chapter **15**

Firearms, Tool Marks, and Other Impressions

Key Terms

bore

breechblock

caliber

choke

distance determination

ejector

extractor

firearms identification

gauge

Greiss test

grooves

lands

rifling

Learning Objectives

After studying this chapter you should be able to:

- Describe techniques for rifling a barrel
- Recognize the class and individual characteristics of bullets and cartridge cases
- Understand the use of the comparison microscope to compare bullets and cartridge cases
- Explain the concept of the NIBIN database
- Explain the procedure for determining how far a weapon was fired from a target
- Identify the laboratory tests for determining whether an individual has fired a weapon
- Explain the forensic significance of class and individual characteristics to the comparison of toolmark, footwear, and tire impressions
- List some common field reagents used to enhance bloody footprints

The Beltway Snipers

During a three-week period in October 2002, ten people were killed and three others were wounded as two snipers terrorized the region in and around the Baltimore–Washington metropolitan area. The arrest of John Allen Muhammad, 41, and Lee Boyd Malvo, 17, ended the ordeal. The semiautomatic .223-caliber rifle seized from them was ultimately linked by ballistic tests to eight of the ten killings. The car that Muhammad and Malvo were driving had been specially configured with one hole in the trunk through which a rifle barrel could protrude, so that a sniper could shoot from inside a slightly ajar trunk.

The major break in the case came when a friend of Muhammad's called police suggesting that Muhammad and his friend Malvo were the likely snipers. Muhammad's automobile records revealed numerous traffic stops in the Beltway area during the time of the shootings. Another break in the case came when Malvo called a priest to boast of a killing

weeks before in Montgomery, Alabama. Investigators traced the claim to a recent liquor store holdup that left one person dead. Fortunately, the perpetrator of this crime left a latent fingerprint at the murder scene. Authorities quickly tracked the print to Malvo, a Jamaican citizen, through his fingerprints on file with the Immigration and Naturalization Service. A description of Muhammad's car was released to the media, leading to tips from alert citizens who noticed the car parked in a rest area with both occupants asleep.

The motive for the shooting spree was believed to be a planned plot to extort $10 million from local and state governments. Muhammad was sentenced to death and Malvo is currently serving life imprisonment without parole.

Just as natural variations in skin ridge patterns and characteristics provide a key to human identification, minute random markings on surfaces can impart individuality to inanimate objects. Structural variations and irregularities caused by scratches, nicks, breaks, and wear permit the criminalist to relate a bullet to a gun; a scratch or abrasion mark to a single tool; or a tire track to a particular automobile. Individualization, so vigorously pursued in all other areas of criminalistics, is frequently attainable in firearms and tool mark examination.

Although a portion of this chapter will be devoted to the comparison of surface features for the purposes of bullet identification, a complete description of the services and capabilities of the modern forensic firearms laboratory cannot be restricted to just this one subject, important as it may be. The high frequency of shooting cases means that the science of **firearms identification** must extend beyond mere comparison of bullets to include knowledge of the operation of all types of weapons, restoration of obliterated serial numbers on weapons, detection and characterization of gunpowder residues on garments and around wounds, estimation of muzzle-to-target distances, and detection of powder residues on hands. Each of these functions will be covered in this chapter.

BULLET COMPARISONS

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. Hence, if one bullet found at the scene of a crime and another test-fired from a suspect's gun show the same markings, the suspect is linked to the crime. Because these inner surface striations are so important for bullet comparison, it is important to know why and how they originate.

The gun barrel is produced from a solid bar of steel that has been hollowed out by drilling. The microscopic drill marks left on the barrel's inner surface are randomly irregular and in themselves impart a uniqueness to each barrel. However, the manufacture of a barrel requires the additional step of 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** (see Figure 15–1). As a fired bullet travels through a barrel, it engages the rifling grooves; these grooves then guide the bullet through the barrel, giving it a rapid spin. This is done because a spinning bullet does not tumble end over end on leaving the barrel, but remains instead on a true and accurate course.

The diameter of the gun barrel, sketched in Figure 15–2, measured between opposite lands, is known as the **caliber** of the weapon. Caliber is normally recorded in hundredths of an inch or in millimeters—for example, .22 caliber and 9 mm. Actually, the term *caliber,* as it is commonly applied, is not an exact measurement of the barrel's diameter; for example, a .38-caliber weapon might actually have a bore diameter that ranges from 0.345 to 0.365 inch.

Before 1940, barrels were rifled by having one or two grooves at a time cut into the surface with steel hook cutters. The cutting tool was rotated as it passed down the barrel, so that the final results were grooves spiraling either to the right or left. However, as the need for increased speed in the manufacture of weapons became apparent, newer techniques were developed that were far more suitable for the mass production of weapons. The broach cutter, shown in Figure 15–3, consists of a series of concentric steel rings, with each ring slightly larger than the preceding one. As the broach passes through the barrel, it simultaneously cuts all grooves into the barrel at the required depth. The broach rotates as it passes through the barrel, giving the grooves their desired direction and rate of twist.

In contrast to the broach, the button process involves no cuttings. A steel plug or "button" impressed with the desired number of grooves is forced under extremely high pressures through the barrel. A single pass of the button down the barrel compresses the metal to create lands and grooves on the barrel walls that are negative forms of those on the button. The button rotates to produce the desired direction and rate of twist (see Figure 15–4).

Like the button process, the mandrel rifling or hummer forging process involves no cutting of metal. A mandrel is a rod of hardened steel machined so its form is the reverse impression of the rifling it is intended to produce. The mandrel is inserted into a slightly oversized bore, and the barrel is compressed with hammering or heavy rollers into the mandrel's form.

Every firearms manufacturer chooses a rifling process that is best suited to meet the production standards and requirements of its product. Once the choice is made, however, 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. For example, .32-caliber Smith & Wesson revolvers have five lands and grooves twisting to the right. On the other hand, Colt .32-caliber revolvers exhibit six lands and grooves twisting to the left. Although these class characteristics permit the examiner to distinguish one type or brand name of weapon from another, they do not impart individuality to any one barrel; no class characteristic can do this.

If one could cut a barrel open lengthwise, a careful examination of the interior would reveal the existence of fine lines, or *striations*, many running the length of the barrel's lands and grooves. These striations 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. The random distribution and irregularities of these markings are impossible to duplicate exactly in any two barrels. **No two rifled barrels, even those manufactured in succession, have identical striation markings.** These striations form the individual characteristics of the barrel.

As the bullet passes through the barrel, its surface is impressed with the rifled markings of the barrel. The bullet emerges from the barrel carrying the impressions of the bore's interior surface; these impressions reflect both the class and individual characteristics of the barrel (see Figure 15–5). Because there is no practical way of making a direct comparison between the markings on the fired bullet and those found within a barrel, the examiner must obtain test bullets fired through the suspect barrel for comparison. To prevent damage to the test bullet's markings and to facilitate the bullet's recovery, test firings are normally made into a recovery box filled with cotton or into a water tank.

