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FIREARMS AND TOOLMARK EVIDENCE

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Because firearms are frequently used in the commission of crimes in this country, defense counsel should have some appreciation of firearms evidence. Firearms identification examiners do more than analyze bullet and cartridge cases; they are also involved in toolmark examinations, firing distance determinations, serial number restoration, and gunshot residue analysis. This article discusses these techniques.

Firearms identification "is the study by which a bullet, cartridge case or shotshell casing may be identified as having been fired by a particular weapon to the exclusion of all other weapons." F.B.I., *Handbook of Forensic Science* 52 (Rev. ed. 1981). The first written reference to firearms identification appeared in 1900. Hall, *The Missile and the Weapon*, 39 Buffalo Med. J. 727 (1900). Calvin Goddard is often credited as the "father" of firearms identification. He was responsible for much of the early work on the subject and also wrote some of the first articles. E.g., Goddard, *Scientific Identification of Firearms and Bullets*, 17 J. Crim. L., Criminology & Police Sci. 254 (1926); Goddard, *The Unexpected in Firearms Identification*, 1 J. Forensic Sci. 57 (1956). For a brief history of firearms identification, see J. Hatcher, F. Jury & J. Weller, *Firearms Investigation Identification and Evidence* ch. 1 (1957); Dougherty, *Report on Two Early United States Firearms Identification Cases*, 14 J. Forensic Sci. 453 (1969); Thomas, *Comments on the Discovery of Striation Matching and on Early Contributions to Forensic Firearms Identification*, 12 J. Forensic Sci. 1 (1967).

Although this subject is popularly known as "ballistics," that term is not correct. Ballistics is the study of the motion of a projectile. Internal ballistics concerns the study of the projectile within the firearm and includes such matters as chamber configuration, chamber pressure, and rifling. Exterior ballistics concerns the study of the projectile after it leaves the firearm and includes such matters as velocity and trajectory. Terminal (wound) ballistics concerns the study of the effects of the projectile on a target. Firearms identification does not directly involve ballistics. Accordingly, a true "ballistics" expert may know very little about firearms identification. Similarly, a firearms expert — a person knowledgeable about weapons and ammunition — may know little about fire-

arms identification. See *State v. Leonard*, 243 N.W.2d 887, 892 (Iowa 1976) (distinguishing between "ballistics" and "firearms" expert); *Firearms Identification*, 29 Am. Jur. Proof of Facts 65, 66-67 (1972).

FIREARMS AND AMMUNITION

Typically, three types of firearms — rifles, handguns, and shotguns — are subject to firearms identification examinations. Other types of firearms, such as machine guns, tear gas guns, zip guns, and flare guns, may also be examined. See generally Koffler, *Zip Guns and Crude Conversions — Identifying Characteristics and Problems*, 61 J. Crim. L., Criminology & Police Sci. 115 (1970). The barrels of modern rifles and handguns are *rifled*; that is, parallel spiral grooves are cut into the inner surface (bore) of the barrel. The surfaces between the grooves are called *lands*. The lands and grooves twist in a direction: right twist or left twist. Each manufacturer specifies the number of lands and grooves, the direction of twist, the angle of twist (pitch), the depth of the grooves, and the width of the lands and grooves. As a bullet passes through the bore, the lands and grooves force the bullet to rotate, giving it stability in flight and thus increased accuracy. Because the lands "bite" into the bullet surface, the land and groove impressions are imprinted on the bullet. These impressions play an important role in firearms identification.

Rifles and handguns are classified according to their caliber. The caliber is the diameter of the bore of the weapon; it is expressed in either hundredths or thousandths of an inch (e.g. .22, .45, .357 caliber) or millimeters (e.g. 7.62mm). Two major types of handguns are revolvers and semiautomatic pistols. One difference between these two types of handguns is that the cartridge case is ejected automatically from a semiautomatic pistol after it is fired. If recovered at the crime scene, it may be possible to identify the cartridge case and the firearm from which it was ejected. In addition to caliber designation, rifles are classified by their loading mechanism — for example, semiautomatic, pump, bolt, or lever action.

Rifle and handgun cartridges (ammunition) consist of the projectile (bullet), case, propellant (powder), and

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primer. The primer contains a small amount of an explosive mixture which detonates when struck by the firing pin. If the primer is located in the center of the base of the cartridge case, the cartridge is called a center fire cartridge. If the primer is in the rim of the base, the cartridge is called a rimfire cartridge. When the firing pin detonates the primer, an explosion occurs which ignites the propellant. Modern propellant is smokeless powder, either single base (nitrocellulose) or double base (nitrocellulose and nitroglycerin).

Shotguns are smooth bore firearms; they do not have lands and grooves. They can be double or single barrel and can be semiautomatic, pump, bolt, or break open firearms. Shot shells consist of a case, primer, propellant, projectiles, and wadding. Generally, the projectiles in a shot shell are spherical balls (pellets). Shotguns, however, can also fire bullets, called slugs. See generally Townshend, *Identification of Rifled Shotgun Slugs*, 15 J. Forensic Sci. 173 (1970). Except for the .410 caliber shotgun, shotguns and shot shells are classified according to their gauge — for example, 12, 16, or 20 gauge. The gauge is the number of spherical balls of pure lead, each exactly fitting the bore, that equals one pound. The wadding keeps the powder and the pellets in position inside the shell.

