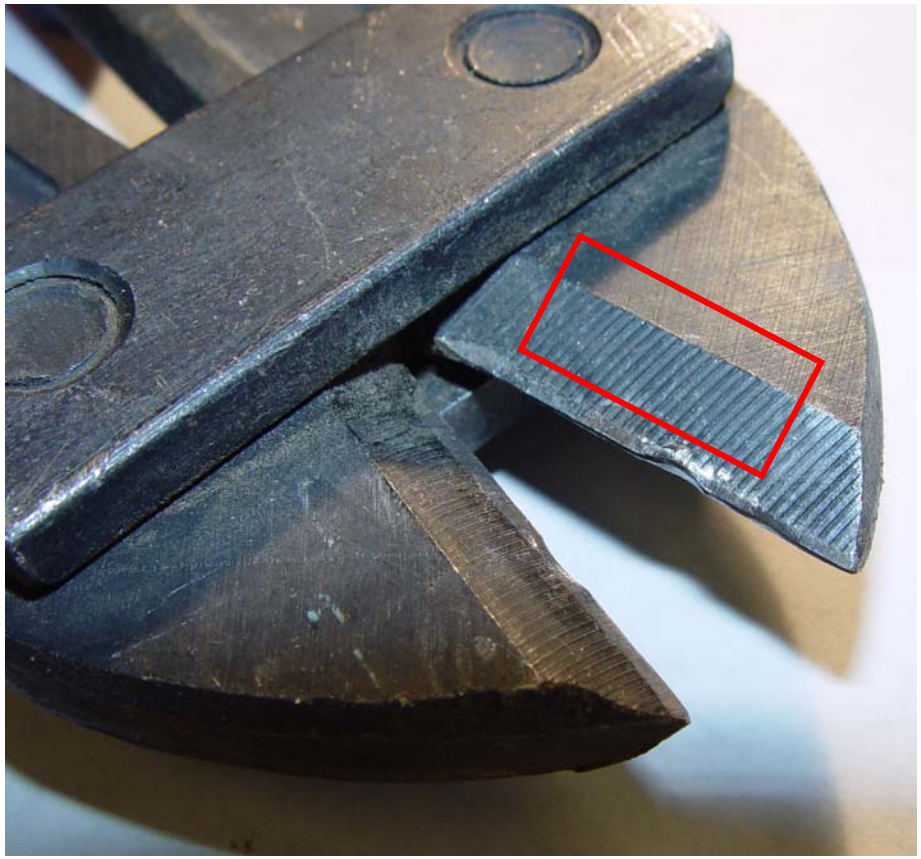
Examples of Class Characteristics

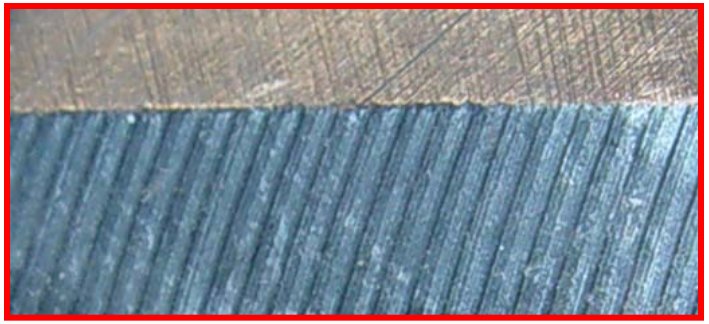


Definition: *Subclass Characteristics*

Features that may be produced during manufacture that are consistent among some items fabricated by the same tool. These are not determined prior to manufacture and are more restrictive than class characteristics.

Example of Subclass



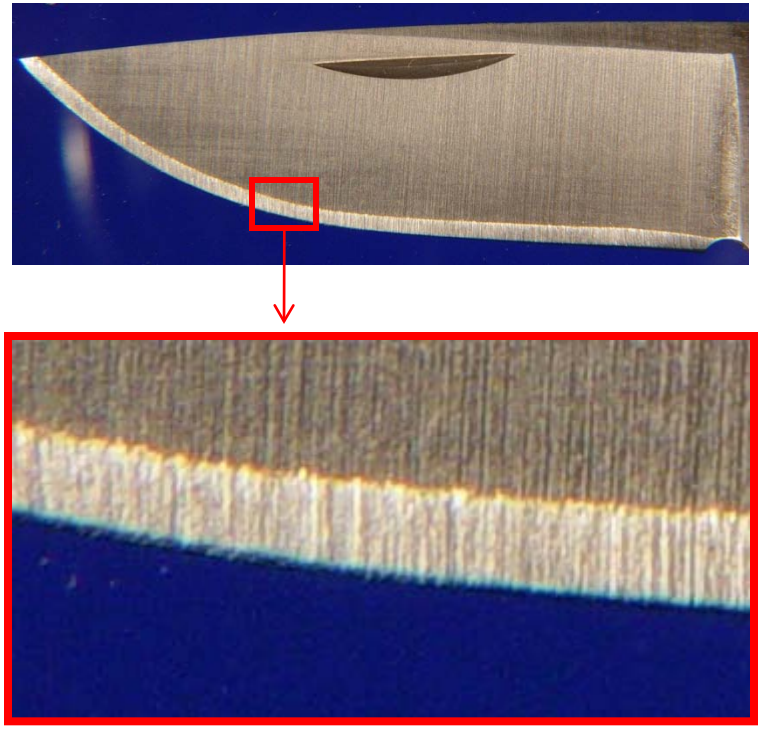


How are individual characteristics produced?

These random imperfections or irregularities can be produced by:

- Manufacture
- Wear from Use
- Wear from Abuse

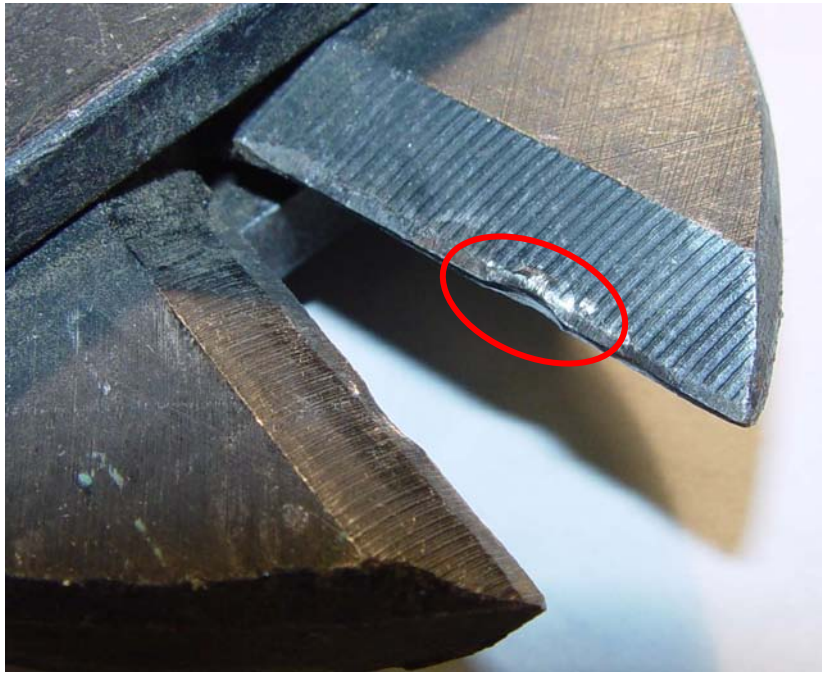
Example of Individual Characteristics from Manufacture