The number of lands and grooves, and their direction of twist, are obvious points of comparison during the initial stages of the examination. Any differences in these class characteristics immediately eliminate the possibility that both bullets traveled through the same barrel. A bullet with five lands and grooves could not possibly have been fired from a weapon of like caliber with six lands and grooves, nor could one having a right twist have come through a barrel impressed with a left twist. If both bullets carry the same class characteristics, the analyst must begin to match the striated markings on both bullets. This can be done only with the assistance of the comparison microscope (see Chapter 7).

Modern firearms identification began with the development and use of the comparison microscope. This instrument is the most important tool at the disposal of the firearms examiner. The test and evidence bullets are mounted on cylindrical adjustable holders beneath the objective lenses of the microscope, each pointing in the same direction (see Figure 15–6). Both bullets are observed simultaneously within the same field of view, and the examiner rotates one bullet until a well-defined land or groove comes into view. Once the striation markings are located, the other bullet is rotated until a matching region is found. Not only must the lands and grooves of the test and evidence bullet have identical widths, but the longitudinal striations on each must coincide. When a matching area is located, the two bullets are simultaneously rotated to obtain additional matching areas around the periphery of the bullets. Figure 15–7 shows a typical photomicrograph of a bullet match as viewed under a comparison microscope.

Unfortunately, the firearms examiner rarely encounters a perfect match all around the bullet's periphery. The presence of grit and rust can alter the markings on bullets fired through the same barrel. More commonly, recovered evidence bullets may become so mutilated and distorted on impact as to yield only a small area with intact markings. Furthermore, striation markings on a barrel are not permanent structures; they are subject to continuing change and alteration through wear as succeeding bullets traverse the length of the barrel. Fortunately, in most cases, these changes are not dramatic and do not prevent the matching of two bullets fired by the same weapon. As with fingerprint comparison, there are no hard-and-fast rules governing the minimum number of points required for a bullet comparison. The final opinion must be based on the judgment, experience, and knowledge of the expert.

Frequently, the firearms examiner receives a spent bullet without an accompanying suspect weapon and is asked to determine the caliber and possible make of the weapon. If a bullet appears not to have lost its metal, its weight may be one factor in determining its caliber. In some instances, the number of lands and grooves, the direction of twist, and the widths of lands and grooves are useful class characteristics for eliminating certain makes of weapons from consideration. For example, a bullet that has five lands and grooves and twists to the right could not come from a weapon manufactured by Colt, because Colts are not manufactured with these class characteristics. Sometimes a bullet has rifling marks that set it apart from most other manufactured weapons, as in the case of Marlin rifles. These weapons are rifled by a technique known as *microgrooving* and may have eight to twenty-four grooves impressed into their barrels; few other weapons are manufactured in this fashion. In this respect, the FBI maintains a record known as the General Rifling Characteristics File. This file contains listings of class characteristics, such as land and groove width dimensions, for known weapons. It is periodically updated and distributed to the law enforcement community to help identify rifled weapons from retrieved bullets.

Unlike rifled firearms, a shotgun has a smooth barrel. It therefore follows that projectiles passing through a shotgun barrel are not impressed with any characteristic markings that can later be related back to the weapon. Shotguns generally fire small lead balls or pellets contained within a shotgun shell (see Figure 15–8). A paper or plastic wad pushes the pellets through the barrel on ignition of the cartridge’s powder charge. By weighing and measuring the diameter of the shot recovered at a crime scene, the examiner can usually determine the size of shot used in the shell. The size and shape of the recovered wad may also reveal the gauge of the shotgun used and, in some instances, may indicate the manufacturer of the fired shell.

The diameter of the shotgun barrel is expressed by the term **gauge**.[1] The higher the gauge number, the smaller the barrel's diameter. For example, a 12-gauge shotgun has a bore diameter of 0.730 inch as contrasted to 0.670 inch for a 16-gauge shotgun. The exception to this rule is the .410-gauge shotgun, which refers to a barrel 0.41 inch in diameter.

CARTRIDGE CASES

The act of pulling a trigger releases 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**. As the bullet is marked by its passage through the barrel, the shell is also impressed with markings by its contact with the metal surfaces of the weapon's firing and loading mechanisms. As with bullets, these markings can be reproduced in test-fired cartridges to provide distinctive points of comparison for individualizing a spent shell to a rifled weapon or shotgun.

The shape of the firing pin is impressed into the relatively soft metal of the primer on the cartridge case, revealing the minute distortions of the firing pin. These imperfections may be sufficiently random to individualize the pin impression to a single weapon. Similarly, the cartridge case, in its rearward thrust, is impressed with the surface markings of the breechblock. The breechblock, like any machined surface, is populated with random striation markings that become a highly distinctive signature for individualizing its surface. Other distinctive markings that may appear on the shell as a result of metal-to-metal contact are caused by the **ejector** and **extractor** mechanism and the magazine or clip, as well as by imperfections on the fire chamber walls. Photomicrographs in Figure 15–9 reveal a comparison of the firing pin and breechblock impressions on evidence and test-fired shells.

Firing pin, breechblock, extractor, and ejector marks may also be impressed onto the surface of the brass portion of shells fired by a shotgun. These impressions provide points for individualizing the shell to a weapon that are just as valuable as cartridge cases discharged from a rifled firearm. Furthermore, in the absence of a suspect weapon, the size and shape of a firing pin impression and/or the position of ejector marks in relationship to extractor and other markings may provide some clue to the type or make of the weapon that may have fired the questioned shell, or at least may eliminate a large number of possibilities.

AUTOMATED FIREARMS SEARCH SYSTEMS

The use of firearms, especially semiautomatic weapons, during the commission of a crime has significantly increased throughout the United States. Because of the expense of such firearms, the likelihood that a specific weapon will be used in multiple crimes has risen. The advent of computerized imaging technology has made possible the storage of bullet and cartridge surface characteristics in a manner analogous to the storage of automated fingerprint files (see pp. 436–438). Using this concept, crime laboratories can be networked, allowing them to share information on bullets and cartridges retrieved from several jurisdictions. The effort to build a national computerized database for firearms evidence in the United States had a rather confusing and inefficient start in the early 1990s. Two major federal law enforcement agencies, the FBI and the ATF, offered the law enforcement community competing and incompatible computerized systems. The automated search system developed for the FBI was known as *DRUGFIRE*. This system emphasized the examination of unique markings on the cartridge casings expended by the weapon. The specimen was analyzed through a microscope attached to a video camera. The magnification allowed for a close-up view to identify individual characteristics. The image was captured by a video camera, digitized, and stored in a database. Although DRUGFIRE emphasized cartridge-case imagery, the images of highly characteristic bullet striations could also be stored in a like manner for comparisons.

The *Integrated Ballistic Identification System (IBIS)*, developed for the Bureau of Alcohol, Tobacco, Firearms and Explosives, processed digital microscopic images of identifying features found on both expended bullets and cartridge casings. IBIS incorporated two software programs: Bulletproof, a bullet-analyzing module, and Brasscatcher, a cartridge-case-analyzing module. A schematic diagram of Bulletproof's operation is depicted in Figure 15–10.[2]

In 1999, members of the FBI and ATF joined forces to introduce the *National Integrated Ballistics Information Network (NIBIN)* program to the discipline of firearms examination. NIBIN guides and assists federal, state, and local laboratories interested in housing an automated search system. The new unified system, incorporates both DRUGFIRE and IBIS technologies available in prior years. ATF has the overall responsibility for the system sites, while the FBI is responsible for the communications network. Agencies using the new IBIS technology produce database files from bullets and cartridge casings retrieved from crime scenes or test fires from retrieved firearms. More than two hundred law enforcement agencies worldwide have adapted to this technology.

