Journal of Criminal Law and Criminology

Volume 39 | Issue 3 Article 11

1948

Tool Mark Comparisons in Criminal Investigations

David Q. Burd

Roger S. Greene

AMERICAN JOURNAL
of POLICE SCIENCE

TOOL MARK COMPARISONS IN CRIMINAL INVESTIGATIONS

David Q. Burd and Roger S. Greene

The authors, David Q. Burd and Roger S. Greene, are known to our readers through their previous contributions to this Journal. Both are Criminologists with the Laboratory of the California State Division of Criminal Identification and Investigation, Sacramento. Mr. Burd has served in his present capacity since 1942 shortly after his graduation (A.B., 1941) from the University of California. Mr. Greene joined the laboratory staff in 1931 when he received his bachelor of science degree from the University of California and has served continuously, except while on military leave (1942-5) as a Captain in the Army Ordnance. The authors have made extensive studies in the field of tool mark identification and have testified as expert witnesses in this field on numerous occasions.—EDITOR.

The examination of a tool mark to establish conclusively that it was made by a particular tool and no other has for many years been a routine procedure in all police laboratories. This type of physical evidence examination has been carried out most frequently in cases involving forcible entry, but also has wide application in other fields of crime detection; and for this reason it should be considered as one of the most important types of laboratory examination.

A number of books on criminal investigation procedures have mentioned briefly the subject of tool marks (1)(2). Also, several articles in this Journal have discussed methods of comparison (3)(4) or the use of this evidence in specific cases (5)(6)(7). Few, if any, references however have given detailed procedures to assist the examiner whose experience is limited. This article is presented to suggest a procedure for expediting tool mark comparisons and is based on the experience of the authors over a number of years. In addition, the various illustrative cases included demonstrate the broad scope of such techniques and should suggest numerous practical applications to the peace officer as well as the criminalist(8).

TYPES OF TOOL MARKS

There are basically two types of marks left by tools on surfaces with which they have come in contact. The first type is an *impression* which is a negative reproduction of the tool surface, such as screw driver or pry bar impressions left on windows or

doors that have been forced open, or punch impressions on safes. Occasionally by the comparison of such impressions with the suspected tool, it is possible to reach a definite conclusion as to whether or not this particular tool left the mark. More frequently, particularly when the impression is in wood, it is only possible to show that the mark was made by a tool having the same class characteristics as the questioned one.

The second type is an *abrasion or friction mark* left by the sliding or cutting action of the tool which produces striated areas on the marked surface. Occasionally impressions made by tools with striated surfaces may resemble in appearance abrasion or friction marks. Examples of true abrasion marks are most bolt cutter marks on rods or wires, screw driver scrape marks, and knife or axe cut marks. By the examination of such abrasions or cuts, it is usually possible to determine definitely whether or not a suspected tool was used, providing no drastic alterations have occurred on the surface of the tool involved or the evidence mark since the time the latter was made.

A possible third class of mark which commonly occurs is a combination impression and abrasion mark. Examples of this type are pry bar and hammer marks where, in addition to the impression of the surface of the tool, some sliding action occurs which leaves characteristic striations.

Method of Comparison

A number of separate steps are required to make a complete tool mark examination. Naturally, the exact technique depends somewhat on the type of mark and tool involved as well as other factors, but the following summary briefly covers the standard comparison methods usually carried out.

1. The first step in a tool mark comparison consists of determining which of two objects in contact was marked by the other. Usually the tool is harder and more resistant than the surface on which it was used and, therefore, marks that surface although exceptions occasionally occur. One exception which came to the attention of the authors was a tool mark left on an improperly hardened wrecking bar by a spike head in a door jam. Care must be taken that such unexpected tool marks are not overlooked.

2. Next a visual and microscopic examination of the suspected tool should be made. This may reveal the presence of minute traces of metal, wood, paint, or other material on the tool which can be compared with the material on which the mark is found. If any such substance is located, it is advisable to take a photograph or photomicrograph and then remove it for separate study.

3. While the tool is being examined for traces of substance from the marked material, or subsequent thereto, its surface should be examined for evidence of recent contact. This may appear as an unusually bright or shiny area on the tool where dust or corrosion has been removed, or contact may be indicated by the presence of the material from the marked surface found in step 2. The latter is especially common where a knife or some type of cutter is used on insulated wire. Where any contact marks or deposits are present that might be at all characteristic, this area on the tool should be photographed before further work is attempted.

4. The tool mark itself is now examined to determine, if possible, whether or not the suspected tool could have produced the mark. In other words, to determine whether or not the class characteristics of the tool are present on the evidence mark.

5. Further examinations are made visually or under low magnification to establish wherever possible the direction of motion of the tool used to make the mark, the approximate angle between the marking tool and its direction of motion, and the approximate degree of roughness of the working surface.

