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TECHNICAL NOTE

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Preparation of Tool Mark Standards with Jewelry Modeling Waxes

ABSTRACT: This paper presents how jewelry modeling waxes are used in the preparation of tool mark standards from exemplar tools. We have previously found that jewelry modeling waxes are ideal for preparing test tool marks from exemplar tools. In this study, simple methods and techniques are offered for the replication of accurate, highly detailed tool mark standards with jewelry modeling waxes. The techniques described here demonstrate the conditioning and proper use of jewelry modeling wax in the production of tool mark standards. The application of each test tool's working surface to a piece of the appropriate wax in a manner consistent with the tool's design is clearly illustrated. The resulting tool mark standards are exact, highly detailed, 1:1, negative impressions of the exemplar tool's working surface. These wax models have a long shelf life and are suitable for use in microscopic examination comparison of questioned and known tool marks.

KEYWORDS: forensic science, tool marks, tool mark comparison, jewelry modeling wax

During the execution of crimes, tools are often employed for a range of purposes. Tools are used in burglaries to force entry into premises; in sex crimes and homicides to cut pieces of wire, cloth, or cord to use as ligatures and/or restraints; in arson and explosion cases to make bombs; in robberies to alter weapons; and in kidnappings and smuggling to construct containers to imprison people or conceal contraband. As the forensic literature demonstrates, the examination and comparison of the marks left by tools to aid in the solving of crimes has a respected history (1–23).

Although there is an endless variety of tools and their marks, there are only three primary ways tool marks are formed by tools: (i) compression; (ii) scraping; and (iii) combination of both compression and scraping. Compression marks are produced when a tool's working surface is pressed into the surface of a softer material in such a manner so as to leave a negative impression of the tool's surface class characteristics and wear or damage features, e.g., stamp or seal (cf. Fig. 1). Scraping marks are produced when a tool's working surface is caused to slide laterally, along the surface of a softer material in such a manner as to leave a negative impression of the tool's minutiae in the form of a pattern of striae, e.g., hack saw (cf. Fig. 2). Combination tool marks are a merger of both the compression and scraping actions mechanisms. All of the resulting marks are thus a negative impression of the tool's surface class characteristics, individual wear patterns, damage features, and minutiae, e.g., a wrench (cf. Fig. 3).

In cases involving tool mark examination and comparison it is always important to record and document a tool mark's morphology as well as its exact location and position, relative to other tool marks and the overall crime scene. After documentation is completed, it is always preferable to remove the object(s) containing the tool marks for laboratory study, examination, and comparison with standards made from the suspected tool (24).

Before comparison standards are prepared, a thorough study of the questioned tool marks should be undertaken to determine the type of tool that produced them and the manner in which the tool was utilized to make the questioned tool marks. Figure 4 depicts a few of the implements and tools used to assess the questioned marks and to prepare accurate standards.

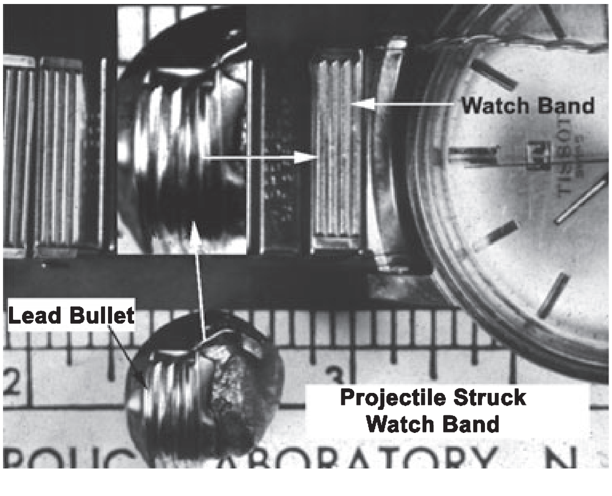

FIG. 1—*A casework example of compression tool marks produced when a soft lead bullet struck a harder stainless steel watchband.*