BULLET IDENTIFICATION

Two types of identifying characteristics are used in firearms identification: class characteristics and individual characteristics. The discussion in this article focuses on the typical case. Sometimes the examiner is faced with an atypical case — for example, one in which the firearm has been altered or an undersized bullet has been used. See generally 1 J. Mathews, *Firearms Identification* ch. 6 (1962) ("Pitfalls for the Unwary"); Munhall, *Firearms Identification Problems Pertaining to Supplemental Chambers, Auxiliary Cartridges, Insert Barrels and Conversion Units*, 5 J. Forensic Sci. 319 (1960); Godard, *The Unexpected in Firearms Identification*, 1 J. Forensic Sci. 57 (1956).

Class Characteristics

The class characteristics of a firearm include its caliber and rifling specifications: (1) the land and groove diameters, (2) the direction of rifling (left or right twist), (3) the number of lands and grooves, (4) the width of the lands and grooves, (5) the degree of the rifling twist, and (6) the depth of the grooves. 1 J. Mathews, *supra*, at 17. A .38 caliber bullet with six land and groove impressions and with a right twist could have been fired only from a firearm with those same characteristics. It could not have been fired from a .32 caliber firearm, nor from a .38 caliber firearm with a different number of lands and grooves or a left twist. In sum, if the class characteristics do not match, the firearm could not have fired the bullet. Class characteristics play another role in criminal investigations. Frequently, the bullet is recovered before the firearm comes into the possession of the police. In this situation, the class characteristics provide significant information concerning the type of firearm that could have fired the bullet.

Individual Characteristics

Once a firearm is recovered and the class characteristics of the firearm and an evidence bullet match, a positive identification may be possible. The procedure used in bullet identification involves a comparison of the evidence bullet and a test bullet fired from the firearm. Test bullets are obtained by firing a firearm into a recovery box or bullet trap, which is usually filled with cotton, or a recovery tank, which is filled with water. The two bullets are compared by means of a comparison microscope. In effect, the comparison microscope is two microscopes, optically paired. Both microscopes are connected so that two objects may be viewed at the same time. See 1 J. Mathews, *supra*, ch. 4 ("Instrumentation"). This type of microscope permits a split-screen view of the two bullets and can be manipulated so that the striations (marks) on both bullets are aligned. A camera, attached to the microscope, is used to take photomicrographs. See generally 1 J. Mathews, *supra*, at 43; 1 C. Scott, *Photographic Evidence* ch. 15 (2d ed. 1969).

A positive identification of a bullet as having been fired from a particular firearm is based on individual barrel characteristics. Barrels are machined during the manufacturing process and imperfections in the tools used in the machining process are imprinted on the bore of the firearm. The subsequent use of the firearm adds additional individual markings. For example, mechanical action (erosion) caused by the friction of bullets passing through the bore of the firearm produces accidental markings. Similarly, chemical action (corrosion) caused by moisture (rust) as well as primer and propellant chemicals produce other markings.

When a bullet is fired, microscopic striations are imprinted on the bullet surface as it passes through the bore of the firearm. These markings are produced by the individual characteristic markings of the bore and since these bore markings are randomly produced, they are unique to each firearm. "No two barrels are microscopically identical, as the surfaces of their bores all possess individual and characteristic markings." G. Burrard, *The Identification of Firearms and Forensic Ballistics* 138 (1962); 1 J. Mathews, *supra*, at 3 ("Experience has shown that no two firearms, even those of the same make and model and made consecutively by the same tools, will produce the same markings on a bullet or a cartridge.").

The probability that two firearms would have identical bore markings is considered so remote that firearms identification examiners often conclude that a bullet has been fired from a particular firearm and could not have been fired by any other firearm. In effect, this opinion is based on probability theory. As McCormick has noted:

[A]ny expert giving any opinion on whether the scientific test identifies the defendant as being the person who left the incriminating trace, such as a . . . bullet, . . . bases this conclusion on an understanding or impression of how similar the items being compared are and how common it is to find items with these similarities. If these beliefs have any basis in fact, it is to be found in the general experience of the criminalists or more exacting statistical studies of these matters. C. McCormick, *Evidence* 652 (3d ed. 1984).

Firearms identification falls into the former category; it is based on the "general experience" of firearms identifica-

tion examiners and not on statistical studies. For articles on the statistical basis of firearms identification, see Biasotti, *A Statistical Study of the Individual Characteristics of Fired Bullets*, 4 J. Forensic Sci. 34 (1959); Biasotti, *The Principles of Evidence Evaluation as Applied to Firearms and Tool Mark Identification*, 9 J. Forensic Sci. 428, 432 (1964) ("we lack the fundamental statistical data needed to develop verifiable criteria"); Deinet, *Studies of Models of Striated Marks Generated by Random Processes*, 26 J. Forensic Sci. 35 (1981).

Moreover, although a positive identification is based on objective data — the striations on the bullet surface — the examiner's conclusion is essentially a subjective judgment. This judgment rests on the reproducible points of identity. No objective criteria are used for this determination: "In general, the texts on firearms identification take the position that each practitioner must develop his own intuitive criteria of identity gained through practical experience." Biasotti, *The Principles of Evidence Evaluation as Applied to Firearms and Tool Mark Identification*, 9 J. Forensic Sci. 428, 429 (1964). See also J. Peterson, E. Fabricant & K. Field, Crime Laboratory Proficiency Testing Research Program 207 (October 1978) [hereinafter cited as Laboratory Proficiency Test] (Ultimately, unless other issues are involved, it remains for the examiner to determine for himself the modicum of proof necessary to arrive at a definitive opinion."). In this sense, firearms identification is more of an art than a science. As one author has noted:

From the number of texts devoted exclusively to the subject of firearms and toolmark identification, it might appear that this specialized area of physical comparison is a highly developed science with well defined criteria for evidence evaluation. On the contrary, a review of the literature reveals a very superficial treatment of this basic problem of evaluating results and establishing identity. Biasotti, *supra*, at 428.