The success of the system has been proven with more than 800,000 images compiled; nationwide, law enforcement agencies have connected more than 11,000 bullets and casings to more than one crime (see Figure 15–11). For example, in a recent case, a Houston security guard was shot and killed during a botched armed robbery. A bullet and .40-caliber Smith and Wesson cartridge casing were recovered and imaged into NIBIN. Earlier that day, a robbery-turneddouble-homicide left two store clerks dead. Again, two bullets and two .40-caliber Smith and Wesson cartridge casings were recovered. Once they were processed into NIBIN, a correlation was found with the murder of the security officer and a separate aggravated robbery that occurred two weeks prior. All three crimes were linked with a firearm believed to be a .40-caliber Smith and Wesson pistol. Further investigation into the use of a victim's credit card aided police in locating two suspects. In the possession of one suspect was a .40-caliber Smith and Wesson pistol. Once retrieved, the gun was test-fired and imaged into NIBIN. The casing from the test-fired weapon matched the evidence obtained in the robbery and the aggravated robbery-homicides. The associations were verified by traditional firearms examination comparisons performed by a firearms examiner. Before this computerized technology was developed, it would have taken years, or may have been impossible, to link all of these shootings to one single firearm. In another example, the ATF laboratory in Rockville, Maryland, received 1,466 cartridge casings from the Ovcara mass burial site in Bosnia. After processing and imaging profiles for all casings, the examiners determined that eighteen different firearms were used at the site. With the help of NIBIN technology and competent examiners, jurists were able to try and convict an individual for war crimes.

NIBIN serves only as a screening tool for firearms evidence. A computerized system does not replace the skills of the firearms examiner. NIBIN can screen hundreds of unsolved firearms cases and may narrow the possibilities to several firearms. However, the final comparison will be made by the forensic examiner through traditional microscopic methods.

Participating crime laboratories in the United States are building databases of bullet and cartridge cases found at crime scenes and those fired in tests of guns seized from criminals. As these databases come online and prove their usefulness in solving crimes, law enforcement officials and the political community are scrutinizing the feasibility of scaling this concept up to create a system of *ballistic fingerprinting*. This system would entail the capture and storage of appropriate markings on bullets and cartridges test-fired from handguns and rifles before they are sold to the public. Questions regarding who will be responsible for collecting the images and details of how they will be stored are but two of many issues to be determined. The concept of ballistic fingerprinting is an intriguing one for the law enforcement community and promises to be explored and debated intensely in the future.

GUNPOWDER RESIDUES

In incidents involving gunshot wounds, it is often necessary to determine the distance from which the weapon was fired. Frequently, in incidents involving a shooting death, the individual apprehended and accused pleads self-defense as the motive for the attack. Such claims are fertile grounds for **distance determinations**, because finding the proximity of the parties involved in the incident is necessary to establish the facts of the incident. Similarly, careful examination of the wounds of suicide victims usually reveals characteristics associated with a very close-range gunshot wound. The absence of such characteristics is a strong indication that the wound was not self-inflicted and signals the possibility of foul play.

Modern ammunition is propelled toward a target by the expanding gases created by the ignition of smokeless powder or nitrocellulose in a cartridge. Under ideal circumstances, all of the powder would be consumed in the process and converted into the rapidly expanding gases. However, in practice the powder is never totally burned. 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 are deposited onto the target. The distribution of gunpowder particles and other discharge residues around the bullet hole permits an assessment of the distance from which a handgun or rifle was fired.

The accuracy of a distance determination varies according to the circumstances of the case. When the investigator is unable to recover a suspect weapon, the best that the examiner can do is to state whether a shot could have been fired within some distance interval from the target. More exact opinions are possible only when the examiner has the suspect weapon in hand and has knowledge of the type of ammunition used in the shooting.

The precise distance from which a handgun or rifle has been fired must be determined by careful comparison of the powder-residue pattern on the victim's clothing or skin against test patterns made when the suspect weapon is fired at varying distances from a target. A white cloth or a fabric comparable to the victim's clothing may be used as a test target (see Figure 15–12). Because the spread and density of the residue pattern vary widely between weapons and ammunition, such a comparison is significant only when it is made with the suspect weapon and suspect ammunition, or with ammunition of the same type and make. By comparing the test and evidence patterns, the examiner may find enough similarity in shape and density on which to judge the distance from which the shot was fired.

Without the weapon, the examiner is restricted to looking for recognizable characteristics around the bullet hole. Such findings are at best approximations made as a result of general observations and the examiner's experience. However, some noticeable characteristics should be sought. For instance, when the weapon is held in contact with or less than 1 inch from the target, a heavy concentration of smokelike vaporous lead usually surrounds the bullet entrance hole. Often, loose fibers surrounding a contact hole show scorch marks from the flame discharge of the weapon, and some synthetic fibers may show signs of being melted as a result of the heat from the discharge. Furthermore, the blowback of muzzle gases may produce a stellate (star-shape) tear pattern around the hole. Such a hole is invariably surrounded by a rim of a smokelike deposit of vaporous lead (see Figure 15–13).

A halo of vaporous lead (smoke) deposited around a bullet hole normally indicates a discharge 12 to 18 inches or less from the target. The presence of scattered specks of unburned and partially burned powder grains without any accompanying soot can often be observed at distances up to approximately 25 inches. Occasionally, however, scattered gunpowder particles are noted at a firing distance as far out as 36 inches. With ball powder ammunition, this distance may be extended to 6 to 8 feet. Finally, a weapon that has been fired more than 3 feet from a target usually does not deposit any powder residues onto the target's surface. In these cases, the only visual indication that the hole was made by a bullet is a dark ring, known as *bullet wipe*, around the perimeter of the entrance hole. Bullet wipe consists of a mixture of carbon, dirt, lubricant, primer residue, and lead wiped off the bullet's surface as it passes through the target. Again, in the absence of a suspect weapon, these observations are general guidelines for estimating target distances. Numerous factors—barrel length, caliber, type of ammunition, and type and condition of the weapon fired—influence the amount of gunpowder residue deposited on a target.

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 gunpowder residue. These particles may be identifiable by their characteristic colors, sizes, and shapes. However, the absence of visual indications does not preclude the possibility that gunpowder residue is present. Sometimes the lack of color contrast between the powder and garment or the presence of heavily encrusted deposits of blood can obscure the visual detection of gunpowder. Often, an infrared photograph of the suspect area overcomes the problem. Such a photograph may enhance the contrast, thus revealing vaporous lead and powder particles deposited around the hole (see Figure 15–14). In other situations, this may not help, and the analyst must use chemical tests to detect gunpowder residues.