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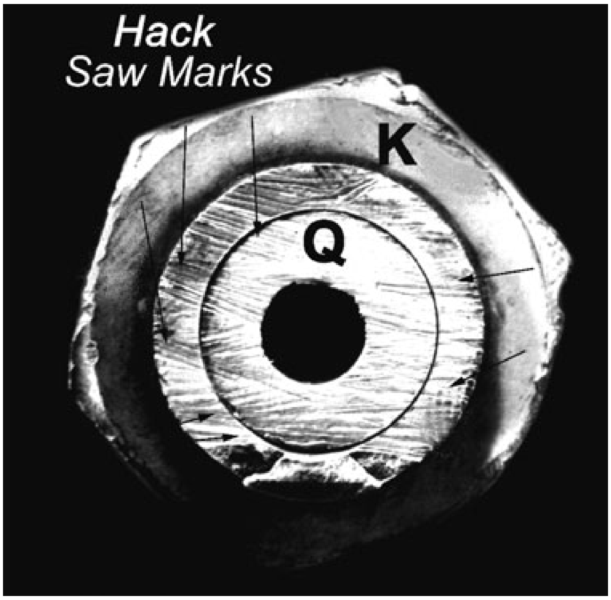

FIG. 2—*A casework example of striation tool marks made by a hack saw. Known (K) is from crime scene, and questioned (Q) is from suspect.*

After the questioned tool mark assessments are complete, tool mark standards are fashioned from jewelry modeling wax for use as comparison standards. A recent article, submitted for publication by three of the authors, introduced the use of these waxes for the preparation of tool mark standards (25). In this study, the authors demonstrate how they use this material to prepare comparison standards with exemplar tools.

Materials and Methods

In crimes involving the possible use of tools and/or the presence of tool marks, a complete study and evaluation of the questioned tool marks must be carried out to determine how the marks were most likely to be produced. All the information gathered during the preliminary examination of the questioned tool marks should be utilized for making the comparison standards with the exemplar tool. Data concerning the possible angle(s), direction, and working area of the tool must all be included when fabricating the comparison standards. If at all possible the entire working surface of the tool should be used to make the tool mark standards. Duplicate standards should be produced for all possible regions and positions of the tool in question.

FIG. 4—*An assortment of devices used to study questioned tool marks for the purpose of preparing tool mark standards in the same or similar manner as the questioned tool marks were made.*

When preparing to make tool mark standards with a suspected tool, a suitable variety of modeling wax should be carefully selected. Jewelry modeling waxes come in many shapes, sizes, flexibilities, and rigidities. After the assessment of the questioned tool marks is complete, an appropriate sized and shaped piece of modeling wax having the desired flexibility and rigidity should be chosen. Table 1 lists a variety of jewelry modeling waxes