An analogy between firearms identification and fingerprint identification is somewhat misleading. A person's fingerprints do not change, whereas the markings on the bore of a firearm may change everytime it is fired. For example, rust or dirt in the bore may leave a mark on one bullet that will not be found on a subsequently fired bullet because the rust or dirt may have been dislodged from the barrel when the first bullet was fired. Metal fouling, which is common with lead bullets, may also change the interior surface of the barrel. See 1 J. Mathews, *supra*, at 21 ("If a test bullet is fired through a barrel which has become fouled subsequent to the passage of the evidence bullet through it, the markings on the test and evidence bullets may be quite different."). The examiner, therefore, must distinguish *unimportant* dissimilar markings from *significant* dissimilar markings. One commentator has written:

[O]ne of the most surprising things which must strike any observer who is examining fired bullets is the astonishing differences which seem to be present on bullets which are known to have been fired through the same barrel. These differences are due to the sliding imprint, but with practice it is possible to detect the difference between variations resulting from the sliding imprint and variations due to different barrels. G. Burrard, *supra*, at 145.

See also Goddard, *Scientific Identification of Firearms and Bullets*, 17 J. Crim. L., Criminology & Police Sci. 254, 262 (1956) ("All the fine striations will not match together

by any means, but enough will do so to dispel any doubts as to the fact that their arm of origin was identical.'").

Thus, given the nature of the identification process, it is not surprising to find two experts who disagree about whether there are sufficient points of identity to render a positive identification in a particular case. See *State v. Nemeth*, 182 Conn. 403, 408, 438 A.2d 120, 123 (1980); *People v. Kirschke*, 53 Cal. App.3d 405, 125 Cal. Rptr. 680 (1975), *cert. denied*, 429 U.S. 820 (1976).

Because of the subjective nature of a positive identification, the examiner's expertise is critical. Generally, this expertise is obtained through on-the-job training and experience, not academic training. Darby, *Firearms Identification*, in 3 Forensic Sciences 38-8 (C. Wecht ed. 1984). The Crime Laboratory Proficiency Testing Program raised questions about the competence of some firearms identification examiners. Each laboratory participating in the test received three bullets, two of which had been fired from the same firearm. Five laboratories, representing 3.8% of those participating in the test, misidentified the bullets. The Project Advisory Committee considered these errors "particularly grave in nature" and concluded that they probably resulted from carelessness, inexperience, or inadequate supervision. Laboratory Proficiency Test, *supra*, at 207-08.

The condition of a firearm or evidence bullet may preclude a positive identification. For example, there may be insufficient marks on the bullet or, due to mutilation, an insufficient amount of the bullet may have been recovered. Similarly, if the barrel of the firearm has changed significantly, due to erosion or corrosion, a positive identification may be impossible. In these situations, the examiner may render a "no conclusion" determination. F.B.I., *supra*, at 52 ("There are not sufficient microscopic marks remaining on the bullet, cartridge case, or shot-shell casing to determine if it was fired by the weapon or the condition of the weapon precludes the possibility of making an identification."). Such a conclusion does have some evidentiary value; that is, the firearm *could have* fired the bullet because the class characteristics match.

CARTRIDGE CASE IDENTIFICATION

Cartridge cases may be identified by breech face, chamber, firing pin, extractor, or ejector marks. Cartridge case identification is based on the same theory as bullet identification: "[T]he whole principle of identification is based on the fact that since the breech face of every weapon must be individually distinct, the cartridge cases which it fires are imprinted with this individuality. The imprints on all cartridges fired from the same weapon are the same, and those on cartridges fired from different weapons must always be different." G. Burrard, *supra*, at 107.

As with barrels, marks produced in the manufacturing process add distinctive characteristics to the breech face, firing pin, chamber, extractor, and ejector. Additional distinctive markings are produced by the subsequent use of the firearm. When the trigger is pulled, the firing pin strikes the primer of the cartridge, causing the primer to detonate. This detonation ignites the propellant (powder). In the process of combustion, the powder is converted rapidly into gases. The pressure produced by this

process propels the projectile from the weapon. This pressure also forces the base of the cartridge case backwards against the breech face, imprinting breech face marks on the base of the cartridge case. Similarly, the firing pin, ejector, and extractor may leave characteristic marks on a cartridge case.

The procedure used in cartridge case identification involves a comparison of the cartridge case recovered at the crime scene and a test cartridge case obtained from the firearm after it has been fired. Shot shell casings as well as cartridge cases inserted into handguns and rifles may be identified in this way.

Bullet and cartridge case identifications differ in several respects. Since the bullet is traveling through the barrel at the time it is imprinted with the bore marks, these marks are "sliding" imprints, called striated marks. In contrast, the cartridge case receives "static" imprints, called impressed marks. G. Burrard, *supra*, at 145. Thus, cartridge case marks may be easier to match. Nevertheless, since some firearms, such as revolvers, do not automatically eject the cartridge case when fired, cartridge case identification is probably not as common as bullet identification.