Nitrites are one type of chemical product that results from the incomplete combustion of smokeless (nitrocellulose) powder. One test method for locating powder residues involves transferring particles embedded on the target surface to chemically treated gelatin-coated photographic paper. This procedure is known as the **Greiss test**. The examiner presses the photographic paper onto the target with a hot iron; once the nitrite particles are on the paper, they are made easily visible by chemical treatment.[3] In addition, comparing the developed nitrite pattern to nitrite patterns obtained from test firings at known distances can be useful in determining the shooting distance from the target. A second chemical test is then performed to detect any trace of lead residue around the bullet hole. The questioned surface is sprayed with a solution of sodium rhodizonate, followed by a series of oversprays with acid solutions. This treatment causes lead particles to exhibit a pink color, followed by a blue-violet color.

The determination of firing distances involving shotguns must again be related to test firings performed with the suspect weapon, using the same type of ammunition known to be used in the crime. In the absence of a weapon, the muzzle-to-target distance can be estimated by measuring the spread of the discharged shot. With close-range shots varying in distance up to 4 to 5 feet, the shot charge enters the target as a concentrated mass, producing a hole somewhat larger than the bore of the barrel. As the distance increases, the pellets progressively separate and spread out. Generally speaking, the spread in the pattern made by a 12-gauge shotgun increases 1 inch for each yard of distance. Thus, a 10-inch pattern would be produced at approximately 10 yards. Of course, this is only a rule of thumb; normally, a great number of variables can affect the shot pattern. Other factors to consider include the barrel length, the size and quantity of the pellets fired, the quantity of powder charge used to propel the pellets, and the choke of the gun under examination. **Choke** is the degree of constriction placed at the muzzle end of the barrel. The greater the choke, the narrower the shotgun pattern and the faster and farther the pellets will travel.

PRIMER RESIDUES ON THE HANDS

The firing of a weapon not only propels residues toward the target, but also blows gunpowder and primer residues back toward the shooter (see Figure 15–15). As a result, traces of these residues are often deposited on the firing hand of the shooter, and their detection can provide valuable information as to whether an individual has recently fired a weapon.

Early efforts at demonstrating powder residues on the hands centered on chemical tests that could detect unburned gunpowder or nitrates. For many years, the *dermal nitrate test* enjoyed popularity. It required the application of hot paraffin or wax to the suspect's hand with a paintbrush. After drying into a solid crust, the paraffin was removed and tested with diphenylamine. A blue color was taken as an indication of a positive reaction for nitrates (see Table 11–3). However, the dermal nitrate test has fallen into disfavor with law enforcement agencies, owing mainly to its lack of specificity. Common materials such as fertilizers, cosmetics, urine, and tobacco all give positive reactions that are indistinguishable from that obtained for gunpowder by this test.

Efforts to identify a shooter now center on the detection of primer residues deposited on the hand of a shooter at the time of firing. With the exception of most .22-caliber ammunition, primers currently manufactured contain a blend of lead styphnate, barium nitrate, and antimony sulfide. Residues from these materials are most likely to be deposited on the thumb web and the back of the firing hand of a shooter, because these areas are closest to gases escaping along the side or back of the gun during discharge. In addition, individuals who handle a gun without firing it may have primer residues deposited on the palm of the hand coming in contact with the weapon. However, with the handling of a used firearm, the passage of time, and the resumption of normal activities following a shooting, gunshot residues from the back of the hand are frequently redistributed to other areas, including the palms. Therefore, it is not unusual to find higher levels of barium and antimony on the palms than on the backs of the hands of known shooters. Another possibility is the deposition of significant levels of barium and antimony on the hands of an individual who is near a firearm when it is discharged.

Determination of whether a person has fired or handled a weapon or has been near a discharged firearm is normally made by measuring the presence and possibly the amount of barium and antimony on the relevant portions of the suspect’s hands. A variety of materials and techniques are used for removing these residues. The most popular approach, and certainly the most convenient for the field investigator, requires the application of an adhesive tape or adhesive to the hand’s surface in order to remove any adhering residue particles. Another approach is to remove any residues present by swabbing both the firing and nonfiring hands with cotton that has been moistened with 5 percent nitric acid. The front and back of each hand are separately swabbed. All four swabs, along with a moistened control, are then forwarded to the crime laboratory for analysis (see Appendix II for a detailed description of residue collection procedures).

In any case, once the hands are treated for the collection of barium and antimony, the collection medium must be analyzed for the presence of these elements. High barium and antimony levels on the suspect's hand(s) strongly indicate that the person fired or handled a weapon or was near a firearm when it was discharged. Because these elements are normally present after a firing in small quantities (less than 10 micrograms), only the most sensitive analytical techniques can be used to detect them.

Unfortunately, even though most specimens submitted for this type of analysis have been from individuals strongly suspected of having fired a gun, there has been a low rate of positive findings. The major difficulty appears to be the short time that primer residues remain on the hands. These residues are readily removed by intentional or unintentional washing, rubbing, or wiping of hands. In fact, one study convincingly demonstrated that it is very difficult to detect primer residues on cotton hand swabs taken as soon as two hours after firing a weapon.[4] Hence, some laboratories do not accept cotton hand swabs taken from living subjects six or more hours after a firing has occurred. In cases that involve suicide victims, a higher rate of positives for the presence of gunshot residue is obtained when the hand swabbing is conducted before the person's body is moved or when the hands are protected by paper bags.[5] However, hand swabbing or the application of an adhesive cannot be used to detect firings with most .22-caliber rim-fire ammunition. Such ammunition may contain only barium or neither barium nor antimony in its primer composition.

Neutron activation analysis and flameless atomic absorption spectrophotometry (see Chapter 6) are analytical methods that have demonstrated a sensitivity high enough to be suitable for detecting barium and antimony in gunshot residues in hand swabs. However, the need for access to a neutron source, expensive counting equipment, and extensive regulatory requirements limit neutron activation analysis technology to a small number of crime laboratories. On the other hand, flameless atomic absorption spectrophotometry (see pp. 168–169) can be purchased at a cost well within the budgets of most crime laboratories, and a number of laboratories use this instrument to detect barium and antimony on a shooter's hands.

Most laboratories possessing gunshot residue detection capabilities require the application of an adhesive to the shooter's hands.[6] Microscopic primer and gunpowder particles on the adhesive are then located with the aid of a scanning electron microscope (SEM). These particles have a characteristic size and shape that readily distinguish them from other contaminants present on the hands (see Figure 15–16). When the SEM is linked to an X-ray analyzer (see pp. 192–194), an elemental analysis of the particles can be conducted. A finding of a select combination of elements (lead, barium, and antimony) confirms that the particles were indeed primer residue (see Figure 15–17). Appendix II contains a detailed description of the SEM residue collection procedure.

The major advantage of the SEM approach for primer residue detection is its enhanced specificity over hand swabbing. The SEM characterizes primer particles by their size and shape as well as by their chemical composition. Unfortunately, the excessive operator time required to search out and characterize gunshot residue has deterred this technique's use. The availability of automated particle search and identification systems for use with scanning electron microscopes may overcome this problem. Results of work performed with automated systems show it to be significantly faster than a manual approach for searching out gunshot residue particles.[7]

SERIAL NUMBER RESTORATION

Today, many manufactured items, including automobile engine blocks and firearms, are impressed with a serial number for identification. Increasingly, the criminalist is asked to restore such a number when it has been removed or obliterated by grinding, rifling, or punching.