Example of Individual Characteristics from Wear

Use

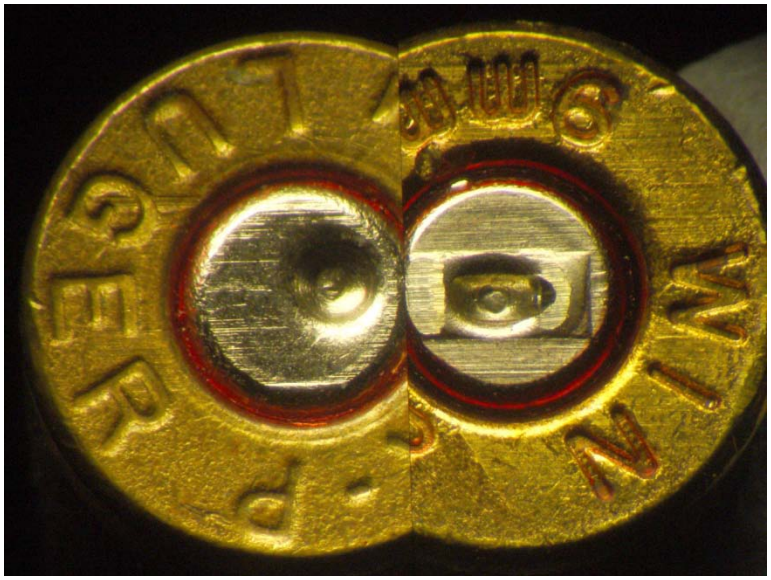
Abuse

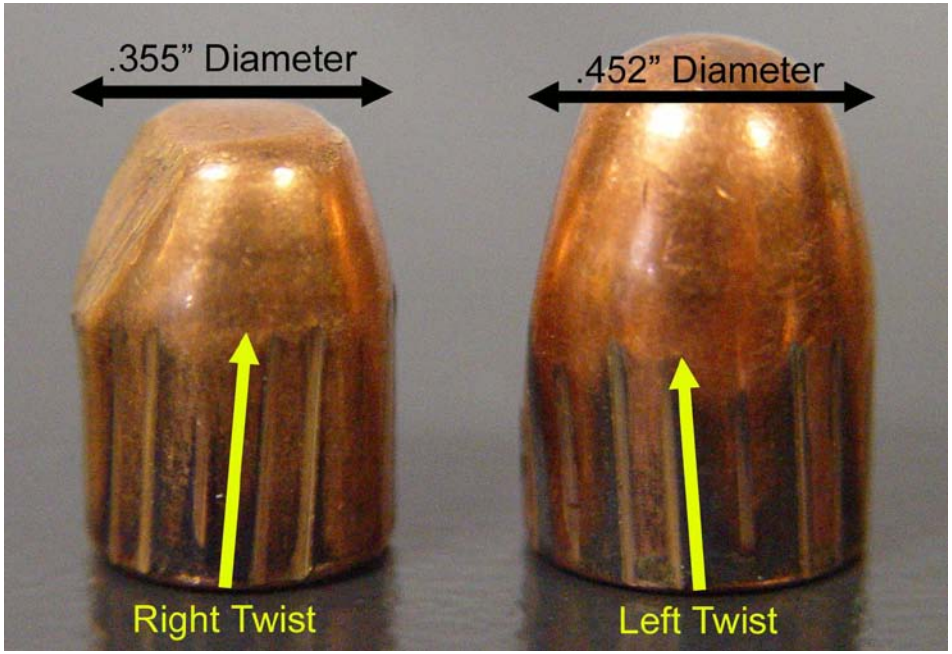


Examination Process

Level 1 analysis - *Class Characteristics*

- Elimination, but not individualization, can occur here

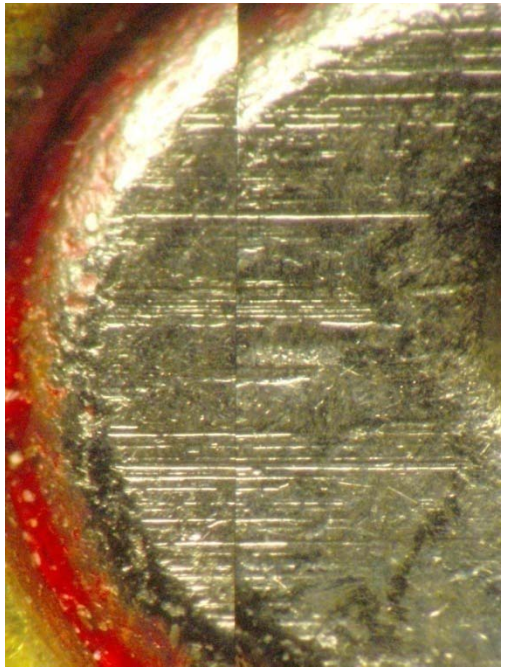




Examination Process

Level 2 analysis - *Comparison Microscopy*

- Individualization occurs only here



The Comparison Microscope

- The comparison microscope serves as the single most important tool to a firearms examiner.
- Two bullets or two casings can be observed and compared simultaneously within the same field of view.
- The longitudinal striations between two bullets must coincide for there to be a match.
- The breech face impressions and/or firing pin impressions must coincide for there to be a match between two casings.

Range of Conclusions

- Identification
- Inconclusive
- Elimination

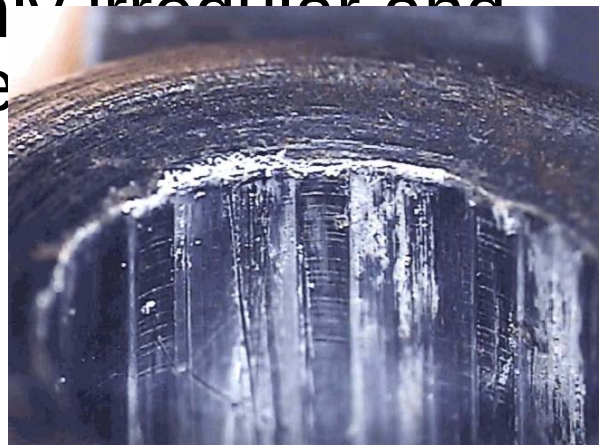
Identification with unique marks.

- Unique variations and irregularities caused by scratches, nicks, breaks, and wear may permit the forensic scientist to relate:
  - A spent projectile to a firearm (striations), a fired casing to a firearm (impressions)
  - A scratch or abrasion mark to a single tool (striated and impressed)
  - A tire track to a particular automobile, a shoe print to a particular shoe (both impressed)

Bullet Comparisons (Part 2 of 8)

Firearm Barrel Markings

- The inner surface of the barrel of a gun leaves its markings on a bullet passing through it.
- These markings are peculiar to each gun.
- The gun barrel is produced from a solid bar of steel that has been hollowed out by drilling, then reaming.
- The microscopic reaming marks left on the barrel's inner surface are random
serve to impart a uniqueness to e

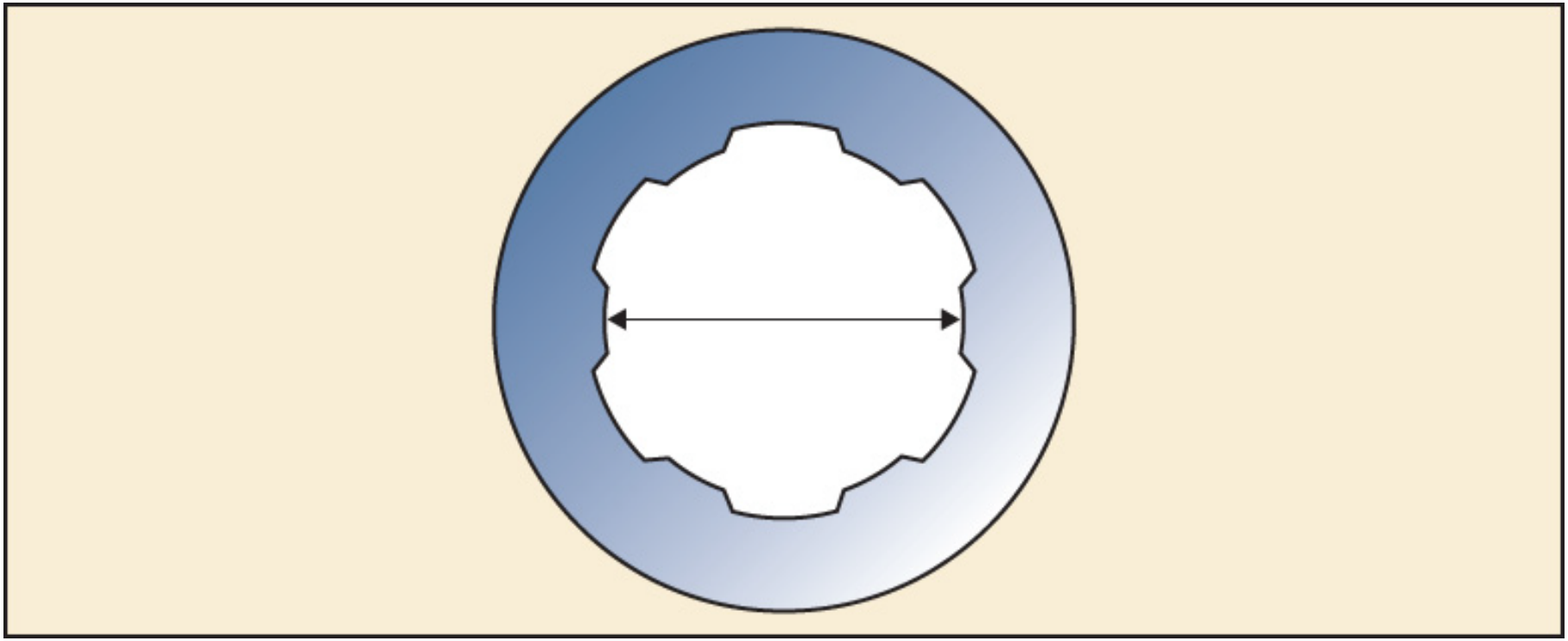


Firearm Barrel Markings

- The manufacture of a barrel also requires impressing its inner surface with spiral grooves, a step known as rifling.
- The surfaces of the original bore remaining between the grooves are called ***lands.***
- The grooves serve to guide a fired bullet through the barrel, imparting a rapid spin to insure accuracy.