As with bullet identification, cartridge case identification was part of the Laboratory Proficiency Testing Program. Two cartridge cases, each fired in a different firearm, were involved in the test. The test required the comparison of both cartridge cases to determine if they had been fired in the same firearm. Five laboratories, representing 3.8% of those participating in the test, misidentified a cartridge case. Laboratory Proficiency Test, *supra*, at 207-08.

FIRING DISTANCE DETERMINATIONS

Determining the distance between a firearm and a target at the time the firearm was discharged is often important in cases in which suicide, self-defense, or accidental shootings are an issue. Under certain circumstances, it may be possible to ascertain the *approximate* firing distance.

Shotguns

When a shot shell is fired from a shotgun, the pellets generally emerge from the muzzle grouped together and then disperse in an ever-increasing pattern as the distance from the muzzle increases. At a very close range the pellets will leave a single hole in the target surface. At greater ranges, multiple single holes are present and the radius of the pattern increases. In sum, the closer the shotgun is to the target, the smaller the dispersion pattern.

By firing a shotgun at different distances, the dispersion pattern for a particular distance may be ascertained and compared to the dispersion pattern present at the crime scene. See generally Guerin, *Shotgun Wounds*, 5 J. Forensic Sci. 294 (1960); Juahari, Chatterjee & Ghosh, *Statistical Treatment of Pellet Dispersion Data for Estimating Range of Firing*, 17 J. Forensic Sci. 141 (1972); Mattoo & Nabar, *Evaluation of Effective Shot Dispersion in Buckshot Patterns*, 14 J. Forensic Sci. 263 (1969).

The relevancy of these experiments depends on the

extent to which the conditions existing at the crime can be replicated. Because the dispersion pattern differs for different shotguns and different types of ammunition, the identical weapon and the same type of ammunition used in the crime typically are required for this type of test. See F.B.I., *supra*, at 54. For example, the choke of a shotgun affects the dispersion pattern. The choke refers to the constriction of a shotgun barrel; that is, the diameter of the barrel is smaller at the muzzle end than at the breech end. The purpose of the choke is to produce a smaller dispersion pattern. Several types of chokes are used: full choke, modified choke, improved cylinder, and cylindrical bore (no choke). The greater the choke, the smaller the dispersion pattern. Similarly, the type of ammunition affects the dispersion pattern; the pattern changes depending on the size of the pellets and the type of wadding used in the shot shell.

Other Firearms

Firing distance determinations for bullets and shot shells differ. When a bullet is fired, unburned or partially burned powder and soot is propelled from the muzzle along with the bullet. Primer particles and bullet fragments may also be ejected from the muzzle. At close ranges these materials will strike the target, causing smudging (blackening) and stippling or tattooing. Spitz, *Gunshot Wounds*, in *Medicolegal Investigation of Death* 216 (W. Spitz & R. Fisher eds. 1980). The presence of these effects is indicative of a close range shot and may permit the muzzle-to-target distance to be approximated.

Testimony concerning the range of fire may involve different types of experts. A pathologist, based on an autopsy and an examination of a homicide victim's clothing, may offer an opinion on the approximate muzzle-to-target distance. *Id.* at 227-28; DiMaio, Petty & Stone, *An Experimental Study of Powder Tattooing of the Skin*, 21 J. Forensic Sci. 367 (1976). A firearms identification expert, based on an examination of the clothing, may also offer an opinion. The examination of the clothing may be visual, microscopic, or involve chemical tests for the presence of gunshot residues. Walker, *Chemistry and Legal Medicine*, 216 New England J. Med. 1024 (1937); Walker, *Bullet Holes and Chemical Residues in Shooting Cases*, 31 J. Crim. L. & Criminology 497 (1940). In addition, instrumental analysis, such as neutron activation analysis, may be used to detect the presence of bullet and primer residues. See Krishnan, *Determination of Gunshot Firing Distances and Identification of Bullet Holes by Neutron Activation Analysis*, 12 J. Forensic Sci. 112 (1967); Krishnan, *Firing Distance Determination by Neutron Activation Analysis*, 12 J. Forensic Sci. 471 (1967). See also Stone & Petty, *Examination of Gunshot Residues*, 19 J. Forensic Sci. 784 (1974) (discussing other instrumental techniques).

Thus, the presence of gunshot residues on the target is indicative of both a bullet wound and a close-range shooting. Once the residue is identified and the dispersion pattern established, it may be possible to provide a more specific approximation of the range of fire. As with shotguns, the particular firearm and the same type of ammunition used in the incident should be used in the tests. Munhall, *Fundamental Ballistics Pertaining to Investigations Involving Firearms*, 6 J. Forensic Sci. 215, 215

(1961) ("It is well recognized that different guns and different ammunition will vary widely in their residue distribution patterns . . ."). One article lists the following factors as affecting the residue pattern: distance, barrel length, propellant burning rate, propellant type, caliber, muzzle-to-target angle, target material, primer, propellant charge weight, and weapon type. Barnes & Helson, *An Empirical Study of Gunpowder Residue Patterns*, 19 J. Forensic Sci. 448, 449 (1974). Most of these factors are accounted for if the same weapon and similar ammunition is used in the experimental tests. The target material will rarely be the same, and thus this factor may affect the conclusions that may be drawn from the tests. As one authority has noted: "A frequent source of error with respect to the evaluation of the distance from which a gun was fired is the comparison of a test pattern on a white paper or cloth with the pattern of the wound on the skin. Scattered specks of gunpowder are certainly not as conspicuous on the skin as they are on a smooth white background such as cloth or paper." Spitz, *supra*, at 228.