Serial numbers are usually stamped on a metal body or frame, or on a plate, with hard steel dies. These dies strike the metal surface with a force that allows each digit to sink into the metal at a prescribed depth. Serial numbers can be restored because the metal crystals in the stamped zone are placed under a permanent strain that extends a short distance beneath the original numbers. When a suitable etching agent is applied, the strained area dissolves faster than the unaltered metal, thus revealing the etched pattern in the form of the original numbers. However, if the zone of strain has been removed, or if the area has been impressed with a different strain pattern, the number usually cannot be restored.

Before any treatment with the etching reagent, the obliterated surface must be thoroughly cleaned of dirt and oil and polished to a mirrorlike finish. The reagent is swabbed onto the surface with a cotton ball. The choice of etching reagent depends on the type of metal surface being worked on. A solution of hydrochloric acid (120 mL), copper chloride (90 g), and water (100 ml) generally works well for steel surfaces.

COLLECTION AND PRESERVATION OF FIREARMS EVIDENCE

Firearms

The Hollywood image of an investigator picking up a weapon by its barrel with a pencil or stick in order to protect fingerprints must be avoided. This practice only disturbs powder deposits, rust, or dirt lodged in the barrel, and consequently may alter the striation markings on test-fired bullets. If recovery of latent fingerprints is a primary concern, hold the weapon by the edge of the trigger guard or by the checkered portion of the grip, which usually does not retain identifiable fingerprints.

The most important consideration in handling a weapon is safety. Before any weapon is sent to the laboratory, all precautions must be taken to prevent an accidental discharge of a loaded weapon in transit. In most cases, it will be necessary to unload the weapon. If this is done, a record should first be made of the weapon's hammer and safety position; likewise, the location of all fired and unfired ammunition in the weapon must be recorded. When a revolver is recovered, the chamber position in line with the barrel should be indicated by a scratch mark on the cylinder. Each chamber is designated with a number on a diagram, and as each cartridge or casing is removed, it should be marked to correspond to the numbered chambers in the diagram. Knowledge of the cylinder position of a cartridge casing may be useful for later determination of the sequence of events, particularly in shooting cases, when more than one shot was fired. Place each round in a separate box or envelope. If the weapon is an automatic, the magazine must be removed and checked for prints and the chamber then emptied.

As with any other type of physical evidence recovered at a crime scene, firearms evidence must be marked for identification and a chain of custody must be established. Therefore, when a firearm is recovered, an identification tag should be attached to the trigger guard. The tag should be marked to show appropriate identifying data, including the weapon's serial number, make and model, and the investigator's initials. The firearm itself may be further identified by being marked directly with a sharp-pointed scriber in an inconspicuous area of the weapon—for example, the inside of the trigger guard. This practice will avoid any permanent defacement of the weapon.

When a weapon is recovered from an underwater location, no effort must be made to dry or clean it. Instead, the firearm should be transported to the laboratory in a receptacle containing enough of the same water necessary to keep it submerged. This procedure prevents rust from developing during transport.

Ammunition

Protection of class and individual markings on bullets and cartridge cases must be the primary concern of the field investigator. Thus, extreme caution is needed when removing a lodged bullet from a wall or other object. If the bullet's surface is accidentally scratched during this operation, valuable striation markings could be obliterated. It is best to free bullets from their target by carefully breaking away the surrounding support material while avoiding direct contact with the projectile.

Bullets recovered at the crime scene are scribed with the investigator's initials, either on the base or the nose of the bullet (see Figure 15–18). Again, obliteration of any striation markings on the bullet must be scrupulously avoided. If the bullet is badly deformed and there is no apparent place for identification, it should just be placed in a container that is appropriately marked for identification. In any case, the investigator must protect the bullet by wrapping it in tissue paper before placing it in a pillbox or an envelope for shipment to the crime laboratory. In handling the bullet, the investigator should be conscious of the possibility that minute traces of evidence, such as paint and fibers, may be adhering to the bullet. Care must be taken to leave these trace materials intact. Similarly, a fired casing must be identified so as to avoid destroying marks impressed on it from the weapon. The investigator's initials should be placed near the outside or inside mouth of the shell (see Figure 15–19). Discharged shells from shotguns are initialed with ink or indelible pencil on the paper or plastic tube remaining on the shell or on the metal nearest the mouth of the shell. In addition, when semiautomatic or automatic weapons have been fired, the ejection pattern of the casings can help establish the relationship of the suspect to his or her victim. For this reason, the exact location of the place from which a shell casing was recovered is important information that must be noted by the investigator.

In incidents involving shotguns, any wads recovered are to be packaged and sent to the laboratory. An examination of the size and composition of the wad may reveal information about the type of ammunition used and the gauge of the shotgun.

Gunpowder Deposits

The clothing of a firearms victim must be carefully preserved so as to prevent damage or disruption to powder residues deposited around a bullet or shell hole. The cutting or tearing of clothing in the area of the holes must be avoided as the clothing is being removed. All wet clothing should be air-dried out of direct sunlight and then folded carefully so as not to disrupt the area around the bullet hole. Each item should be placed in a separate paper bag.

TOOL MARKS

A *tool mark* is any impression, cut, gouge, or abrasion caused by a tool coming into contact with another object. Most often, tool marks are encountered at burglary scenes that involve forcible entry into a building or safe. Generally, these marks occur as indented impressions into a softer surface or as abrasion marks caused by the tool cutting or sliding against another object.

Typically, an indented impression is left on the frame of a door or window as a result of the prying action of a screwdriver or crowbar. A careful examination of these impressions can reveal important class characteristics—that is, the size and shape of the tool. However, they rarely reveal any significant individual characteristics that could permit the examiner to individualize the mark to a single tool. Such characteristics, when they do exist, usually take the form of discernible random nicks and breaks that the tool has acquired through wear and use (Figure 15–20).

Just as the machined surfaces of a firearm are impressed with random striations during its manufacture, the edges of a pry bar, chisel, screwdriver, knife, or cutting tool likewise display a series of microscopic irregularities that look like ridges and valleys. Such markings are left as a result of the machining processes used to cut and finish tools. The shape and pattern of such minute imperfections are further modified by damage and wear during the life of the tool. Considering the unending variety of patterns that the hills and valleys can assume, it is highly unlikely that any two tools will be identical. Hence, these minute imperfections impart individuality to each tool.

If the edge of a tool is scraped against a softer surface, it may cut a series of striated lines that reflect that pattern of the tool's edge. Markings left in this manner are compared in the laboratory through a comparison microscope with test tool marks made from the suspect tool. The result can be a positive comparison, and hence a definitive association of the tool with the evidence mark, when a sufficient quantity of striations match between the evidence and test markings.

One of the major problems associated with tool mark comparisons is the difficulty in duplicating in the laboratory the tool mark left at the crime scene. A thorough comparison requires the preparation of a series of test marks obtained by applying the suspect tool at various angles and pressures to a soft metal surface (lead is commonly used). This approach gives the examiner ample opportunity to duplicate many of the details of the original evidence marking. A photomicrograph of a typical tool mark comparison is illustrated in Figure 15–21.