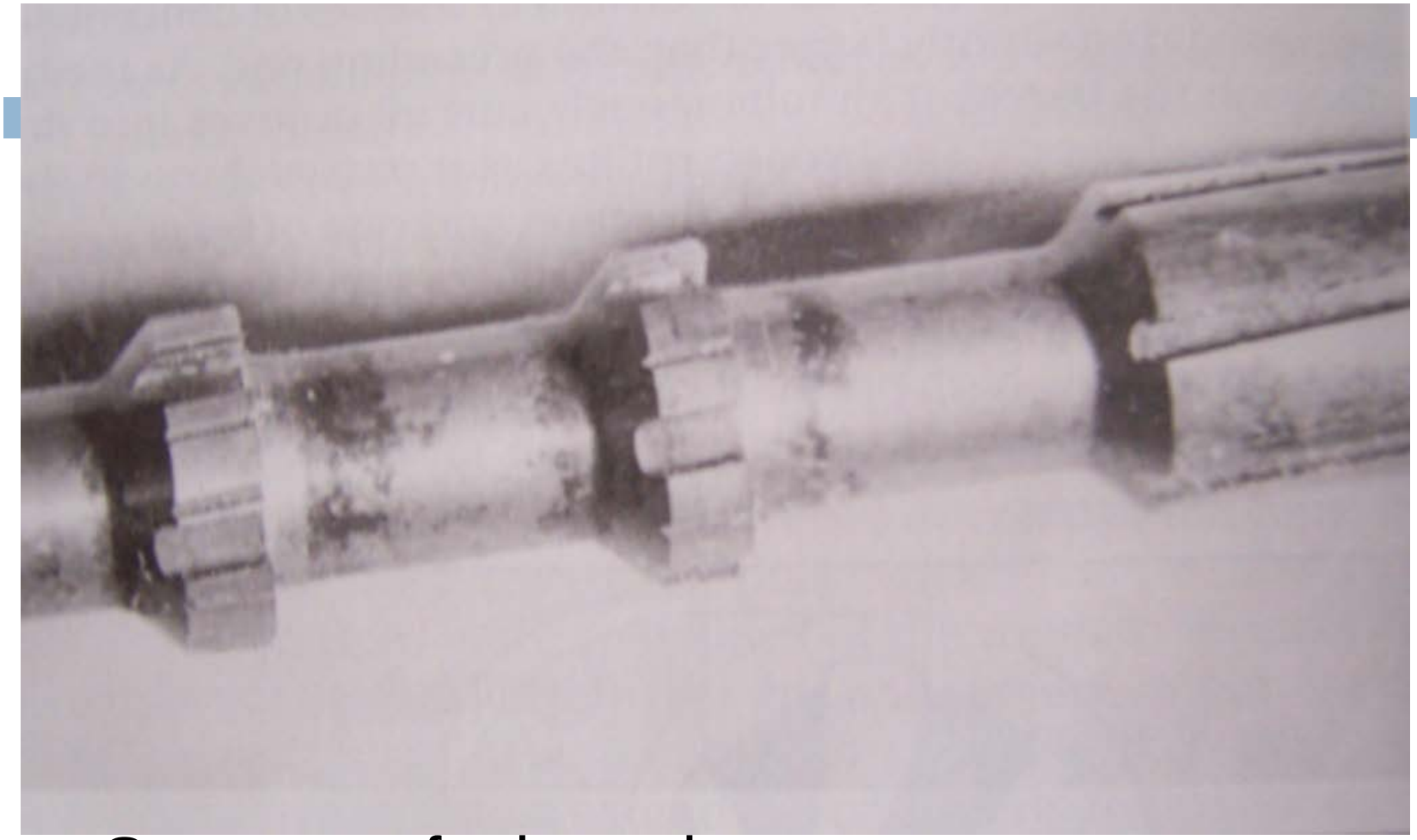
Firearm Barrel Markings

- The diameter of the firearm barrel, measured between opposite lands, is known as **caliber**.
- Once a manufacturer chooses a rifling process, the class characteristics of the weapon's barrel will remain consistent, each will have the same number of lands and grooves, with the same approximate width and direction of twist.

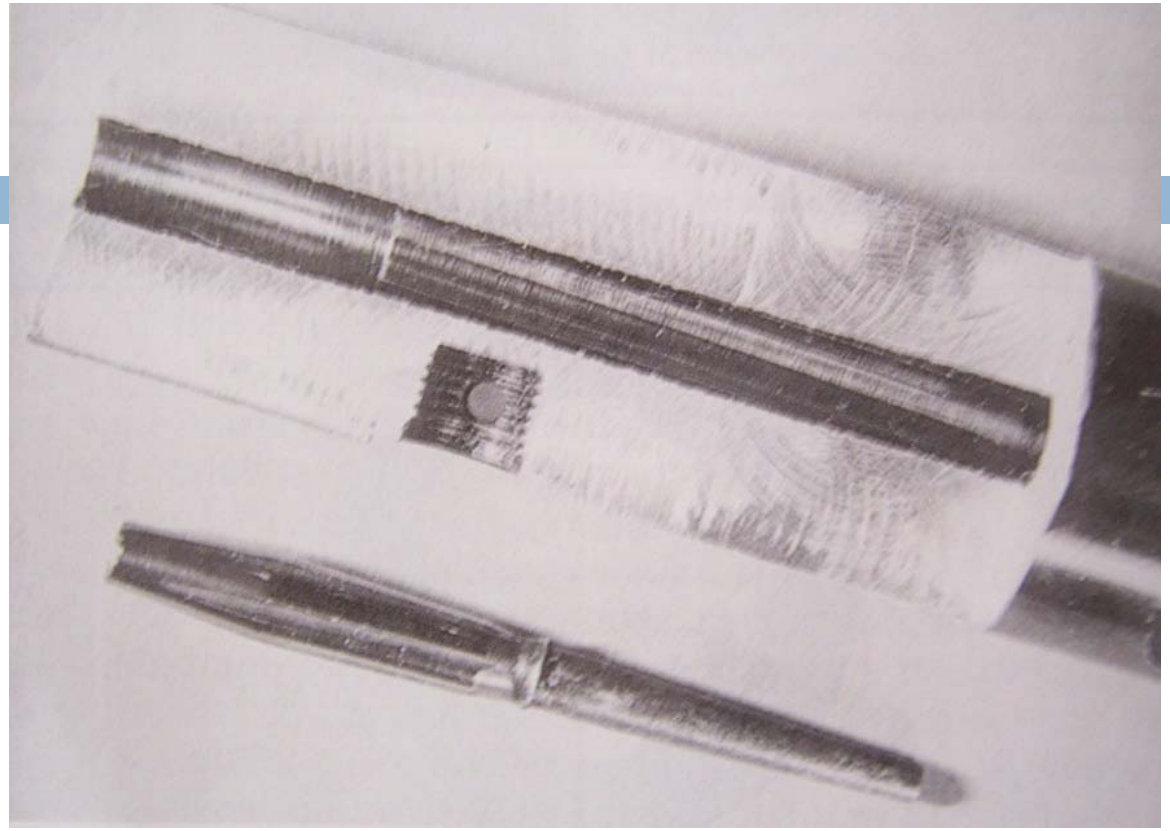


Cross-section of a barrel with six grooves. The diameter of the bore is the caliber.

- Lands and grooves give a spin to a projectile allowing it to stay true on its trajectory.
- Lands and grooves are made during the manufacturing process.



- Segment of a broach cutter



- (Top) Cross section of a .22-caliber rifled barrel.
- (Bottom) Button used to produce the lands and grooves in the barrel

Evidence bullets (different levels received condition)

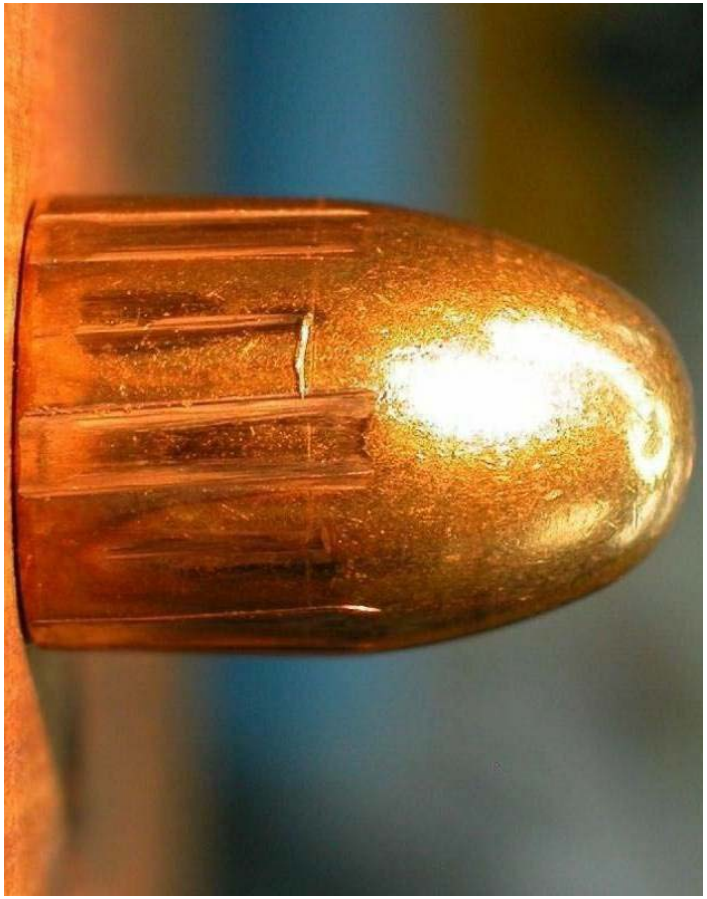
- Pristine value → Damaged → No comparison

Making Standards

- A suspect firearm is test fired into a water filled tank.
- The spent projectile is recovered from the bottom of the tank.
- The fired casings are collected off the floor of the room containing the tank.
- These known standards are used to compare to unknown evidence.

“Pristine” projectile from water tank, great for comparison.

- A bullet is impressed with the rifling markings of the barrel when it emerges from the weapon.



Class Characteristics (Bullets)

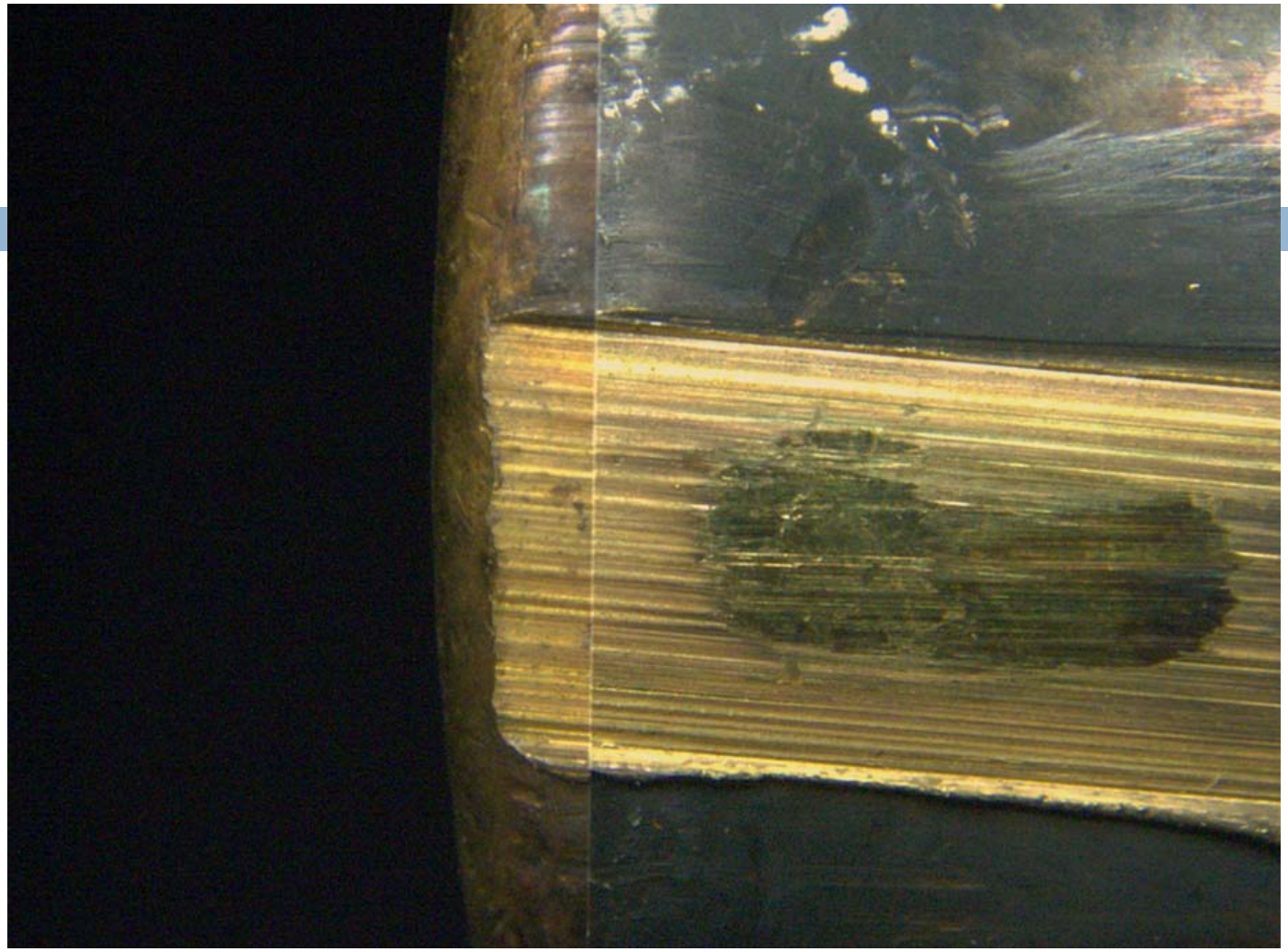
- Twist direction (right or left)
- Number of lands and grooves (# lands = # grooves)
- Caliber (9mm, .40 S&W, .357 Magnum, .380 Auto, .45 Auto)
- Land width, Groove width