OTHER PROCEDURES

In addition to the examinations discussed above, a firearms identification examiner may conduct several other types of examinations. For example, if a defendant claims that a weapon fired accidentally, the condition of the weapon may be an issue. In such a case, the examiner may check the weapon to determine whether any parts are worn, broken, or missing. In particular, the functioning of the safety, hammer, and trigger are tested. The pressure required to pull the trigger can be measured and compared with other weapons of the same make. See Ceccaldi, *The Examination of Firearms and Ammunition*, in 1 *Methods of Forensic Science* 593, 608-09 (F. Lundquist ed. 1962).

Serial number restoration is another procedure typically conducted by firearms identification examiners. Firearms as well as numerous other metal objects, such as typewriters and automobiles, are imprinted with serial numbers. Various procedures, such as rolling, stamping, and engraving, are used to imprint the serial number at the time the item is manufactured. Sometimes a firearm or other object recovered in a criminal investigation has had its serial number obliterated by filing or grinding. Even though the number is visually removed, it may be possible to restore it. When the serial number is originally stamped, for example, the stamping process strains the metal to a depth greater than the visual number. If the filing does not penetrate to this depth, several restoration procedures, such as chemical etching and electrolytic processing, may be used to restore the number. See 1 J. Mathews, *supra*, ch. 5. See also Young, *The Restoration of Obliterated Stamped Serial Numbers by Ultrasonically Induced Cavitation in Water*, 19 J. Forensic Sci. 820 (1974).

TOOLMARK IDENTIFICATION

"Toolmark examinations include, but are not limited to, microscopic studies to determine if a given toolmark was produced by a specific tool." F.B.I., *supra*, at 60. Toolmark identifications are based on the same theory as firearms identifications. See Biasotti, *The Principles of Evidence*

Evaluation as Applied to Firearms and Tool Mark Identification, 9 J. Forensic Sci. 428 (1964). Tools have both class characteristics and individual characteristics. Individual characteristics are accidental marks produced in the machining process and by subsequent use. When the tool is used these characteristics are often imparted onto the surface of another object.

Firearms identification could be considered a subspecialty of toolmark identification; the firearm (tool) imprints its individual characteristics on the bullet. Toolmark identification, however, is often more difficult than firearms identification. The markings on a bullet or cartridge case are imprinted in the same way every time a firearm is fired. In contrast, a tool can be used in a variety of different ways, each producing a different mark: "[I]n toolmark work the angle at which the tool was used must be duplicated in the test standard, pressures must be dealt with, and the degree of hardness of metals and other materials must be taken into account." Flynn, *Toolmark Identification*, 2 J. Forensic Sci. 95, 105 (1957).

Toolmarks may be impressions (compression marks) or striations (friction or scrape marks) or a combination of both. Burd & Greene, *Tool Mark Examination Techniques*, 2 J. Forensic Sci. 297, 298 (1957). The marks may be left on a variety of different materials, such as wood or metal. In some cases, only class characteristics can be matched. For example, it may be possible to identify a mark (impression) left on a piece of wood as having been produced by a hammer, punch, or screwdriver. A comparison of the mark and the tool may establish that the size of the tool (another class characteristic) and the mark also match. Unusual features of the tool, such as a chip, may permit a positive identification. Striations caused by scraping with a tool may also produce individual characteristic marks in much the same way that striations are imprinted on a bullet when a firearm is discharged. This type of examination has the same limitations as firearms identification: "[T]he characteristics of a tool will change with use." Flynn, *supra*, at 102.

As with firearms identification testimony, toolmark identification testimony is based on the subjective judgment of the examiner, who determines whether sufficient marks of similarity are present to permit a positive identification. There are no objective criteria. As one commentator has noted: "[I]t is not possible at present to categorically state the number and percentage of the lines which must correspond." Burd & Green, *supra*, at 310. For other articles on toolmark identification, see Burd & Greene, *Tool Mark Comparisons in Criminal Investigations*, 39 J. Crim. L. & Criminology 379 (1948); Burd & Kirk, *Tool Marks*, 32 J. Crim. L. & Criminology 679 (1942); Green & Burd, *Special Techniques Useful in Tool Mark Comparisons*, 41 J. Crim. L. & Criminology 523 (1950); Meyers & Kivela, *Interesting Applications of Tool Mark Identifications*, 6 J. Forensic Sci. 316 (1961).

ADMISSIBILITY OF FIREARMS AND TOOLMARK EVIDENCE

Firearms identification developed in the early part of this century. By the 1930s courts were admitting firearms identification evidence. *E.g.*, *People v. Fisher*, 340 Ill. 216, 172 N.E. 743 (1930); *Evans v. Commonwealth*, 230 Ky.

411, 19 S.W.2d 1091 (1929); *Burchett v. State*, 35 Ohio App. 463, 172 N.E. 555 (1928). *But see* *People v. Berkman*, 307 Ill. 492, 501, 139 N.E. 91, 94 (1923) (positive identification of bullet "preposterous").