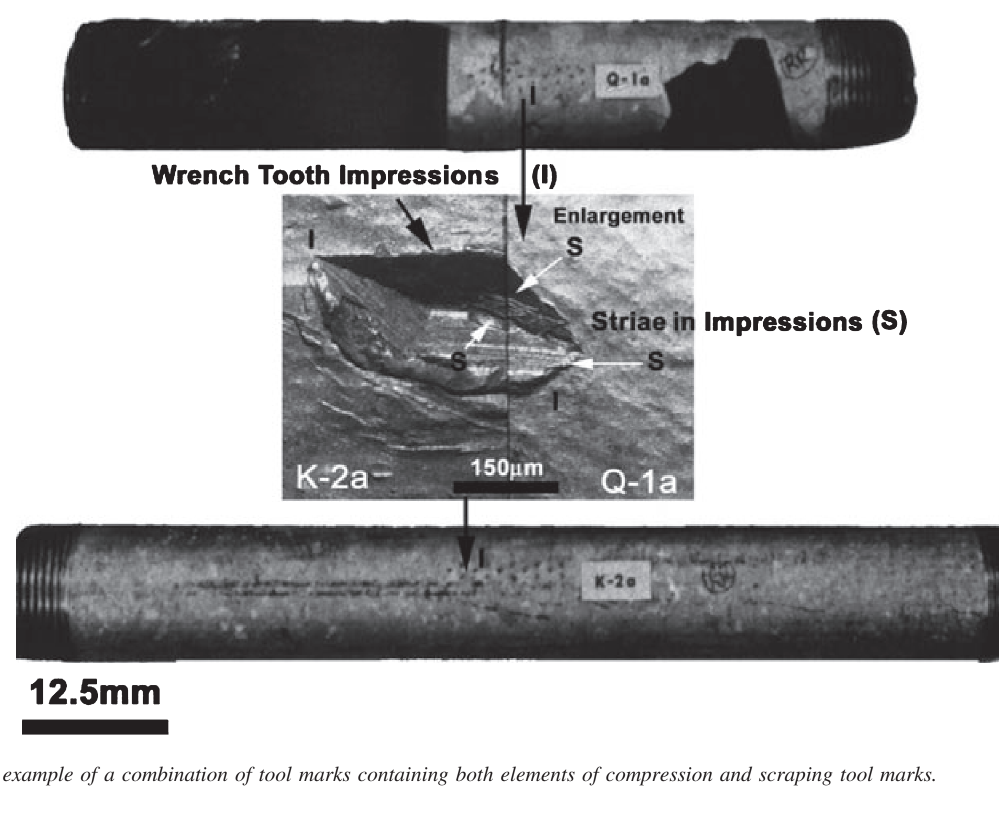

FIG. 3—*Casework example of a combination of tool marks containing both elements of compression and scraping tool marks.*

TABLE 1—*A selection of modeling waxes for preparing tool mark standards.*

Trade marks	Color	Hardness	Mp*	Sheets**	Wires**	Blocks**	Tubes**	Best results—tool
Matt™	Blue	Soft very flexible	93.3	Yes	Yes	Yes	Yes	Wire and bolt cutters, knives, scissors, hammers, pliers
	Purple	Medium some flexibility	104.4	Yes	Yes	Yes	Yes	Hammers, axes, hatchets, knives, pipe wrenches, wrenches, pliers, scissors, prying tools
	Green	Hard brittle	110.0	Yes	Yes	Yes	Yes	Saws, drills, chisels, screwdrivers, prying tools, pipe wrenches
Kerr® Sculpt	Purple	Very soft	72.8			Yes		Hammers, axes, hatchets, blunt objects
Corning Wax Co.	Pink	Soft flexible	75.0	Yes				Wire and bolt cutters, knives, scissors, hammers, pliers
	Green	Soft flexible	75.0	Yes	Yes			Wire and bolt cutters, knives, scissors, tin snips, pliers
Sculpt Wax	Purple	Soft	71.2			Yes		Hammers, axes, hatchets, blunt objects
Modeler's™	Pink	Flexible	75.0	Yes				Scissors, tin snips, pruners
	Green	Flexible	75.0	Yes				Scissors, tin snips, pruners
	Blue	Flexible	75.0		Yes***			Wire and bolt cutters, knives, scissors, tin snips, hammers, pliers
Ferris™	Blue	Soft flexible	115.8	Yes	Yes	Yes	Yes	Wire and bolt cutters, knives, scissors, tin snips, hammers, pliers
	Purple	Medium some flexibility	115.8	Yes	Yes	Yes	Yes	Hammers, axes, hatchets, knives, pipe wrenches, wrenches, pliers, scissors, prying tools
	Green	Hard brittle	115.8	Yes	Yes	Yes	Yes	Saws, drills, chisels, screwdrivers, prying tools, pipe wrenches
Wolf™ Wax	Silver	Medium with slight flexibility	72.0			Yes	Yes	Saws, drills, chisels, screwdrivers, prying tools, pipe wrenches
	Gold	Medium with slight flexibility	72.0			Yes	Yes	Saws, drills, chisels, screwdrivers, prying tools, pipe wrenches

*Melting Point (Mp) in degrees centigrade (°C); **available shapes; ***wire shapes for Modeler's™ Wax: round, half-round, squares, rectangle, triangle, half-pear, tubes, bars, and sheets.