6. A microscopic examination under low magnification is made of the tool mark for any obvious coarse detail which is readily discernible.

7. The suspected tool is also examined visually or under low magnification for coarse details similar to those found on the mark which indicates the areas on the tool that are most likely to result in an identification. The results of the examinations in steps 2 and 3 may also assist here or, in some instances, may eliminate the necessity for steps 6 and 7. The latter may also be dispensed with if the surface of the tool which could have made the mark is small, as in the case of a screw driver.

8. When these steps have been completed the test material is selected. The types of material for use in making tests vary greatly, but generally it is best to duplicate the material on which the evidence mark is found. However, there are several situations that indicate the desirability of using substitute materials. Usually these are softer and less resistant substances. Their use is indicated when the tool is only slightly harder than the material on which the evidence mark is found or when the evidence mark is on an extremely abrasive material. Under either of these circumstances the tool might be altered in producing the necessary number of test marks. Another reason for using softer material is that the force required to produce test marks is often more than can be readily applied under simple laboratory con-

ditions. In the case of tool marks on many metallic surfaces, such as safes and cash boxes, test marks can be made on sheet lead. This material can be used to advantage even more frequently for preliminary tests to further isolate the exact area on the tool involved. The authors have found that when the evidence marks are on metallic surfaces, sheet lead varying in thickness from 1/16 to 1/4 inch or at times rods of lead of different diameters are usually suitable for test purposes. Test marks have been successfully produced on materials such as plasticene, wax, sheet copper, tin, iron, or mild steel.

The questioned tool is now used to produce the test marks on the selected material in accordance with the results of the observations made in the previous steps. It is usually necessary to make numerous tests with various areas on the tool held in different positions and angles and using different pressures before a definite identification can be made.

9. The test marks are subjected to a preliminary examination under low power, preferably with a stereoscopic microscope, to locate areas that appear similar to the questioned mark. This examination is necessary only when the test and evidence marks are large in size.

10. The final comparisons are usually made under a comparison microscope, although occasionally it is more satisfactory to take separate photographs of the evidence and test marks at identical magnification and from the prints obtained make a composite photograph. This latter method must be followed when the marks are very large or when the evidence mark is on some object that cannot be placed under a comparison microscope.

11. Before and during the time the microscopic or photographic comparisons are made, care must be taken not to confuse marks caused by the manufacturing process of the metal or made after the evidence impressions or abrasions were produced.

Results of Comparisons

As a result of the microscopic or photographic comparisons made, four conclusions are possible:

1. No opinion or conclusion is reached due to alteration in the questioned mark or tool since the crime occurred.

2. The questioned tool did not make the evidence mark.

3. The questioned tool may have made the evidence mark, but a conclusive identification is not justified. Most cases involving tool marks where only class characteristics of the tool are present fall in this category. Occasionally, this conclusion may remain

after microscopic comparison. The strength or value of this conclusion may vary greatly and depends upon the examiner's judgment of the probabilities involved.

4. The questioned tool did produce the evidence mark. This conclusion is based upon the similarity of the test and evidence tool marks and the absence of significant differences which cannot be explained. The factors to be taken into consideration are the shape of the evidence and test marks, their contour (demonstrated by identity of distribution, width, depth, etc.) and the proportion of the striation lines present which match. For further information on proof of identity, reference should be made to an article previously published in this Journal by Burd and Kirk(3). The probabilities involved in the identification of impression marks are similar to those in fingerprint comparisons, while abrasion or friction mark comparison probabilities are similar to bullet identification as mentioned by Hatcher(9) and many others.

Illustrative Cases

The following tool mark comparison cases illustrate typical uses of this type of evidence in criminal investigation. All comparisons described and illustrated were made in criminal cases in California during the last few years. The photographs shown duplicate those prepared for use in the Courts.

Mention should also be made of the fact that these illustrations are half tone reproductions and that the detail, therefore, is limited. Experience has shown that it is seldom possible to produce even in an original photograph the detail that is visible through the comparison microscope. As in the case of bullet comparisons, photographs are taken primarily for illustrative purposes and ordinarily should not be considered alone as the basis for an opinion, except in those instances where a composite photograph is the only practical method for comparison.