Recent cases have followed these precedents. Numerous courts have admitted evidence of bullet identification. *E.g.*, *United States v. Wolff*, 5 M.J. 923, 926 (N.C.M.R. 1978); *petition denied*, 6 M.J. 305 (C.M.A. 1979); *State v. Nemeth*, 182 Conn. 403, 408, 438 A.2d 120, 123 (1980); *People v. Torres*, 100 Ill. App.3d 931, 937, 427 N.E.2d 329, 334-35 (1981); *Commonwealth v. Ellis*, 373 Mass. 1, 5-6, 364 N.E.2d 808, 811-12 (1977); *State v. Hill*, 294 N.C. 320, 332-33, 240 S.E.2d 794, 802-03 (1978); *State v. Benton*, 413 A.2d 104, 112-13 (R.I. 1980); *McDaniel v. State*, 632 P.2d 534, 536-37 (Wyo. 1981). See *generally* Annot., 26 A.L.R.2d 892 (1952).

Courts have also admitted evidence of cartridge case identification. *E.g.*, *State v. Gonzales*, 92 Idaho 152, 155, 158, 438 P.2d 897, 900, 903 (1968); *State v. Goyette*, 407 A.2d 1104, 1113-14 (Me. 1979); *State v. Thomas*, 299 A.2d 919, 920 (Me. 1973); *Edwards v. State*, 198 Md. 132, 143-44, 81 A.2d 631, 635-36 (1951); *People v. King*, 58 Mich. App. 390, 398-99, 228 N.W.2d 391, 396 (1975); *State v. Hindman*, 543 S.W.2d 278, 284 (Mo. App. 1976); *State v. Aiken*, 72 Wash.2d 306, 352, 434 P.2d 10, 39 (1967), *vacated on other grounds*, 392 U.S. 652, (1968). See *generally* Annot., 26 A.L.R.2d 892 (1952).

Similarly, shot shell identification evidence has been admitted in evidence. *E.g.*, *Williams v. State*, 384 So.2d 1205, 1210-11 (Ala. App. 1980); *Lewis v. State*, 335 So.2d 426, 428 (Ala. App. 1975), *cert. denied*, 335 So.2d 429 (Ala. 1976); *Douglas v. State*, 42 Ala. App. 314, 329, 163 So.2d 477, 492 (1963), *cert. denied*, 163 So. 2d 496 (Ala. 1964); *Burge v. State*, 282 So.2d 223, 229 (Miss. 1973), *cert. denied*, 415 U.S. 985 (1974).

If the weapon used in the crime is not recovered and therefore a test bullet or case cartridge cannot be obtained, a bullet or cartridge case fired by the weapon at a different time may be used for comparison. *E.g.*, *State v. Lane*, 72 Ariz. 220, 225-26, 233 P.2d 437, 440-41 (1951); *Commonwealth v. Ellis*, 373 Mass. 1, 5-6, 364 N.E.2d 808, 811-12 (1977); *People v. Williams*, 15 Mich. App. 683, 687-88, 167 N.W.2d 358, 360 (1969); *State v. Boccadoro*, 105 N.J.L. 352, 354-55, 144 A. 612, 613 (1929). See also *United States v. Bowers*, 534 F.2d 186, 193-94 (9th Cir.), *cert. denied*, 429 U.S. 942 (1976).

The Federal Rules of Evidence treat this issue as one of authentication. Rule 901(b)(3) provides that an item of evidence may be identified by an expert witness through a comparison of the item and specimens which have been authenticated. The Advisory Committee's Notes to that rule specifically mention "ballistics" comparisons. See *generally* 5 J. Weinstein & M. Berger, *Weinstein's Evidence* ¶ 901(b)(3)[05] (1983) ("Ballistics"). Under the Federal Rule, bullet or cartridge case identification evidence is admissible if evidence sufficient to support a finding of identification has been introduced. Fed. R. Evid. 901(a).

Lack of Positive Identification

A number of courts have also permitted an expert to testify that a bullet *could have been fired* from a particular firearm. *E.g.*, *State v. Edgin*, 110 Ariz. 416, 418-19, 520

P.2d 288, 290-91 (1974); *Ruiz v. State*, 265 Ark. 875, 896, 582 S.W.2d 915, 925 (1979), *cert. denied*, 454 U.S. 1093 (1981); *State v. Hatton*, 95 Idaho 856, 861, 522 P.2d 64, 69 (1974); *People v. Singletary*, 73 Ill. App.3d 239, 248, 391 N.E.2d 440, 447 (1979); *State v. Reynolds*, 307 N.C. 184, 196-97, 297 S.E.2d 532, 539-40 (1982); *State v. Ward*, 300 N.C. 150, 153-54, 266 S.E.2d 581, 583-84 (1980); *State v. Bayless*, 48 Ohio St.2d 73, 111, 357 N.E.2d 1035, 1058-59 (1976), *vacated on other grounds*, 438 U.S. 911 (1978); *Commonwealth v. Moore*, 462 Pa. 231, 237-38, 340 A.2d 447, 451 (1975); *Commonwealth v. Pierce*, 453 Pa. 319, 324-25, 309 A.2d 371, 373-74 (1973); *Commonwealth v. Hoss*, 445 Pa. 98, 115-16, 283 A.2d 58, 67-68 (1971). See *generally* Annot., 31 A.L.R.4th 486 (1984).

In other words, the class characteristics of the bullet and the firearm match. Although this type of evidence is not as probative as a positive identification, it nevertheless has some probative value and satisfies the test for relevancy. See Fed. R. Evid. 401 (" 'Relevant evidence' means evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence."). As one court has commented, the expert's "testimony, which established that the bullet which killed [the victim] could have been fired from the same caliber and make of gun found in the possession of [the defendant], significantly advanced the inquiry." *Commonwealth v. Hoss*, 445 Pa. 98, 115-16, 283 A.2d 58, 68 (1971).