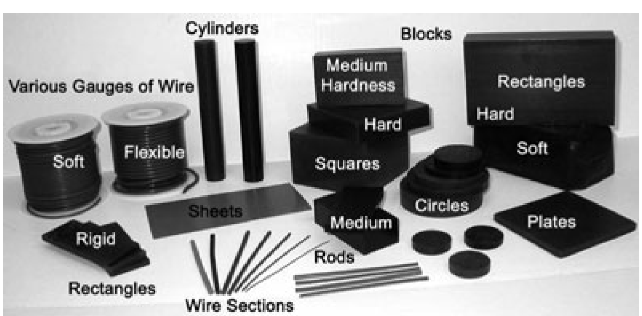

FIG. 5—*An assortment of the various sizes, shapes, and hardness of jewelry modeling waxes commercially available.*

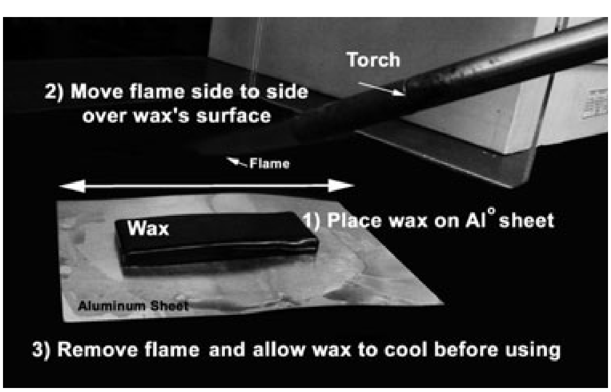

FIG. 6—*To remove heavy scratches, gently heat wax surface with a torch and allow to cool.*

commercially available with their obtainable shapes and physical properties. Figure 5 depicts a selection of the different types, shapes, and sizes of jewelry modeling waxes commercially available.

FIG. 7—*Removal of fine surface marks and scratches from the surface of a piece of modeling wax. The surface of the wax is filed or sanded. Next, any fine abrasions are removed by swabbing the wax with organic wax solvent, i.e., Wax Brite™.*

In most situations the modeling wax can be utilized without any preparation. In some cases the outer surfaces of the modeling wax may have to be made free of surface marks, scuffs, cuts, scratches, dents, and so on. This can be accomplished in several ways. The surface of the wax can be gently heated with a torch and allowed to cool as shown in Fig. 6. Next, the surface of the wax can be made smooth by lightly sanding it with a fine grit sand paper (200–400 mesh) or by filing it with a fine wax file. After sanding or filing, any wax shavings can be removed with an air gun. Next, any remaining minor abrasions are then removed by swabbing the wax with the organic solvent Wax Brite®. This process is demonstrated in Fig. 7. Application of these treatments will give the treated piece of wax a smooth polished surface.

Tool mark standards are prepared by applying the exemplar tool's working surface to a suitably sized and shaped piece of the desired jewelry modeling wax in the same manner it is theorized that the tool was applied to produce the questioned tool marks

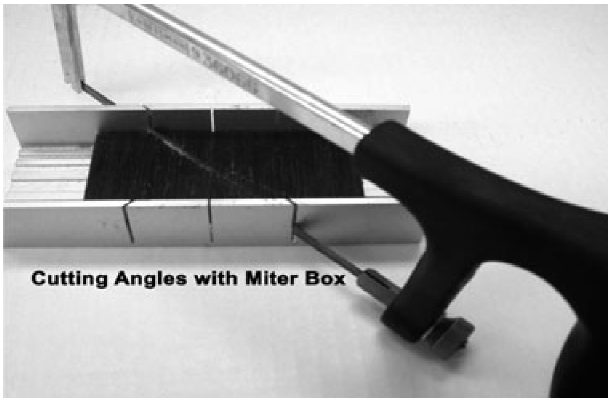

FIG. 8—*Preparing hacksaw tool marks by cutting a piece of jewelry modeling wax with the exemplar saw and the aid of a miter box.*