Striations

- **Striations**, which are fine lines found in the interior of the barrel, are impressed into the metal as the negatives of minute imperfections found on the rifling cutter's surface, or they are produced by minute chips of steel pushed against the barrel's inner surface by a moving broach cutter.

- These striations form the individual characteristics of the barrel.

- It is the inner surface of the barrel of a firearm that leaves its striation markings on a bullet passing through it.

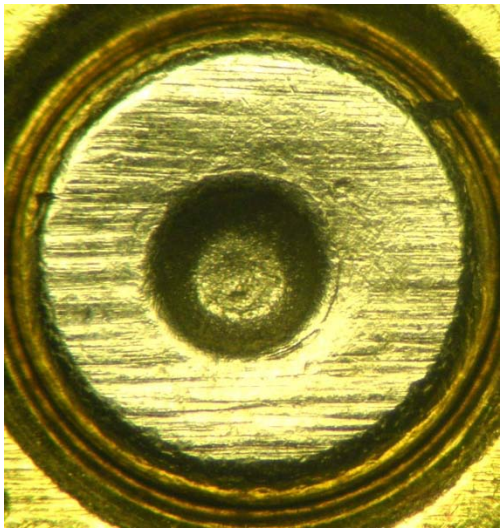


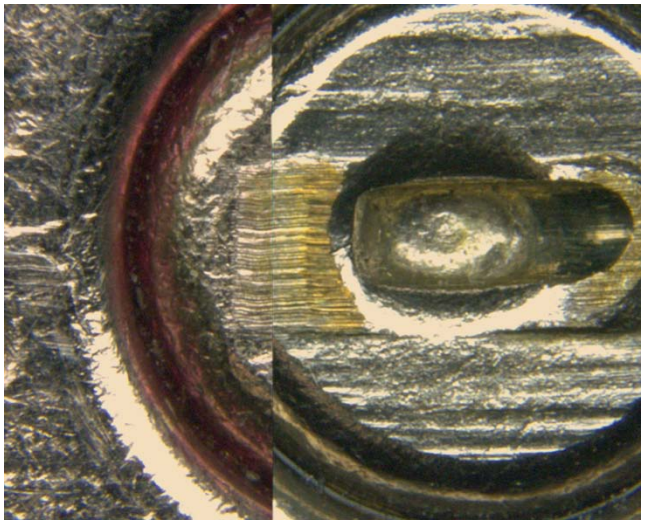
- Photomicrograph of two bullets that match as viewed through a comparison microscope. The test bullet is on the right; the questioned is on the left.

Casing Comparisons (Part 3 of 8)

Fired Casings

Unfired casing head/primer view vs. fired primer





- Breech face, extractor, and firing pin aperture (window for firing pin protrusion).
- These parts are all products of a manufacturing process.

Firing a Weapon

- The act of pulling the trigger serves to release the weapon’s firing pin, causing it to strike the primer, which in turn ignites the powder.
- The expanding gases generated by the burning gunpowder propel the bullet forward through the barrel, simultaneously pushing the spent cartridge case or shell back with equal force against the breechblock.
- The shell is impressed with markings by its contact with the metal surfaces of the weapon’s firing and loading mechanisms.

Cartridge Case Comparison

- *The firing pin, breechblock, ejector and extractor mechanism also offer a highly distinctive signature for individualization of cartridge cases*.
- The shape of the *firing pin* will be impressed into the relatively soft metal of the primer on the cartridge case.
- The cartridge case, in its rearward thrust, is impressed with the surface markings of the *breechblock*.

Impression marks

- The negative of one surface being imparted onto a second, softer surface.
- A mark, indentation, figure, etc., produced by pressure.

Examples include BFMs, FPIs, Ejector marks.

Cartridge Case Comparison

- Other distinctive markings that may appear on the shell as a result of metal to metal contact are caused by the:
  - *Ejector*, the mechanism in a firearm that throws the cartridge or fired case from the firearm.
  - *Extractor*, the mechanism in a firearm by which a cartridge of a fired case is withdrawn from the firing chamber.
  - *Magazine* or clip, the part of a firearm that holds the bullets.

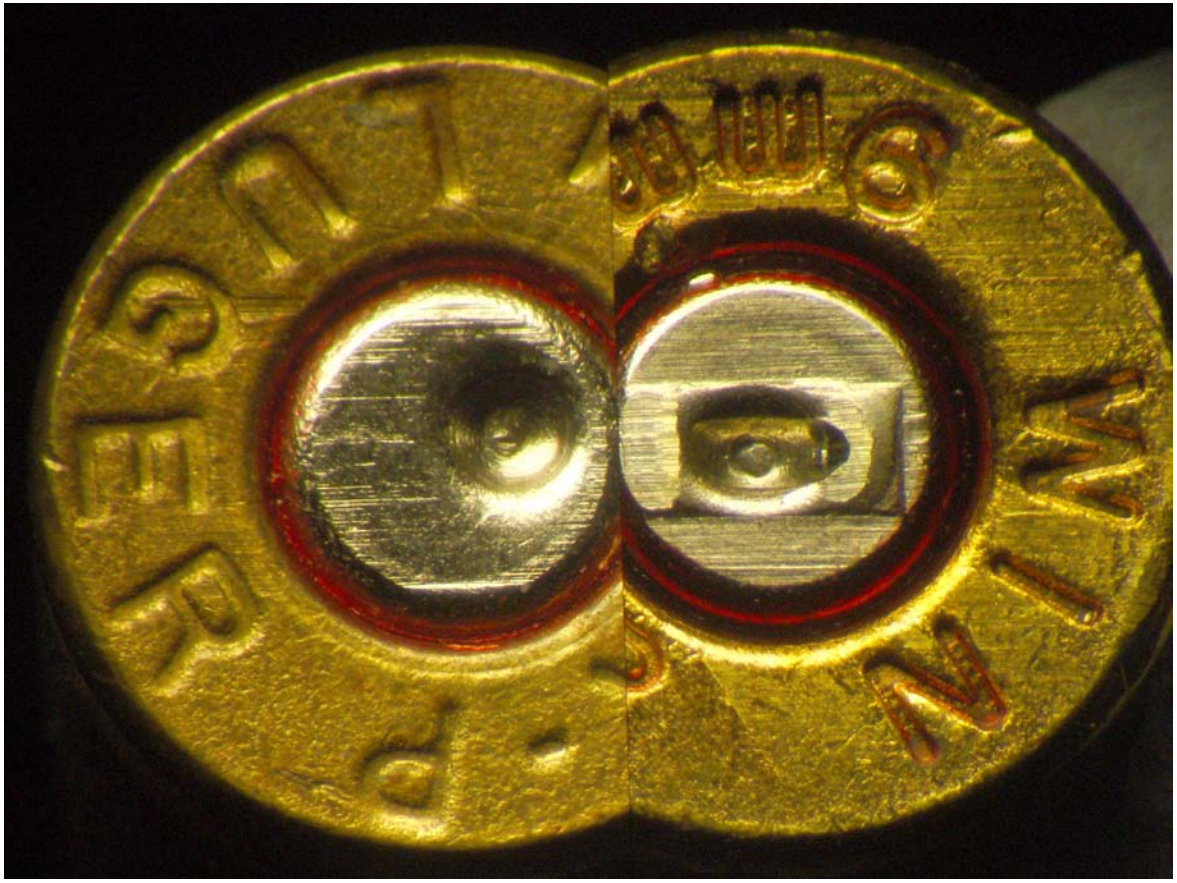
Class characteristics (Cartridge Casings)

- Firing pin impression (Hemispherical, Elliptical, etc.)
- Breech face marks (cross-hatched, parallel, arcs, etc.)
- Ejector Marks (wedge shaped, circular, etc.)