Expert Qualifications

Determining whether a witness is qualified to testify concerning a firearms identification is a decision entrusted to the discretion of the trial court and that decision will be reversed on appeal only for an abuse of discretion: "Unless the trial court's exercise of discretion is clearly erroneous, its decision as to the qualifications of an expert witness should not be disturbed." *Ignacio v. Territory of Guam*, 413 F.2d 513, 520 (9th Cir. 1969), *cert. denied*, 397 U.S. 943 (1970). *Accord* *Brown v. State*, 245 Ga. 588, 589, 266 S.E.2d 198, 200 (1980); *State v. Zigler*, 42 N.C. App. 148, 156, 256 S.E.2d 479, 484 (1979). See *generally* Joling & Stern, *An Overview of Firearms Identification Evidence for Attorneys. III: Qualifying and Using the Firearms Examiner as a Witness*, 26 J. Forensic Sci. 166 (1981).

Although rare, appellate courts have found an abuse of discretion, especially when a defense expert's testimony has been excluded for lack of qualifications. *State v. Macumber*, 112 Ariz. 569, 570-71, 544 P.2d 1084, 1085-86 (1976). Typically, a firearms identification examiner will be qualified on the basis of his on-the-job training and experience.

Photographic Evidence

Courts have admitted photomicrographs in connection with the testimony of firearms identification examiners. *E.g.*, *Redus v. State*, 243 Ala. 320, 325, 9 So.2d 914, 918 (1942), *cert. denied*, 318 U.S. 774 (1943); *State v. Jefferson*, 204 Kan. 50, 54, 460 P.2d 610-614 (1969); *Commonwealth v. Giacomazza*, 311 Mass. 456, 470-71, 42 N.E.2d 506, 514-15 (1942); *State v. Hackett*, 215 S.C. 434, 447, 55

S.E.2d 696, 702 (1949). See generally 2 C. Scott, *Photographic Evidence* ch. 39 (2d ed. 1969); Annot., 72 A.L.R.2d 308, 331 (1960) (admissibility of enlarged photographs of bullets and shells).

As with other types of photographs, the offering party must lay a foundation establishing that the photograph is an accurate representation of the object depicted. If the photomicrographs of the comparison are not offered, the expert may still testify concerning the identification. *E.g.*, *People v. Buckowski*, 37 Cal.2d 629, 631, 233 P.2d 912, 913 (1951), *cert. denied*, 342 U.S. 928 (1952); *People v. O'Neal*, 118 Ill. App.2d 116, 123, 254 N.E.2d 559, 562 (1969); *State v. White*, 321 So.2d 491, 496 (La. 1975).

There is disagreement about the value of photomicrographs. 1 J. Mathews, *supra*, at 47. Since the identification is based on the overall length and circumference of the bullet — each land and groove impression — and juries are not trained to interpret photomicrographs, photomicrographs are often not taken or brought to court. One commentator, however, has rejected this practice:

When a firearms identification expert testifies in court and does not produce photographs to demonstrate his opinion as to why no photographs were made. . . . Always regard as suspect the statement that the ballistics expert could see the identity or nonidentity under the microscope but that it was impossible to photograph it. Ordinarily anything that can be seen can be photographed. 2 C. Scott, *supra*, at 657-58.

Disagreement Among Experts

As noted above, experts may disagree over whether sufficient marks are present to permit a positive identification. In *State v. Nemeth*, 182 Conn. 403, 408, 438 A.2d 120, 123 (1980), the court held that such a disagreement does not affect the admissibility of firearms identification evidence. See also *Commonwealth v. Ellis*, 373 Mass. 1, 5, 364 N.E.2d 808, 812 (1977) ("The Commonwealth's two [firearms identification] experts did not fully agree.").

In *People v. Kirschke*, 53 Cal. App.3d 405, 125 Cal. Rptr. 680 (1975), *cert. denied*, 429 U.S. 820 (1976), a prosecution expert testified that an evidence bullet had been fired by a particular firearm and that "no other in the world was the murder weapon." *Id.* at 410, 125 Cal. Rptr. at 683. However, in post-conviction proceedings court-appointed experts testified that a positive identification could not be made. *Id.* at 411, 125 Cal. Rptr. at 684. Although the court found that the expert had "negligently presented false demonstrative evidence in support of his ballistics testimony," it denied post-conviction relief because the defendant had failed to challenge the testimony at trial, even though he had the opportunity to do so. *Id.* at 408, 125 Cal. Rptr. at 682.

Other Types of Examinations

Courts have also admitted other types of firearms evidence — for example, evidence identifying bullets by their elemental composition. See *Medley v. United States*, 155 F.2d 857, 860 (D.C. Cir.), *cert. denied*, 328 U.S. 873 (1946) (spectroscopic analysis); *Jones v. State*, 425 N.E.2d 128, 130-31 (Ind. 1981) (neutron activation analysis); *State v. Krummacher*, 269 Or. 125, 143, 523 P.2d 1009, 1017 (1974) (neutron activation analysis). In addition, evidence of accidental shootings has been

admitted. See *Hilburn v. State*, 166 Ga. App. 357, 357, 304, S.E.2d 480, 482 (1983). One court also admitted evidence of serial number alteration, although a firearm was not involved. See *People v. Snow*, 21 Ill. App.3d 873, 876-77, 316 N.E.2d 216, 218-19 (1974) (expert testimony concerning alteration of serial number on automobile admitted).