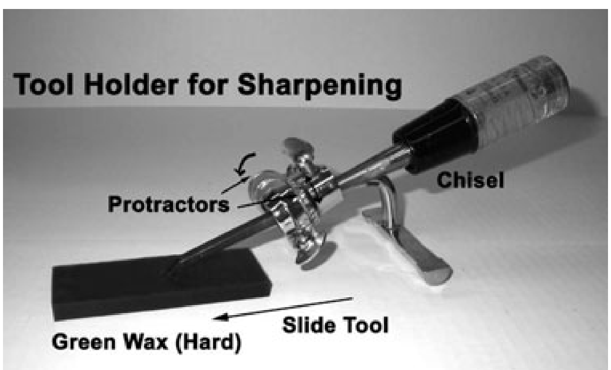

FIG. 9—*Preparation of tool mark standards being made on a piece of hard green wax. A tool holder with variable vertical and horizontal angle adjustment screws is employed to make the exemplar tool marks in a manner suggested by Burd and Kirk (7).*

(cf. Figs. 8–10). As shown in Figs. 8 and 9, in some cases, tool holding devices are useful in the preparation of accurate test standards. Most standards made in modeling wax are ready for direct examination and comparison. However, some standards may require excess wax to be removed before they are ready for examination, as shown in Figs. 11 and 12.

Illustrated in Fig. 13 are the various steps in the production of tool mark standards with the exemplar tool and jewelry modeling wax: (i) an appropriate piece of modeling wax is selected and the tool mark standards are then prepared; (ii) excess wax is removed as necessary both prior to and after making the tool marks; (iii) any veil of wax obscuring the tool mark standards is removed by treatment with a solvent as necessary; and (iv) finally each tool mark standard is marked for identification.

Discussion

In Fig. 14, the reproduction of three consecutive holes in the same piece of jewelry modeling wax with the same auger drill bit used in Fig. 13 demonstrates the replication of the auger bit's class characteristics and striation patterns in jewelry modeling wax. Figure 15, a photomicrograph of two chisel tool marks shown in Fig. 12, plainly illustrates the reproducibility of the microscopic striations and grooves within the modeling wax. Figure 16 depicts a tool mark standard made in modeling wax (Tool mark No. 10 in Fig. 10) on the right, being compared

FIG. 10—*A ball peen hammer striking the surface of a block of soft sculpting wax at an angle of 23°. Ten tool mark standards were produced for comparison purposes. All ten exhibited the same class characteristics, damage marks, and patterns.*

FIG. 11—*A soft brush being used to remove wax dust from the wax shown being cut in Fig. 8.*

directly to the working surface of an exemplar tool, on the left. Note the eight damaged areas within the white circle encompassing the striking surface of the exemplar tool, and the eight corresponding damaged areas reproduced as exact, negative, 1:1 imprints in the standard wax. The illustrations presented in Figs. 14–16 clearly demonstrate the ability of jewelry modeling

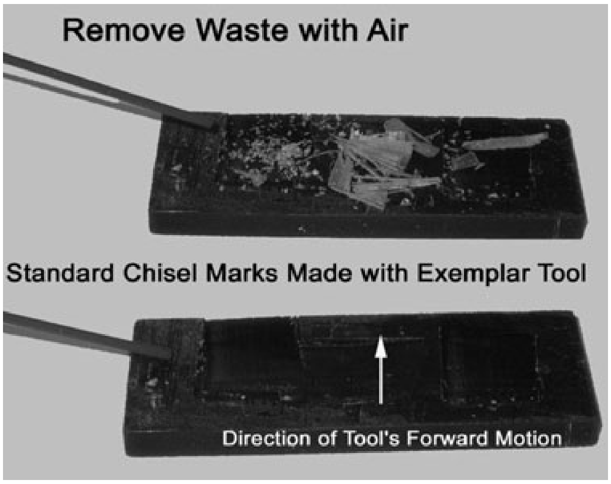

FIG. 12—*An air gun being used to gently remove wax shavings and dust from the surface of the piece of wax depicted in Fig. 9.*

waxes as a means of reproducing and retaining class characteristics, wear patterns, and damage features as well as microscopic size individualizing characteristics.

Conclusions

This study offers an alternative material for preparing test tool marks from exemplar tools. We believe that jewelry modeling waxes provide the forensic community with an excellent material for the reproduction of tool marks. The replicas obtained are accurate, precise, highly detailed, and 1:1 negative copies of the exemplar tool's working surface. They reveal in fine detail the class characteristics, wear patterns, damage, and accidental markings present on a tool's surface.