Whenever practical, the entire object or the part of the object bearing a tool mark should be submitted to the crime laboratory for examination. When removal of the tool mark is impractical, the only recourse is to photograph the marked area to scale and make a cast of the mark. Under these circumstances, liquid silicone casting material has been found to be the most satisfactory for reproducing most of the fine details of the mark. See Figure 15–22. However, even under the most optimum conditions, the clarity of many of the tool mark's minute details will be lost or obscured in a photograph or cast. Of course, this will reduce the chance of individualizing the mark to a single tool.

The crime-scene investigator must never 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. The suspect tool and mark must be packaged in separate containers, with every precaution taken to avoid contact between the tool or mark and another hard surface. Failure to properly protect the tool or mark from damage could result in the destruction of its individual characteristics. Furthermore, the tool or its impression may contain valuable trace evidence. Chips of paint adhering to the mark or tool provide perhaps the best example of how the transfer of trace physical evidence can occur as a result of using a tool to gain forcible entry into a building. Obviously, the presence of trace evidence greatly enhances the evidential value of the tool or its mark and requires special care in handling and packaging the evidence to avoid losing or destroying these items.

OTHER IMPRESSIONS

From time to time, impressions of another kind are left at a crime scene. This evidence may take the form of a shoe, tire, or fabric impression and may be as varied as a shoe impression left on a piece of paper at the scene of a burglary (Figure 15–23), a hit-and-run victim's garment that has come into violent contact with an automobile (Figure Figure 15–24), or the impression of a bloody shoe print left on a floor or carpet at a homicide scene (Figure 15–25).

The primary consideration in collecting impressions at the crime scene is the preservation of the impression or its reproduction for later examination in the crime laboratory. Before any impression is moved or otherwise handled, it must be photographed (a scale should be included in the picture) to show all the observable details of the impression. Several shots should be taken directly over the impression as well as at various angles around the impression. The skillful use of side lighting for illumination will help highlight many ridge details that might otherwise remain obscured. Photographs should also be taken to show the position of the questioned impression in relation to the overall crime scene.

Although photography is an important first step in preserving an impression, it must be considered merely a backup procedure that is available to the examiner if the impression is damaged before reaching the crime laboratory. Naturally, it is preferable for the examiner to receive the original impression for comparison to the suspect shoe, tire, garment, and so forth. In most cases when the impression is on a readily recoverable item, such as glass, paper, or floor tile, little or no difficulty is presented in transporting the evidence intact to the laboratory.

If an impression is encountered on a surface that cannot be submitted to the laboratory, the investigator may be able to preserve the print in a manner that is analogous to lifting a fingerprint. This is especially true of impressions made in light deposits of dust or dirt. A lifting material large enough to lift the entire impression should be used. Carefully place the lifting material over the entire impression. Use a fingerprint roller to eliminate any air pockets before lifting the impression off the surface.

A more exotic approach to lifting and preserving dust impressions involves the use of a portable electrostatic lifting device.[8] The principle employed is similar to that of creating an electrostatic charge on a comb and using the comb to lift small pieces of tissue paper. A mylar sheet of film is placed on top of the dust mark, and the film is pressed against the impression with the aid of a roller. The high-voltage electrode of the electrostatic unit is then placed in contact with the film while the unit's earth electrodes are placed against a metal plate (earth plate) (see Figure 15–26). A charge difference develops between the mylar film and the surface below the dust mark so that the dust is attached to the lifting film. In this manner, dust prints on chairs, walls, floors, and the like can be transferred to the mylar film. Floor surfaces up to 40 feet long can be covered with a mylar sheet and searched for dust impressions. The electrostatic lifting technique is particularly helpful in recovering barely visible dust prints on colored surfaces. Dust impressions can also be enhanced through chemical development (see Figure 15–27).[9]

When shoe and tire marks are impressed into soft earth at a crime scene, their preservation is best accomplished by photography and casting.[10] Class I dental stone, a form of gypsum, is widely recommended for making casts of shoe and tire impressions. A series of photographs clearly illustrating the steps to be carried out in the casting of an impression may be found at *www.sccja.org/csr-cast.htm*. The cast should be allowed to air-dry for twenty-four to forty-eight hours before it is shipped to the forensic science laboratory for examination. Figure 15–28 illustrates a cast made from a shoe print in mud. The cast compares to the suspect shoe. An aerosol product known as Snow Impression Wax is available for casting snow impressions.[11] The recommended procedure is to spray three light coats of the wax at an interval of one to two minutes between layers and then let it dry for ten minutes. A viscous mixture of Class I dental stone is then poured onto the wax-coated impression. After the casting material has hardened, the cast can be removed.

A number of chemicals can be used to develop and enhance footwear impressions made with blood. In areas where a bloody footwear impression is very faint or where the subject has tracked through blood leaving a trail of bloody impressions, chemical enhancement can visualize latent or nearly invisible blood impressions (see Figure 15–29). A number of chemical formulas useful for bloody footwear impression development are listed in Appendix V.

A number of blood enhancement chemicals have been examined for their impact on STR DNA typing. None of the chemicals examined had a deleterious effect, on a short-term basis, on the ability to carry out STR DNA typing on the blood.[12]

Whatever the circumstances, the laboratory procedures used for examining any type of impression remain the same. Of course, a comparison is possible only when an item suspected of having made the impression is recovered. Test impressions may be necessary to compare the characteristics of the suspect item with the evidence impression. The evidential value of the impression is determined by the number of class and individual characteristics that the examiner finds. Agreement with respect to size, shape, or design may permit the conclusion that the impression could have been made by a particular shoe, tire, or garment; however, one cannot entirely exclude other possible sources from having the same class characteristics. More significant is the existence of individual characteristics arising out of wear, cuts, gouges, or other damage. A sufficient number or the uniqueness of such points of comparison support a finding that both the evidence and test impressions originated from one and only one source.

When tire tread impressions are left at a crime scene, the laboratory can examine the design of the impression and possibly determine the style and/or manufacturer of the tire. This may be particularly helpful to investigators when a suspect tire has not yet been located.

New computer software may be able to help the forensic scientist make shoe print comparisons. For example, an automated shoe print identification system developed in England, called Shoeprint Image Capture and Retrieval (SICAR), incorporates multiple databases to search known and unknown footwear files for comparison against footwear specimens. Using the system, an impression from a crime scene can be compared to a reference database to find out what type of shoe caused the imprint. That same impression can also be searched in the suspect and crime databases to reveal whether that shoe print matches the shoes of a person who has been in custody or the shoe prints left behind at another crime scene. When matches are made during the searching process, the images are displayed side by side on the computer screen (see Figure 3–5).

An excellent resource for shoe print and tire impression examiners is a Web site that has been assembled by the Chesapeake area shoe print and tire track examiners at *http://members.aol.com/varfee/mastssite/*. The Web site’s goal is to enable examiners to enhance their footwear or tire track impression examinations by providing references, databases, and links to manufacturers, experts, vendors, trade associations, and professional societies connected to these forensic disciplines.