Firing Distance Determinations

The results of tests conducted to determine muzzle-to-target distance have been admitted in cases involving rifles and handguns. *E.g.*, *State v. Castagna*, 170 Conn. 80, 90-91, 364 A.2d 200, 206 (1976); *People v. Carbona*, 27 Ill. App.3d 988, 1004, 327 N.E.2d 546, 561 (1975), *cert. denied*, 424 U.S. 914 (1976); *State v. Jiles*, 258 Iowa 1324, 1328-32, 142 N.W.2d 451, 453-56 (1966); *State v. Atwood*, 250 N.C. 141, 108 S.E.2d 219 (1959); *State v. Goins*, 24 N.C. App. 468, 472, 211 S.E.2d 481, 483-84, *cert. denied*, 287 N.C. 262, 214 S.E.2d 434 (1975); *State v. Kahan*, 268 S.C. 240, 245-46, 233 S.E.2d 293, 294 (1977); *State v. Brooks*, 16 Wash. App. 535, 540, 557 P.2d 362, 366 (1976). See also Annot., 86 A.L.R.2d 611 (1962).

Similarly, the results of tests conducted to determine the firing distance of shotguns have been held admissible. *E.g.*, *State v. Polan*, 78 Ariz. 253, 358-59, 278 P.2d 432, 436 (1954); *West v. State*, 200 Ga. 566, 571, 37 S.E.2d 799, 801-02 (1946); *State v. Tourville*, 295 S.W.2d 1, 6-7 (Mo. 1956), *cert. denied*, 352 U.S. 1018 (1957); *State v. Bates*, 48 Ohio St.2d 315, 321-22, 358 N.E.2d 584, 588-89 (1976), *vacated on other grounds*, 438 U.S. 910 (1978); *Andrews v. State*, 555 P.2d 1079, 1083-84 (Okla. Crim. App. 1976); *Williams v. State*, 147 Tex. Crim. 178, 184, 179 S.W.2d 297, 300 (1944). See also Annot., 86 A.L.R.2d 611 (1962).

One court has stated the test for determining the admissibility of such tests as follows:

The results of tests to determine the distance from which a weapon had been fired are admissible into evidence provided the test was conducted under conditions sufficiently similar to the actual conditions involved in the case that they can be fairly said to have probative value and will enlighten, not confuse the jury. *Andrews v. State*, 555 P.2d 1079, 1083 (Okla. Crim. App. 1976).

If the conditions are not substantially similar, the results are not admissible. *E.g.*, *Millier v. State*, 250 Ind. 656, 236 N.E.2d 585 (1968); *Roberts v. State*, 117 Tex. Crim. 418, 424-25, 35 S.W.2d 175, 178 (1931). For example, some courts have excluded dispersion pattern tests on the grounds that the target material used in the test was not shown to be similar to human skin tissue. *E.g.*, *Roberts v. State*, 189 So.2d 543, 546 (Fla. App. Dist. Ct. 1966); *People v. Cohen*, 50 N.Y.2d 908, 409 N.E.2d 921, 431 N.Y.S.2d 446 (1980). Other courts have held that this factor does not affect the admissibility of the test results. *E.g.*, *State v. Brooks*, 16 Wash. App. 535, 540, 557 P.2d 362, 366 (1976).

Toolmark Identifications

Finally, courts have admitted toolmark identification evidence. *E.g.*, *United States v. Taylor*, 334 F. Sup. 1050, 1056-57 (D.C. Pa. 1971) (impressions on stolen vehicle and impressions made by dies found in defendant's possession), *aff'd*, 469 F.2d 284 (3d Cir. 1972); *People v.*

Perrini, 14 Ill.2d 581, 591-92, 153 N.E.2d 578, 583 (1958) (crowbar matched marks on safe); State v. McClelland, 162 N.W.2d 457, 462 (Iowa 1968) (pry bar and marks on "jimmied" door); State v. Dillon, 161 N.W.2d 738, 741 (Iowa 1968) (screwdriver and nail bar fit marks on door frame); State v. Hazelwood, 209 Kan. 649, 655-56, 498 P.2d 607, 612 (1972) (screwdriver and imprint on window molding); State v. Montgomery, 175 Kan. 176, 180, 261 P.2d 1009, 1011-12 (1953) (punch and marks on safe); State v. Wade, 465 S.W.2d 498 (Mo. 1971) (screwdriver and pry marks on door jamb); State v. Brown, 291 S.W.2d 615, 618-19 (Mo. 1956) (crowbar and screwdriver and marks on window sash and door); State v. Eickmeier, 187 Neb. 491, 493, 191 N.W.2d 815, 816 (1971) (screwdriver and marks on door); Graves v. State, 563 P.2d 646, 650 (Okla. Crim. App. 1977) (blade and knife handle matched); Adcock v. State, 444 P.2d 242, 243-44 (Okla. Crim. App. 1968) (tool matched pry marks on door molding); State v. Olsen, 212 Or. 191, 195-96, 317 P.2d 938, 940 (1957) (hammer and marks on safe); State v. Clarke, 156 Wash. 543, 549, 287 P. 18, 20 (1930) (knife and cuts on tree branches). As one court has noted, toolmark identification "rests upon a scientific basis and is a reliable and generally accepted procedure." United States v. Bowers, 534 F.2d 186, 193 (9th Cir.), cert. denied, 429 U.S. 942 (1976).

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