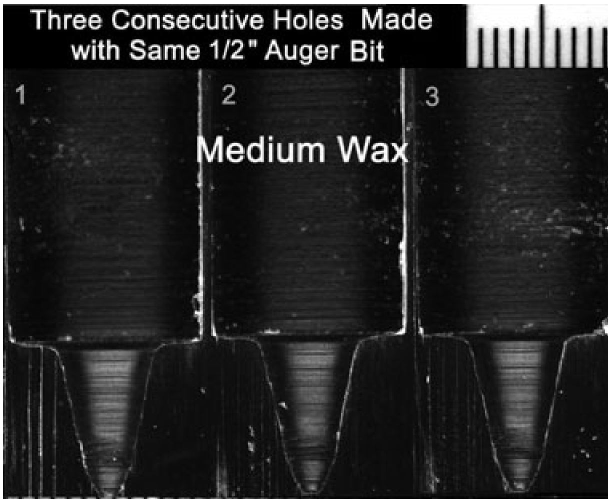

FIG. 14—*Reproduction of three consecutive holes in the same piece of jewelry modeling wax with the same auger drill bit used in Fig. 13. The scale is in mm.*

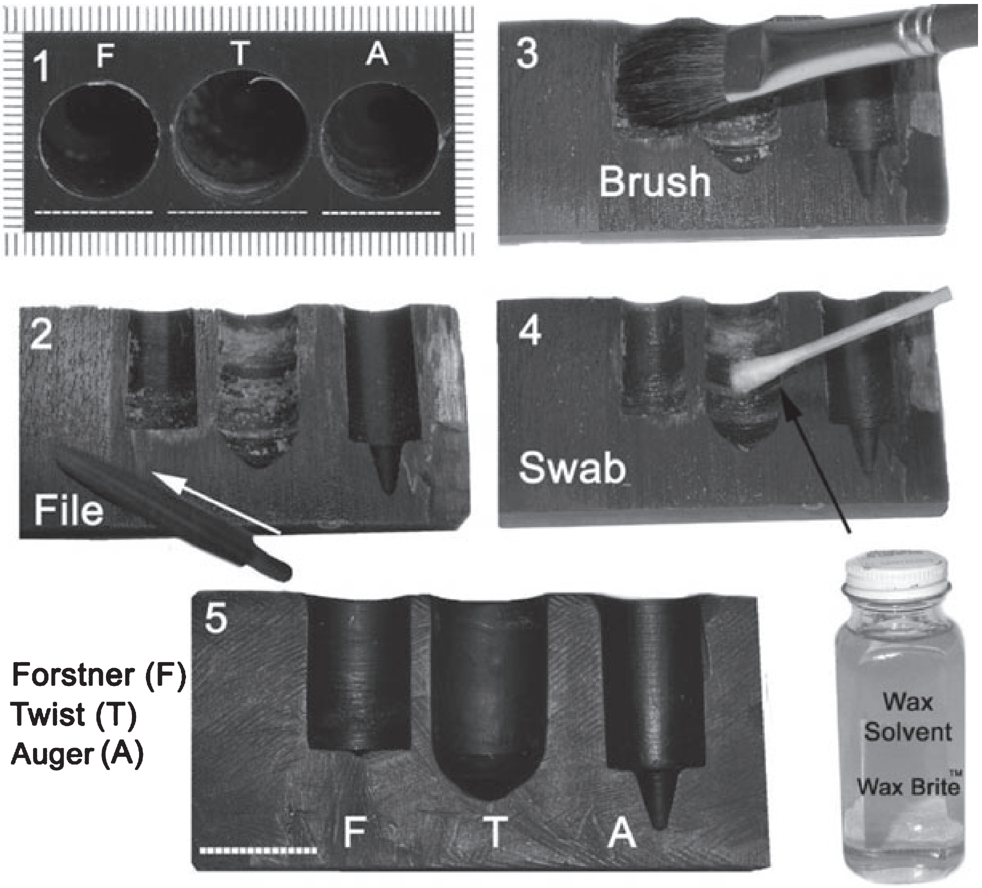

FIG. 13—*A depiction of the entire process used to prepare exemplar standards with jewelry modeling wax: (1) select an appropriate piece of wax and prepare the tool marks as theorized; (2) remove excess wax as necessary; (3) gently remove veil of obscuring wax with solvent as necessary; and (4) mark tool mark standards for identification. The scales are in mm.*