Class characteristics

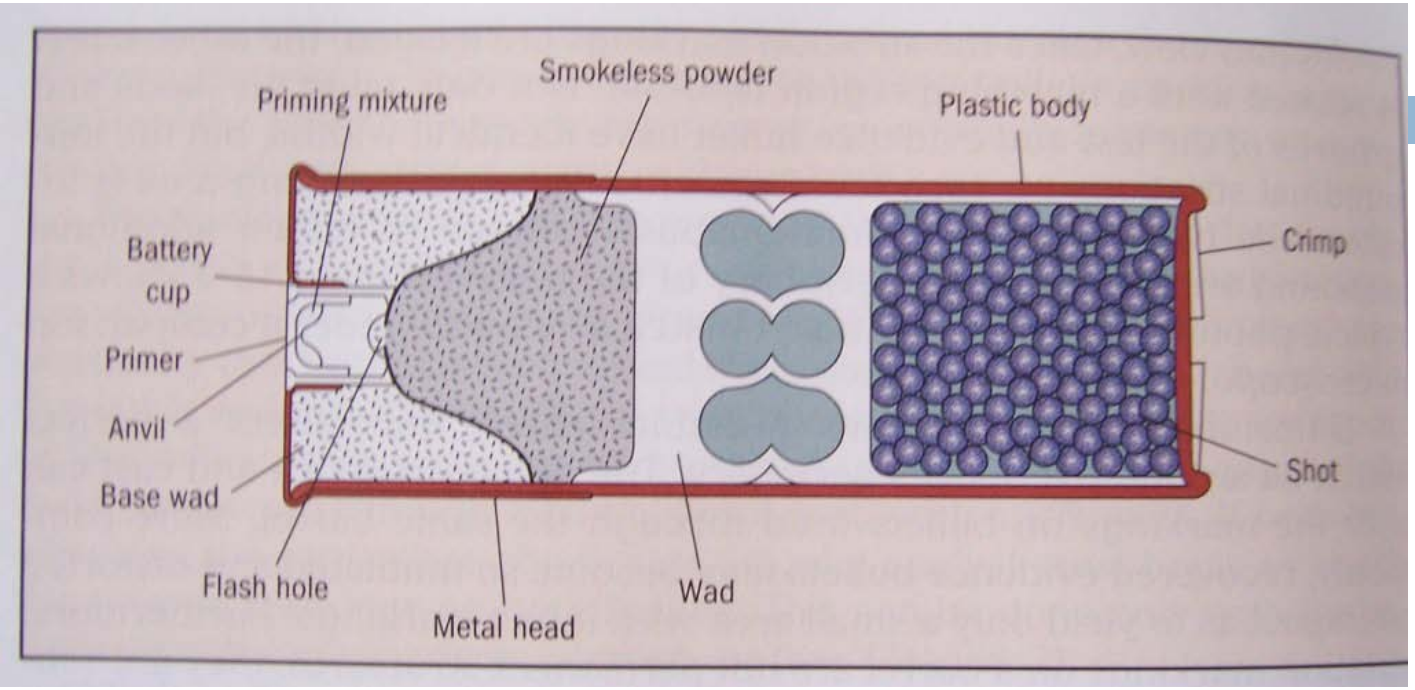
- Arched BFMs
- Hemispherical FPI
- FPI is of the concentric circle class

Examples of an Elimination based on differences in Class Characteristics



Shotguns

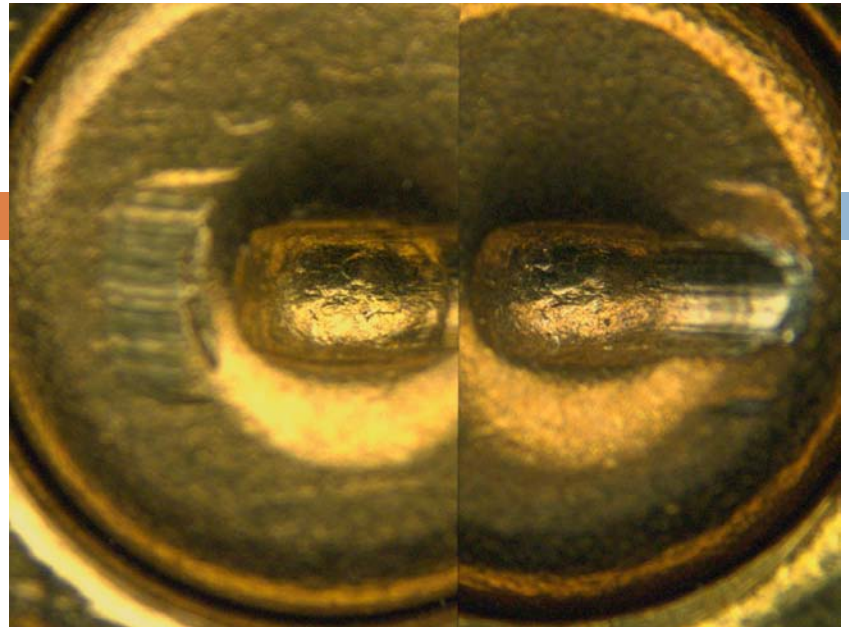
- Unlike rifled firearms, *a shotgun has a smooth barrel.*
- Shotguns generally fire small *lead balls or pellets that are not impressed with any characteristic markings that can be related back to the weapon*.
- Shotgun shells can be compared for firing pin and breech face marking.
- The diameter of the shotgun barrel is expressed by the term *gauge*.
- The higher the gauge number, the smaller the barrel's diameter. (a 12ga. has a larger barrel diameter than a 20ga.)

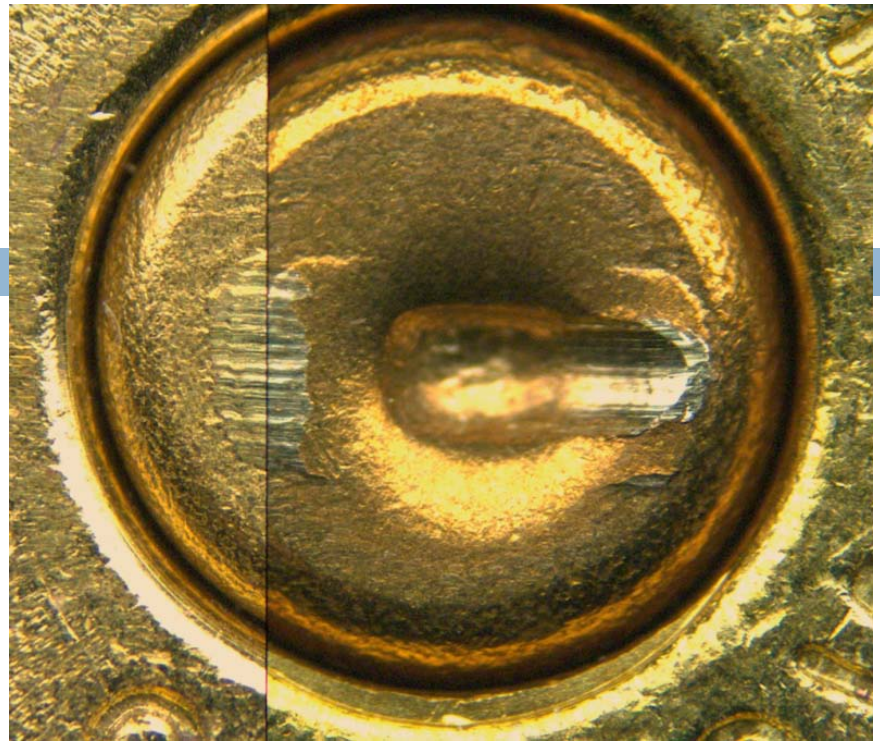


- Cross section of a loaded shotgun shell

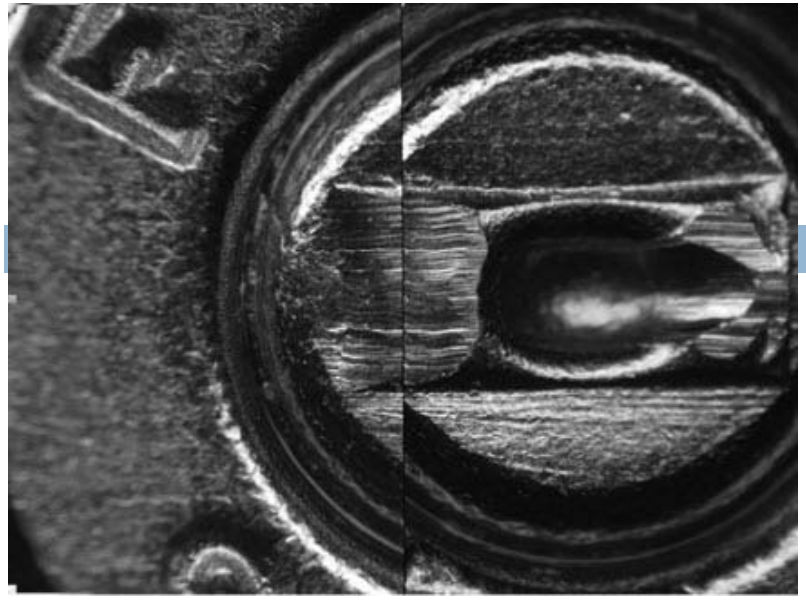
Comparison

- The test fired casings and projectiles are then compared to the casings and projectiles from the crime scene.
- This is done with a comparison microscope.

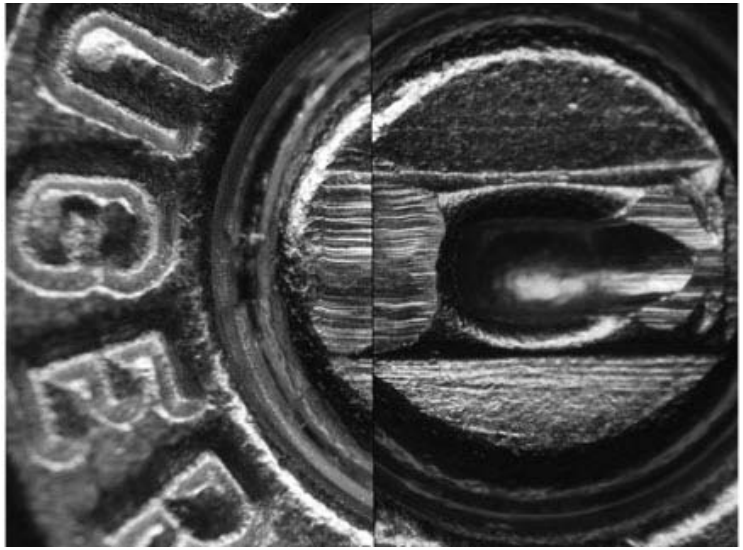




- (Left) Identification between firing pin impressions on two different casings fired from one firearm.
- (Right) Identification between breech face markings on two different casings fired from one firearm.
- Elliptical FPI shown above.