Human bite mark impressions on skin and foodstuffs have proven to be important items of evidence for convicting defendants in a number of homicide and rape cases in recent years. If a sufficient number of points of similarity between test and suspect marks are present, a forensic odontologist may conclude that a bite mark was made by one particular individual (see Figure 15–30).

Chapter Summary

Structural variations and irregularities caused by scratches, nicks, breaks, and wear permit the criminalist to relate a bullet to a gun; a scratch or abrasion mark to a single tool; or a tire track to a particular automobile. The manufacture of a barrel 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. No two rifled barrels, even those manufactured in succession, have identical striation markings. These striations form the individual characteristics of the barrel. The inner surface of the barrel of a gun leaves its striation markings on a bullet passing through it. The number of lands and grooves and their direction of twist are obvious points of comparison during the initial stages of an examination. Any differences in these class characteristics immediately eliminate the possibility that both bullets traveled through the same barrel.

The comparison microscope is the most important tool to a firearms examiner. Two bullets can be observed and compared simultaneously within the same field of view. Not only must the lands and grooves of the test and evidence bullet have identical widths, but the longitudinal striations on each must coincide. The firing pin, breechblock, and ejector and extractor mechanism also offer a highly distinctive signature for individualization of cartridge cases. The advent of computerized imaging technology has made possible the storage of bullet and cartridge surface characteristics in a manner analogous to automated fingerprint files. However, the final comparison will be made by the forensic examiner through traditional microscopic methods.

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. The firing of a weapon not only propels residues toward the target, but also blows gunpowder and primer residues back toward the shooter. As a result, traces of these residues are often deposited on the firing hand of the shooter, and their detection can provide valuable information as to whether an individual has recently fired a weapon. Examiners measure the amount of barium and antimony on the relevant portion of the suspect's hands or characterize the morphology of particles containing these elements to determine whether a person has fired or handled a weapon, or was near a discharged firearm.

Increasingly, the criminalist is asked to restore a serial number that has been 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.

A tool mark is any impression, cut, gouge, or abrasion caused by a tool coming into contact with another object. Hence any minute imperfections on a tool impart individuality to that tool. The shape and pattern of such imperfections are further modified by damage and wear during the life of the tool. The comparison microscope is used to compare crime-scene toolmarks with test impressions made with the suspect tool. When shoe and tire marks are impressed into soft earth at a crime scene, their preservation is best accomplished by photography and casting. In areas where a bloody footwear impression is very faint or where the subject has tracked through blood, leaving a trail of bloody impressions, chemical enhancement can visualize latent or nearly invisible blood impressions. A sufficient number of points of comparison or the uniqueness of such points support a finding that both the questioned and test impressions originated from one and only one source.

Review Questions

1. The ___________ is the original part of the bore left after rifling grooves are formed.
2. The diameter of the gun barrel is known as its ___________.
3. The number of lands and grooves is a(n) (class, individual) characteristic of a barrel.
4. The (individual, class) characteristics of a rifled barrel are formed by striations impressed into the barrel's surface.
5. The most important instrument for comparing bullets is the ___________.
6. True or False: On bullets fired in succession from the same weapon, all of the individual characteristics are always identical. ___________
7. It is (always, sometimes) possible to determine the make of a weapon by examining a bullet it fired.
8. A shotgun has a (rifled, smooth) barrel.
9. The diameter of a shotgun barrel is expressed by the term ___________.
10. True or False: Shotgun pellets can be individualized to a single weapon. ___________
11. A cartridge case (can, cannot) be individualized to a single weapon.
12. True or False: The shape of the indentation caused by the firing pin may be a characteristic peculiar to a firearm. ___________
13. True or False: The distribution of gunpowder particles and other discharge residues around a bullet hole permits an approximate determination of the distance from which the gun was fired. ___________
14. True or False: Without the benefit of a weapon, an examiner can make an exact determina-

tion of firing distance. ___________

15. A halo of vaporous lead (smoke) deposited around a bullet hole normally indicates a discharge ___________ to ___________ inches from the target.

16. A(n) ___________ photograph may help visualize gunpowder deposits around a target.

17. True or False: One test method for locating powder residues involves transferring particles embedded on the target surface to chemically treated photographic paper. ___________

18. As a rule of thumb, the spread in the pattern made by a 12-gauge shotgun increases one inch for every ___________ of distance from the target.

19. Current methods for identifying a shooter rely on the detection of (primer, gunpowder) residues on the hands.

20. Determining whether an individual has fired a weapon is done by measuring the elements ___________ and ___________ present on the hands.

21. True or False: Firings with all types of ammunition can be detected by hand swabbings with nitric acid. ___________

22. True or False: Restoration of serial numbers is possible because in the stamped zone the metal is placed under a permanent strain that extends beneath the original numbers. ___________

23. It (is, is not) proper to insert a pencil into the barrel when picking up a crime-scene gun.

24. Recovered bullets are initialed on either the ___________ or ___________ of the bullet.

25. True or False: Cartridge cases are best marked at the base of the shell. ___________

26. The clothing of the victim of a shooting must be handled so as to prevent disruption of

___________ around bullet holes.

27. A(n) ___________ is any impression caused by a tool coming into contact with another object.

28. Tool marks compare only when a sufficient number of ___________ match between the evidence and test markings.

29. A wear pattern can impart (class, individual) characteristics to a shoe.

30. Shoe and tire marks impressed into soft earth at a crime scene are best preserved by ___________ and ___________.

Further References

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Firearms Identification

A discipline mainly concerned with determining whether a bullet or cartridge was fired by a particular weapon. It is not to be confused with ballistics, which is the study of a projectile in motion.

Grooves

The cut or low-lying portions between the lands in a rifled bore.

Rifling

The spiral grooves formed in the bore of a firearm barrel that impart spin to the projectile when it is fired.

Bore

The interior of a firearm barrel.

Lands

The raised portion between the grooves in a rifled bore.

Caliber

The diameter of the bore of a rifled firearm. The caliber is usually expressed in hundredths of an inch or millimeters—for example, .22 caliber and 9 mm.

WebExtra 15.1

Practice Matching Bullets with the Aid of a 3-D Interactive Illustration

www.prenhall.com/Saferstein

Gauge

Size designation of a shotgun, originally the number of lead balls with the same diameter as the barrel that would make a pound. For example, a 12-gauge shotgun would have a bore diameter of a lead ball 1/12 pound in weight. The only exception is the .410 shotgun, in which bore size is

0.41 inch.

WebExtra 15.2

3-D Shotshell Illustrations

www.prenhall.com/Saferstein

Breechblock

The rear part of a firearm barrel.

WebExtra 15.3

3-D Revolver Cartridge Illustrations

www.prenhall.com/Saferstein

WebExtra 15.4

3-D Pistol Cartridge Illustrations

www.prenhall.com/Saferstein

WebExtra 15.5

3-D Rifle Cartridge Illustrations

www.prenhall.com/Saferstein

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 chamber.

WebExtra 15.6

View Animations to Illustrate the Firing Process and the Extraction/Ejection Process of a Semiautomatic Pistol

www.prenhall.com/Saferstein

Distance Determination

The process of determining the distance between the firearm and a target, usually based on the distribution of powder patterns or the spread of a shot pattern.