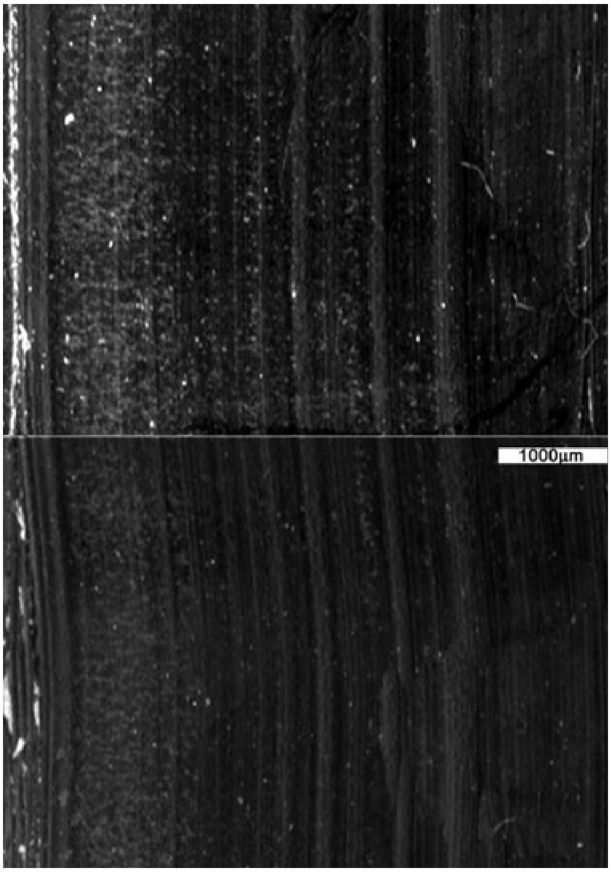

FIG. 15—*A photomicrograph clearly depicting the reproducibility of microscopic striation patterns. Both of these chisel marks were made with the chisel as shown in Fig. 9, and piece of jewelry modeling wax shown in Fig. 12.*

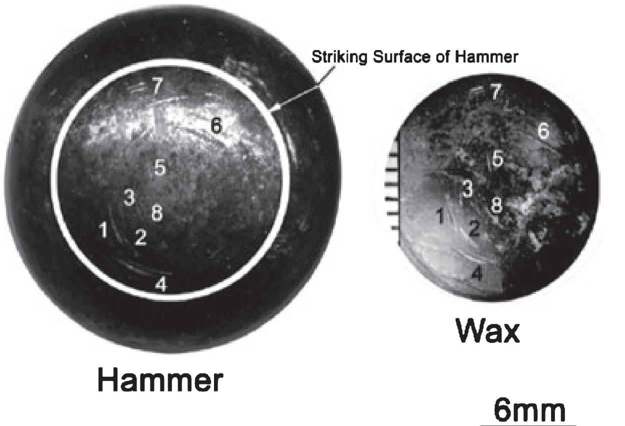

FIG. 16—*Photomicrographs depicting reproducibility of damage marks and patterns in modeling wax. On the left is the head of a ball peen hammer with damaged areas; on the right is an imprint in wax (No. 10 in Fig. 10) of the hammer's head. Note the presence of eight damaged areas within the white circle, and the eight corresponding damaged areas reproduced in the standard wax imprint.*

These excellently detailed and easy-to-make tool mark exemplars also allow one to produce a plethora surface feature data to carry out statistical studies for the numerical comparison of impression patterns. Such studies can provide a quantitative complement to the qualitative analysis of tool mark examinations. We are currently carrying out several statistical studies for tool mark comparisons using the impression methods detailed in this study. Given the vast scientific literature on statistical pattern recognition and the modern industrial use of these techniques, the authors feel that such studies are feasible to carry out and necessary in order to meet the glut of "Daubert" and "Frye" challenges to tool mark evidence currently in the courts. Details of our statistical tool mark impression comparison studies are forthcoming.

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