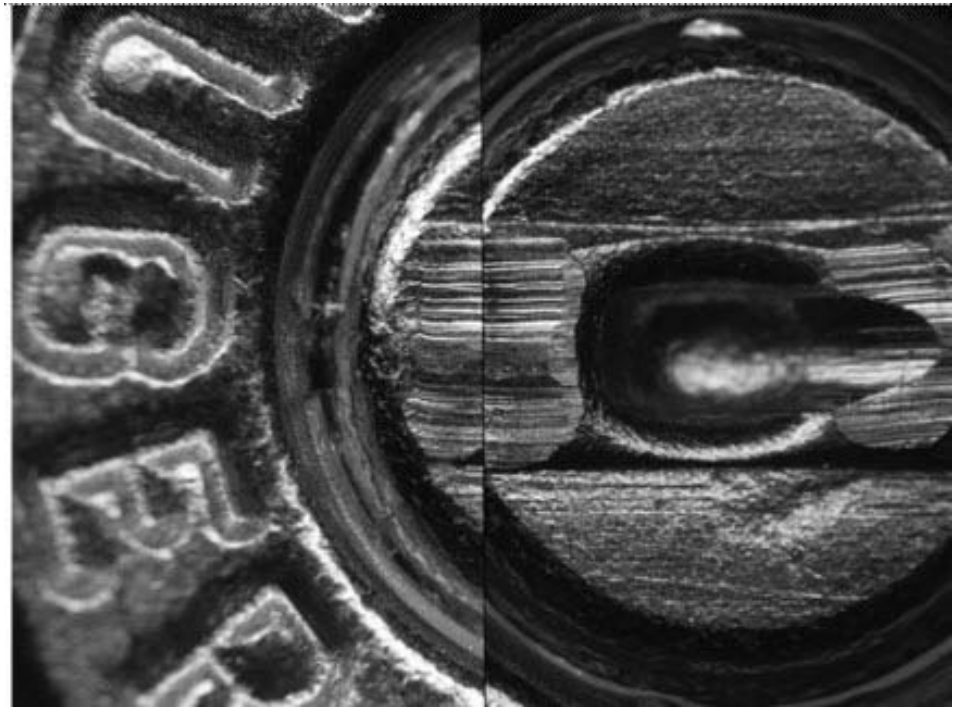


- Sufficient Agreement



- Lack of sufficient agreement

Individual Characteristics



- Example of Identification between Firing Pin Aperature shearing on two casings.
- The length, width, depth, and spatial relationship between the parallel marks make up what are considered the Individual marks.

N.I.B.I.N. (The National Integrated Ballistic Information Network)

(Part 4 of 8)

Computerized Imaging

- The advent of computerized imaging technology has made possible the storage of cartridge case surface characteristics in a manner analogous to automated fingerprint files.
- The National Integrated Ballistic Information Network (NIBIN) produces database files from cartridge cases or projectiles retrieved from crime scenes or test fires from retrieved firearms, often linking a specific weapon to multiple crimes.
- It is important to remember, however, that the ultimate decision for making a final comparison will be determined by the forensic examiner through traditional microscopic methods.

IBIS BRASSTRAX

Collect

IBIS BRASSTRAX-3D

IBIS BULLETTRAX-3D

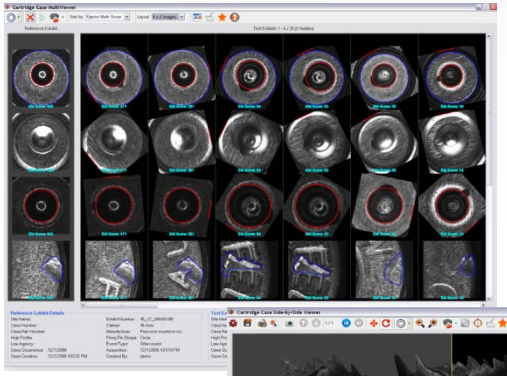
Store & Compare

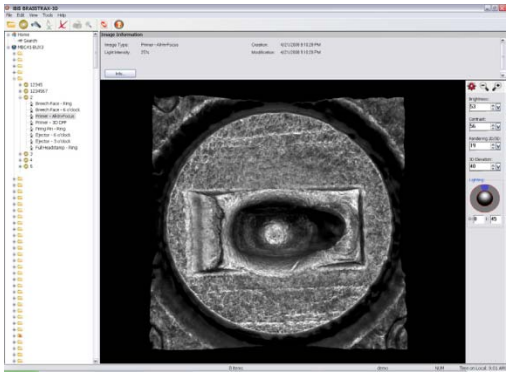
IBIS Data Concentrator

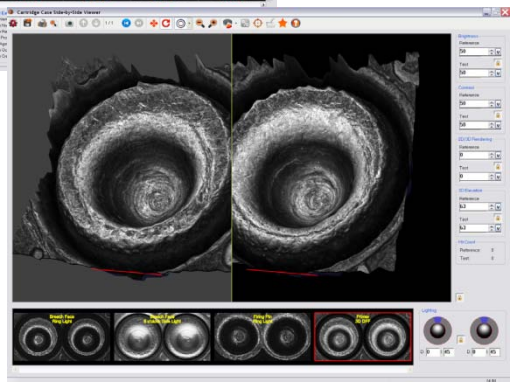
IBIS Correlation Server

Analyze & Report

IBIS MATCHPOINT+







Muzzle to Target Distance Determination

(Part 5 of 8)

Gunpowder Residue

- When a firearm is discharged, unburned and partially burned particles of gunpowder in addition to smoke are propelled out of the barrel along with the bullet toward the target.

- If the muzzle of the weapon is sufficiently close, these products will be deposited onto the target.

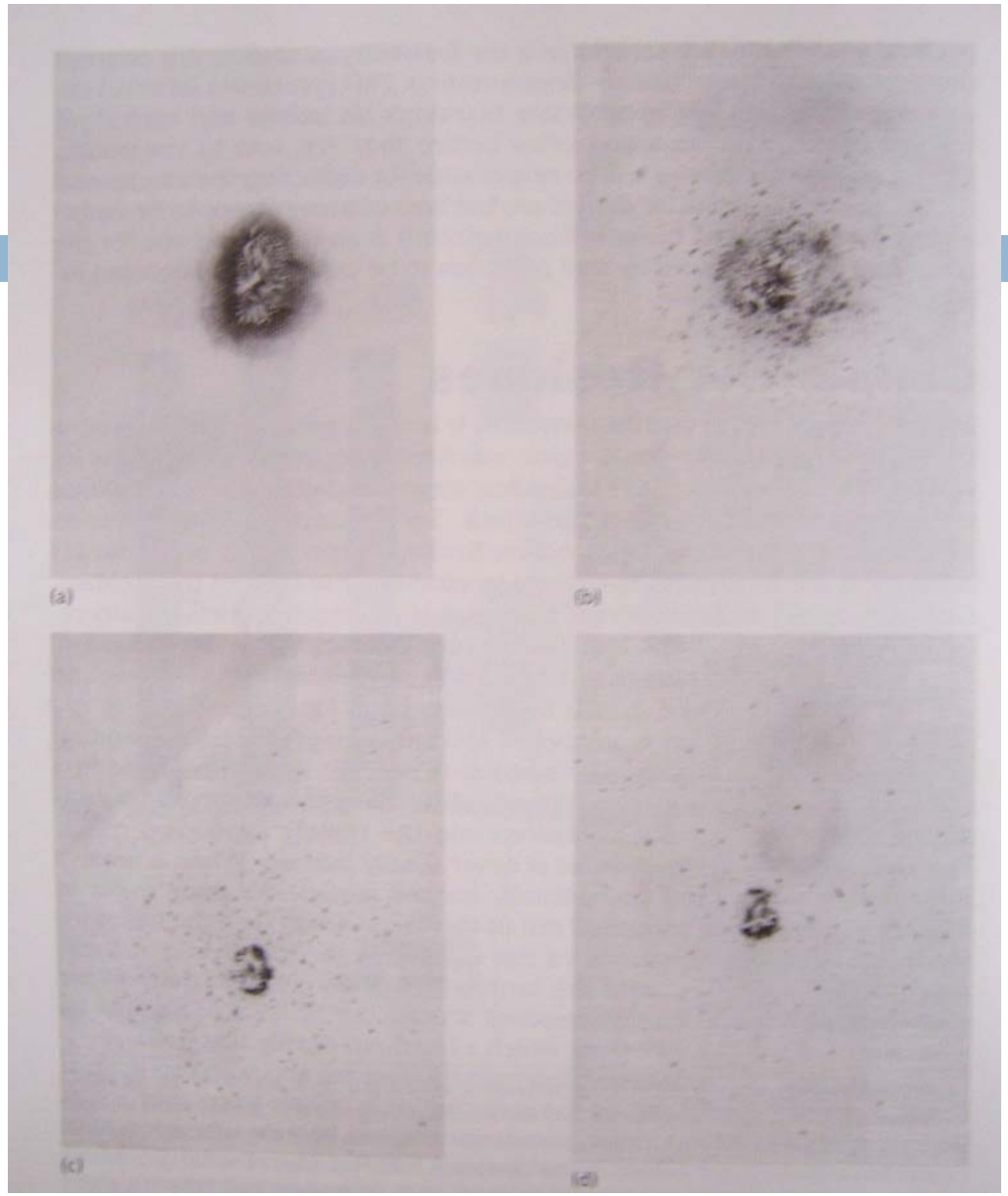
- *The distribution of gunpowder particles and other discharge residues around a bullet hole permits an assessment of the distance from which a handgun or rifle was fired.*

Gunpowder Residue

- The distance from which a handgun or rifle has been fired must be determined by means of a careful *comparison* of the powder-residue pattern located on the victim's clothing against test patterns made using the suspect weapon at varying distances.
- By comparing the test and evidence patterns, the examiner may find enough similarity in pattern diameter upon which to base an opinion as to the distance from which the shot was fired.