Greiss Test

A chemical test used to develop patterns of gunpowder residues around bullet holes.

Choke

An interior constriction placed at or near the muzzle end of a shotgun's barrel to control shot dispersion.

WebExtra 15.7

Casting a Footwear Impression

www.prenhall.com/Saferstein

Figure 15–1 Interior view of a gun barrel, showing the presence of lands and grooves.

Figure 15–2 Cross-section of a barrel with six grooves. The diameter of the bore is the caliber.

Figure 15–3 A segment of a broach cutter. *Courtesy Susan Walsh, AP Wide World Photos*

Figure 15–4 ***(top)*** **Cross-section of a .22-caliber rifled barrel.** ***(bottom)*** **A button used to**

produce the lands and grooves in the barrel. *Courtesy New Jersey State Police*

Figure 15–5 A bullet is impressed with the rifling markings of the barrel when it emerges from the weapon. *Courtesy New Jersey State Police*

Figure 15–6 A bullet holder beneath the objective lens of a comparison microscope. *Courtesy Leica Microsystems, Buffalo, N.Y., www.leica-microsystems.com*

Figure 15–7 Photomicrograph of two bullets through a comparison microscope. The test bullet is on the right; the questioned bullet is on the left. *Courtesy Philadelphia Police Department Laboratory*

Figure 15–8 Cross-section of a loaded shotgun shell.

Figure 15–9 Comparison microscope photomicrograph showing a match between (a) firing pin impressions and (b) the breechblock markings on two shells. *Courtesy Ronald Welsh, Bureau of Forensic Services, Central Valley Laboratory, Ripon, Calif.*

Figure 15–10 Bulletproof configuration. The sample is mounted on the specimen manipulator and illuminated by the light source from a microscope. The image is captured by a video camera and digitized. This digital image is then stored in a database, available for retrieval and comparison. The search for a match includes analyzing the width of land and groove impressions along with both rifling and individual characteristics. The Brasscatcher software uses the same system configuration but emphasizes the analysis of expended cartridge casings rather than the expended bullets. *Courtesy Forensic Technology (WAI) Inc., Côte St-Luc, Quebec, Canada*

Figure 15–11 Bullets A, B, C, and D were acquired in the IBIS database at different times from different crime scenes. D is a fragmented bullet that had only three land impressions

available for acquisition. Upon the entry of bullet D, IBIS found a potential matching candidate in the database: B. On the far right, bullet D is compared to bullet B using the IBIS imaging software. Finally, a forensic firearms examiner using the actual evidence under a conventional comparison microscope will confirm the match between B and D. *Courtesy Forensic Technology WAI Inc.*

Figure 15–12 Test powder patterns made with a .38 Special Smith & Wesson revolver fired at the following distances from the target: (a) contact, (b) 6 inches, (c) 12 inches, and (d) 18 inches. *Courtesy New Jersey State Police*

Figure 15–13 A contact shot. *Courtesy New Jersey State Police*

Figure 15–14 (a) A shirt bearing a powder stain, photographed under normal light. (b) Infrared photograph of the same shirt. *Courtesy New Jersey State Police*

Figure 15–15 When a handgun is fired, gunpowder and primer residues are normally blown back toward the hand of the shooter. *Courtesy Centre for Forensic Sciences, Toronto, Canada*

Figure 15–16 An SEM view of gunshot residue particles. *Courtesy Jeol USA Inc., Peabody, Mass., www.jeol.usa.com*

Figure 15–17 Spectrum showing the presence of lead, barium, and antimony in gunshot residue. *Courtesy Jeol USA Inc., Peabody, Mass., www.jeolusa.com*

Figure 15–18 Discharged evidence bullets should be marked on the base or nose. When there is more than one bullet, a number should accompany the initials. ***Never*** **mark bullets on the side.**

Figure 15–19 Discharged evidence shells should be marked on the outside or inside, as close as possible to the mouth of the shell. Discharged shotgun shells should be marked on the brass, close to the paper or plastic. *Never* mark the shells where the firing pin strikes the primer.

Figure 15–20 A comparison of a tool mark with a suspect screwdriver. Note how the presence of nicks and breaks on the tool's edge helps individualize the tool to the mark. *Courtesy New Jersey State Police*

Figure 15–21 A photograph of a tool mark comparison seen under a comparison microscope. *Courtesy Leica Microsystems, Buffalo, N.Y., www.leica-microsystems.com*

Figure 15–22 (a) Casting a tool mark impression with a silicone-based putty. (b) Impression alongside suspect tool. *Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com*

Figure 15–23 (a) Impression of shoe found at a crime scene. (b) Test impression made with suspect shoe. A sufficient number of points of comparison exist to support the conclusion that the suspect shoe left the impression at the crime scene.

Figure 15–24 A small child was found dead at the edge of a rural road near a railroad crossing, the victim of a hit-and-run driver. A local resident was suspected, but he denied any knowledge of the incident. The investigating officer noted what appeared to be a fabric imprint on the bumper of the suspect's automobile. The weave pattern of the clothing of the deceased was compared with the imprint on the bumper and was found to match. When the suspect was confronted with this information, he admitted his guilt. *Courtesy Centre for Forensic Sciences, Toronto, Canada*

Figure 15–25 A bloody imprint of a shoe was found on the carpet in the home of a homicide victim (b). The suspect's shoe, shown in (a), made the impression. Note the distinctive impression of the hole present in the shoe's sole. *Courtesy Dade County Crime Lab, Miami, Fla.*

Figure 15–26 Electrostatic lifting of a dust impression off a floor using an electrostatic unit. *Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com*

Figure 15–27 (a) A dust impression of a shoe print on cardboard before enhancement. (b) Shoe print after chemical enhancement with Bromophenol Blue and exposure to water vapor. *Courtesy Division of Identification and Forensic Science, Israel Police Headquarters, Jerusalem, Israel*

Figure 15–28 (a) Shoe impression in mud. (b) Cast of shoe impression. (c) Shoe suspected of leaving muddy impression. *Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com*

Figure 15–29 (a) Bloody footprint on cardboard treated with amido black. (b) Bloody footprint treated with Hungarian Red dye. (c) Bloody footprint visualized with leucocrystal violet. (d) Bloody footprint enhanced with patent blue. (e) Bloody foot impression treated with amido black. (f) Bloody footprint visualized with fushin acid dye. (g) Bloody foot impression visualized with tartrazine. (h) Bloody footprint treated with diaminobenzidine. *(a) Courtesy Dwane S. Hilderbrand and David P. Coy, Scottsdale Police Crime Laboratory, Scottsdale, Ariz. (b) Courtesy ODV Inc., South Paris, Maine. (c–h) Courtesy William Bodziak, FBI Laboratory*

Figure 15–30 (a) Bite mark impression on the victim's fore-arm. (b) Upper dental model

from the teeth of the suspect matches the individual teeth characteristics of the bite marks. *Courtesy Haskin Askin, D.D.S., Chief Forensic Odontologist, City of Philadelphia, Pa.*

[1] Originally, the number of lead balls with the same diameter as the barrel would make a pound. For example, a 20-gauge shotgun has an inside diameter equal to the diameter of a lead ball that weighs 1/20 of a pound.

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