Gunpowder Residue

- Star-shaped (stellate) tear pattern
- Halo of vaporous lead (smoke)
- Scattered specks of unburned and partially burned powder
- Bullet wipe



- Test powder paterns made with a .38 Special S&W revolver fired at (a) contact, (b) 6 inches, (c) 12 inches, and (d) 18 inches

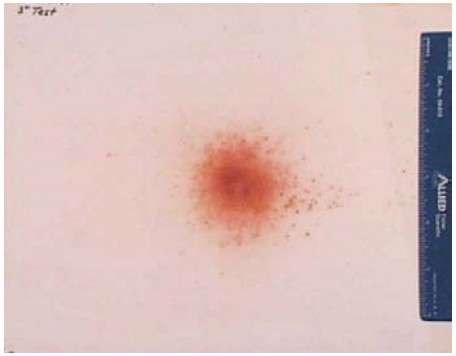
- A contact shot (AKA stellate pattern)

Gunpowder Residue

- When garments or other evidence relevant to a shooting are received in the crime laboratory, the surfaces of all items are first examined microscopically for the presence of gunpowder residue.
- Chemical tests, such as the *Modified Greiss test*, may be needed to detect gunpowder residues that are not visible. (positive reaction for *burned* gunpowder…nitrites)
- The firing distances involving shotguns must be related to test firing and the muzzle to target distances can be established by measuring the spread of the discharged shot.

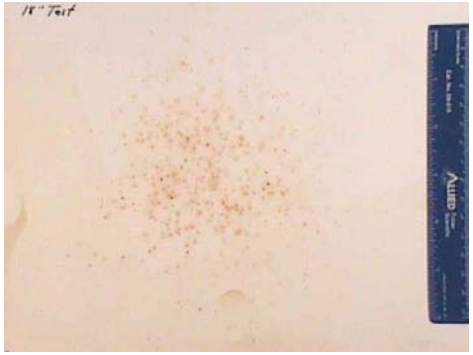
Unknown

- Modified Greiss test comparison of questioned (above) to tests (below)



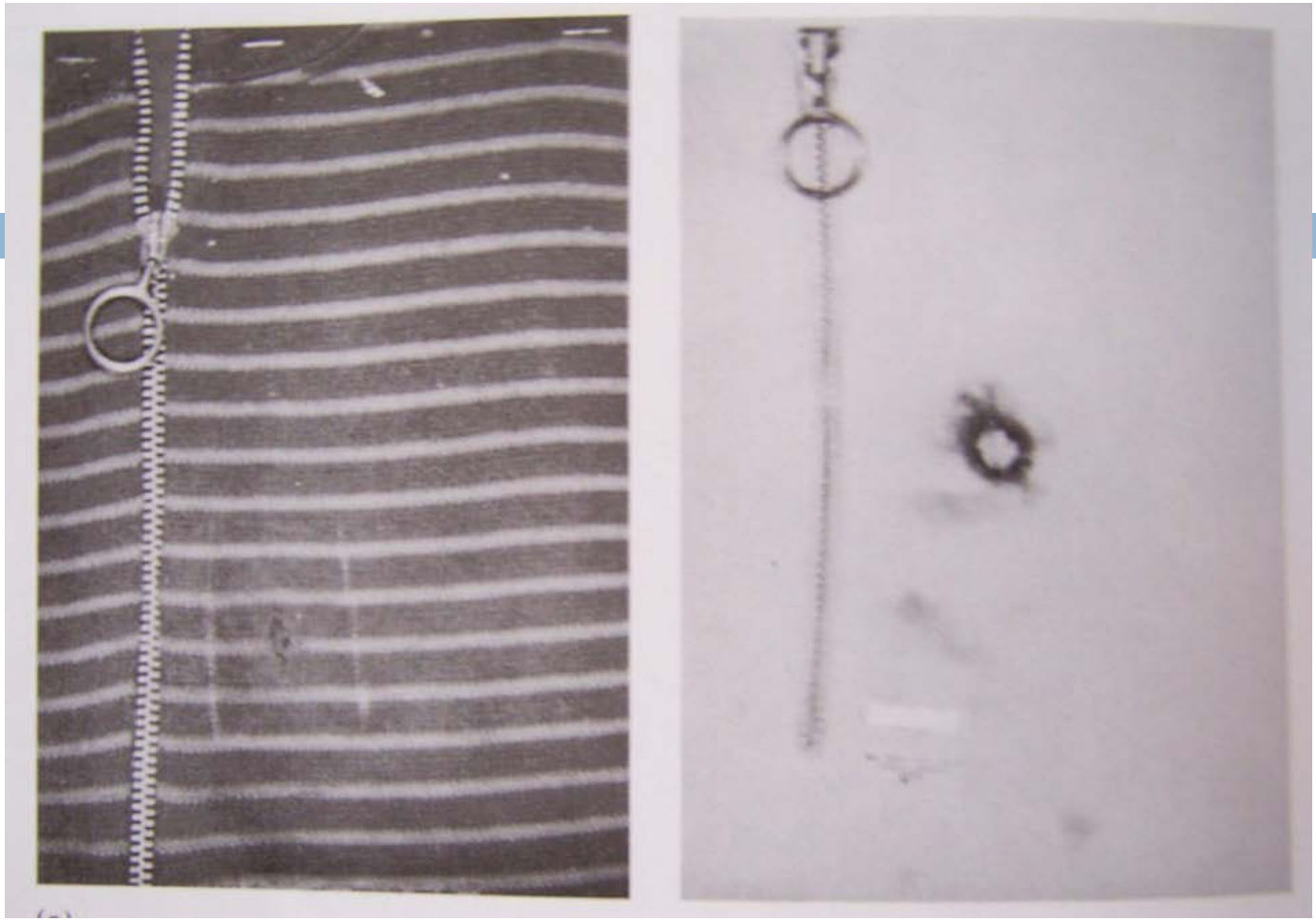
3in

12in



18in

- For the previous example, the muzzle-to-garment distance would then be reported as *greater than 3 inches but less than 18 inches*



- (left) A shirt bearing a powder stain under normal light, (right) Infrared imaging of the same shirt

Serial Number Restoration (Part 6 of 8)

Serial Numbers

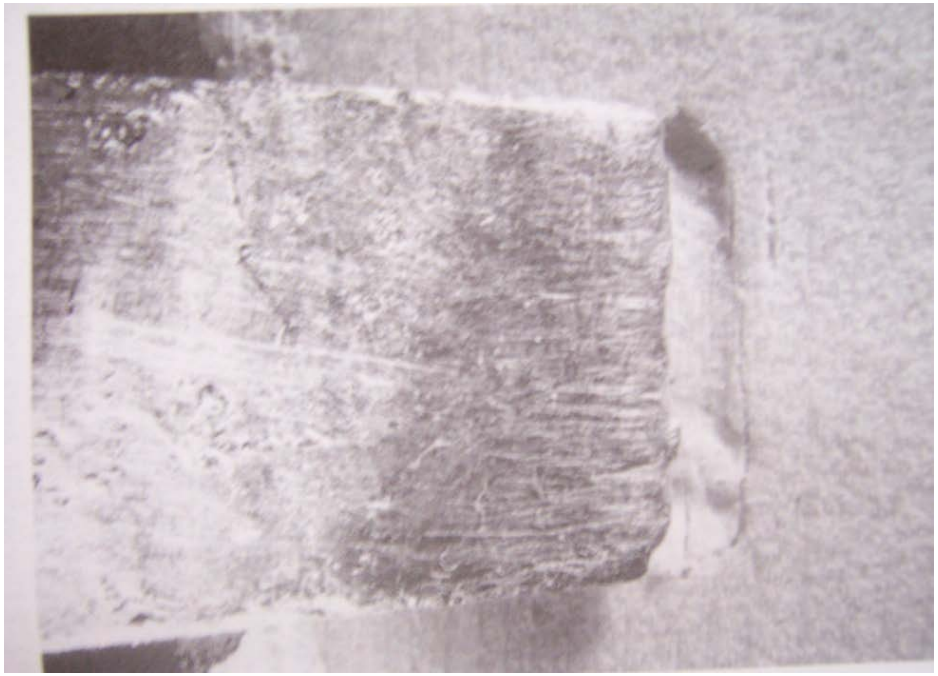
- Increasingly, the examiner is requested to restore a serial number when it has been removed or obliterated by grinding, rifling, or punching.
- *Restoration of serial numbers* is possible through chemical etching because the metal crystals in the stamped zone are placed under a permanent strain that extends a short distance beneath the original numbers.

5 7 2 / 6

Tool Marks
(Part 7 of 8)

Tool Marks

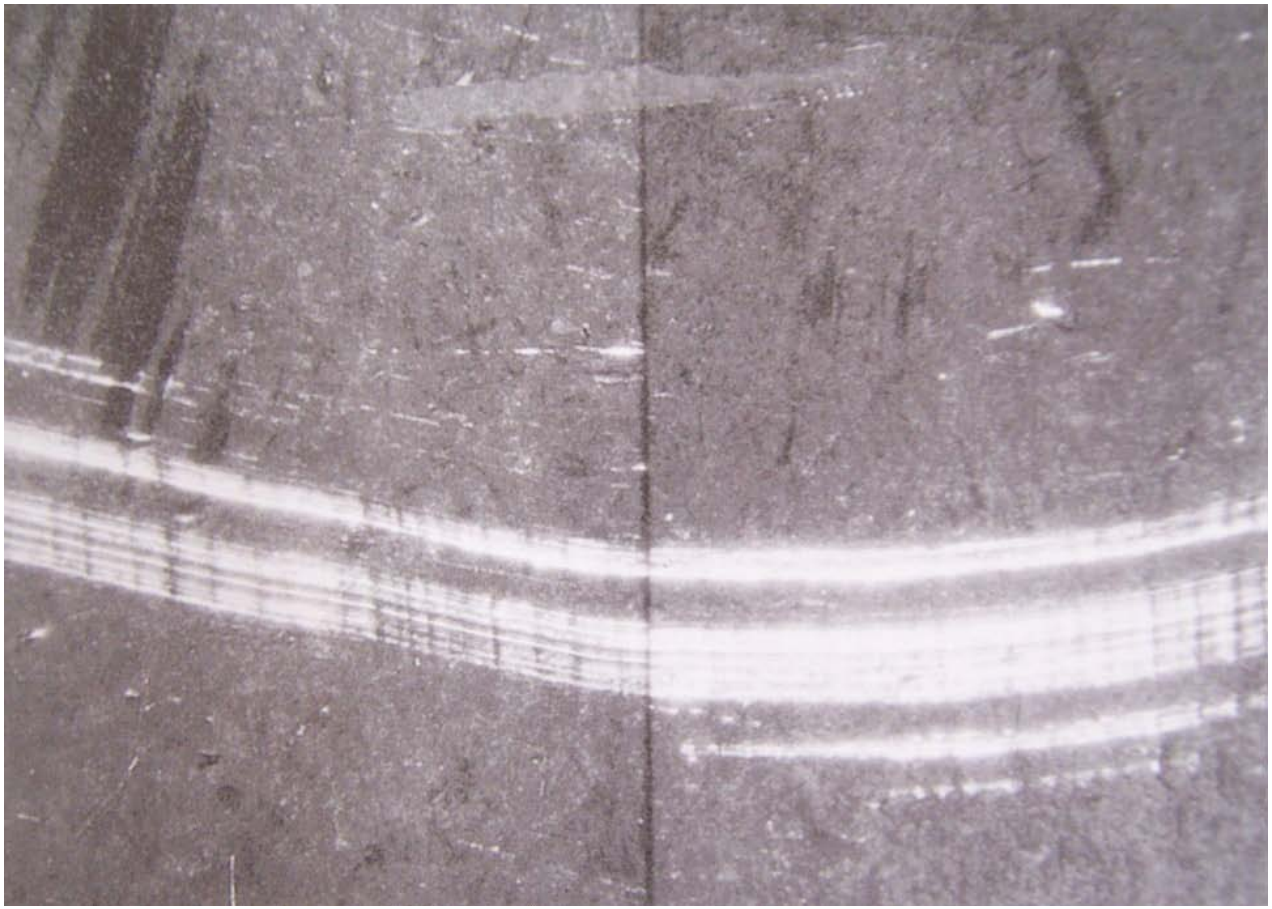
- A *tool mark* is considered to be any impression, cut, gouge, or abrasion caused by a tool coming into contact with another object.
- A careful examination of the impression can reveal important class characteristics, such as the size and shape of the tool.
- The presence of any minute imperfections on a tool imparts individuality to that tool.
- The shape and pattern of such imperfections are further modified by damage and wear during the life of the tool.



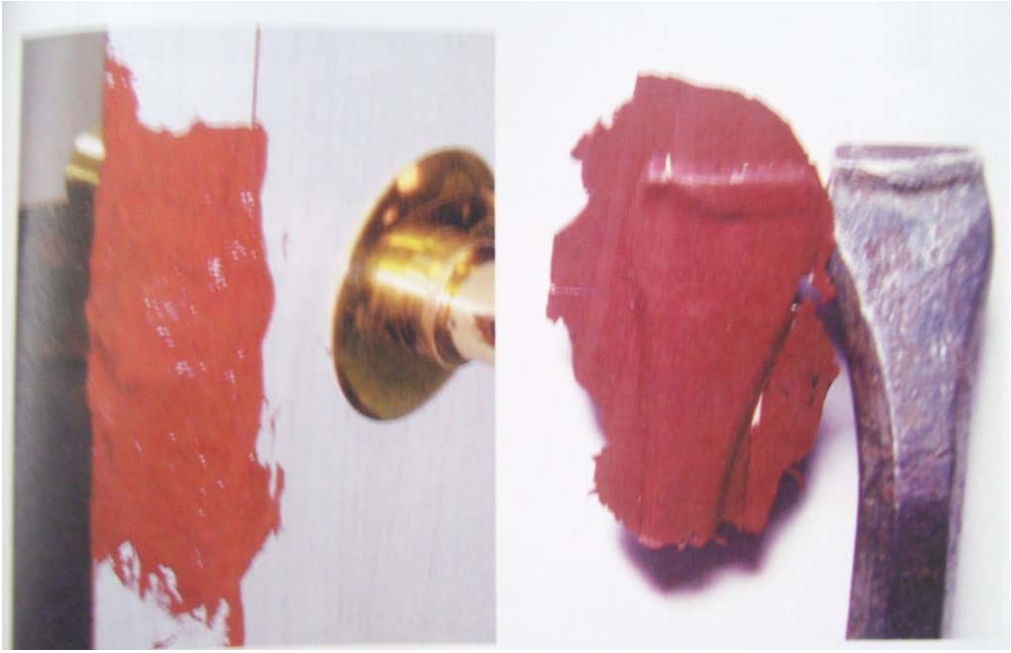
- A comparison of a tool with a suspect screw driver. Note how the presence of nicks and breaks on the tool’s edge helps to individualize the tool to the mark.

Tool Marks

- The comparison microscope is used to compare crime-scene toolmarks with test impressions made with the suspect tool.
- When practical, the entire object or the part of the object bearing the tool mark should be submitted to the crime laboratory for examination.
- *Under no circumstances must the crime scene investigator attempt to fit the suspect tool into the tool mark.*
  - *Any contact between the tool and the marked surface may alter the mark and will, at the least, raise serious questions about the integrity of the evidence.*



- A photograph of a tool mark comparison seen under a comparison microscope.



- (left) casting a toolmark impression with a silicone-based putty, (right) impression alongside suspect tool

Footwear impressions
(Part 8 of 8)

- From left to right: Shoe impression in mud, Cast of shoe impression, Shoe suspected of leaving impression in mud

Comparison of Shoe/tire Evidence

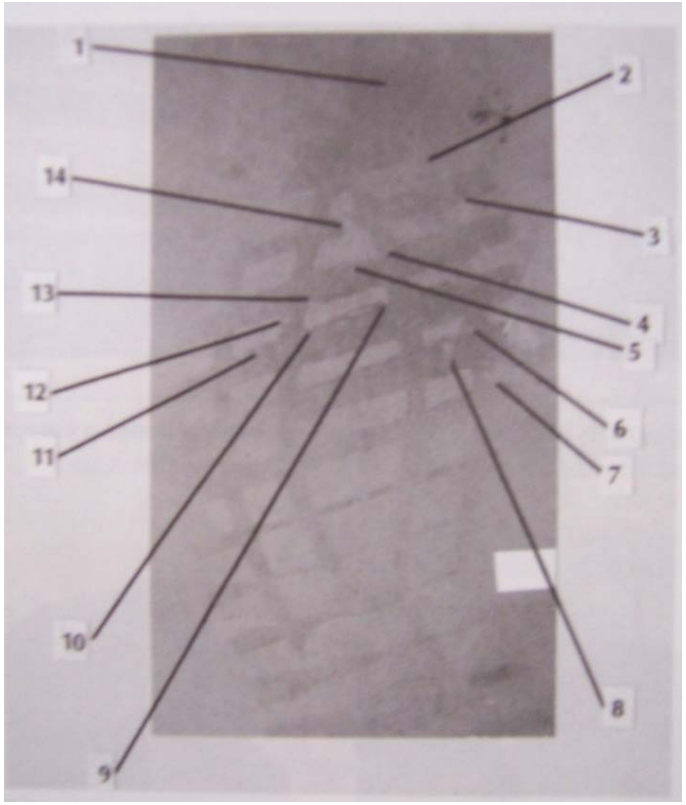
- Individual identifying characteristics are those that randomly occur on the shoe outsole from use. Each of these characteristics were not planned or intentionally manufactured and their combined position, orientation, size and features are unlikely to re-occur in another shoe/tire.

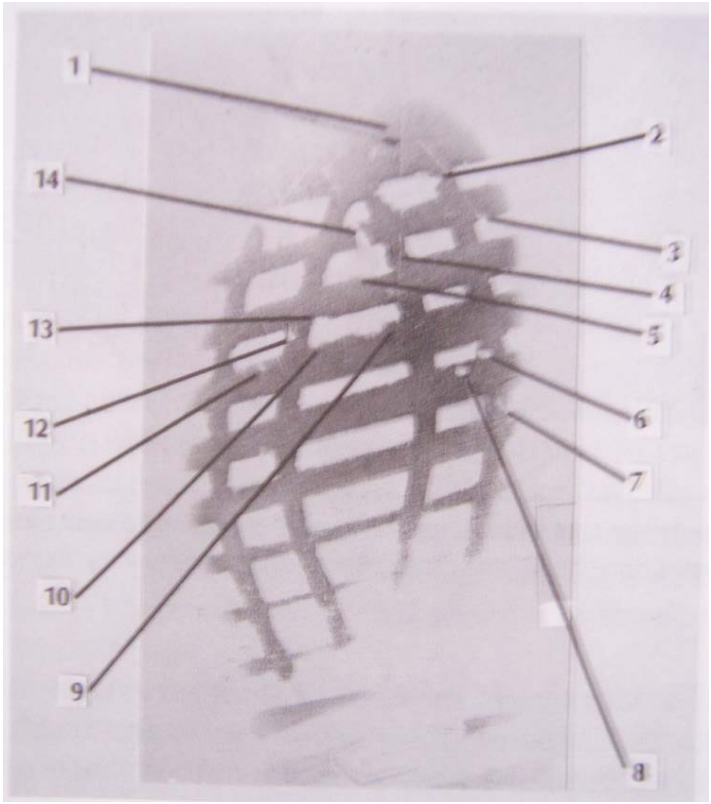
- Comparison of such points will support a finding that both the questioned and test impressions originated from one source.

- According to William Bodziak (2000), “If both the questioned impression and a shoe contain sufficient individual identifying characteristics in common, it can be concluded that the shoe positively make that impression.”

- New computer software and web sites may be able to assist in making shoe print and tire impression comparisons.

Bodziak, William J. Footwear Impression Evidence: Detection, Recovery, and Examination 2nd





- (Left) Impression of shoe found at a crime scene, (Right) Test impression made with suspect shoe.

The END

Thank You!