1. Cold Chisel Impression Marks on Safe. In connection with a burglary case, a small safe from a store and tools found in the possession of two suspects were submitted for comparison. Numerous markings were found on the safe which were made with tools having the same class characteristics as some of the tools belonging to the suspects. Among these markings were two impressions which appeared very similar to the end of a cold chisel. To make a complete comparison, it was necessary to remove with a hack saw a portion of the metal from the safe. This was compared under the comparison microscope with test impressions of the end of the cold chisel made on lead. The evidence marks at first appeared to be abrasion marks, since they

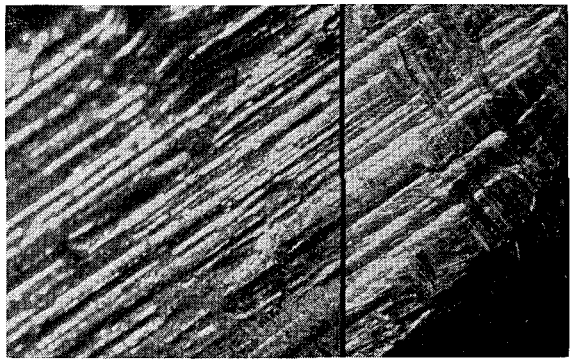

Figure 1..
Comparison photomicrograph of test sledge hammer mark on lead (left) and hammer mark on burglarized safe dial (right).

contained numerous striations, but on examining the pointed end of the chisel similar lines were found and, therefore, it was assumed that the mark was an impression. The striations in the evidence mark were extremely short and made by just one edge of the pointed end of the chisel. A comparison photomicrograph was taken which showed conclusively that both the evidence and test marks were made with the same tool. In addition to this positive identification, the safe and wood from a door through which entry was made into the store contained tool impressions and abrasions that were found to have the same class characteristics as other tools belonging to the suspects although no conclusive identifications could be made. Testimony concerning the laboratory examinations was given at the trial of the two defendants and an enlarged photograph was used as an exhibit. Both defendants were found guilty of burglary by the jury.

2. *Hammer Abrasion Marks on Safe.* A small safe and a sledge hammer believed to have been used to open the safe in a store burglary case illustrate the need for careful observation of the tool before test marks are made. In this instance a number of flakes of green paint identical with the outer coat of paint on the safe were found on the head of the questioned sledge hammer. Abrasion marks which appeared to have been made with a hammer were found on the safe dial and surrounding area. Considerable difficulty was experienced in attempting to reproduce the marks with the sledge hammer on lead for comparison purposes, but one small abrasion was found on microscopic comparison to match exactly a portion of one of the tests. The photomicrograph taken is shown in Figure 1, which in itself would justify a positive identification of the sledge hammer as having made one mark on the safe dial.

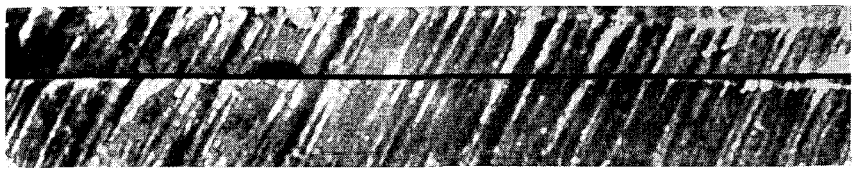

Figure 2.
Comparison photomicrograph of test mark on aluminum tubing made with diagonal cutters (bottom) and evidence mark on gasoline primer line of damaged Army fighter plane (top).

3. *Diagonal Cutter Impression on Aluminum Tubing.* During the war inspectors found several damaged fighter planes at an Army Air Depot. This damage consisted of nicks or incomplete cuts on the aluminum gasoline primer lines of the airplanes. These pieces of damaged aluminum tubing were compared with test marks made on identical material with a pair of diagonal cutters issued to and used only by a certain civilian employee at the Army Air Depot where the damage occurred. Incidentally, he was the person who reported the discovery of the damage. The microscopic comparison of the tool and evidence marks, as illustrated in Figure 2, showed that the cutters submitted were responsible for the marks on the gasoline lines. The markings which appeared to be scrape striations were actually impressions of the cutting edges of the tool. Testimony concerning the identification of the tool used was given in a U. S. District Court where the defendant was tried and convicted on a charge of damaging government property. This charge, rather than sabotage, was made due to other factors involved in the case.

4. *Marlinespike Marks on Door Lock.* In a burglary case in which a considerable amount of liquor was removed from a bar, entry was apparently made by forcing open the door. In the automobile of two suspects in this case was found a marlinespike, on the tip of which were several particles of brass identical with the brass on the open lock and lock catch from the door which was forced open. Test marks made with the questioned tool on lead were compared with various evidence marks on the brass parts from the door. As a result of these comparisons, several tool mark striation matches were found. This evidence was of considerable aid in influencing the suspects to plead guilty.

5. *Bolt Cutter Marks on Padlock Hasp.* Some weeks after a gasoline station burglary in which a padlock was cut from the door with a pair of bolt cutters, a man was arrested in a stolen car in another county by the California Highway Patrol. The defendant in the automobile theft case was apparently driving the stolen car back to a garage where he had left his own car

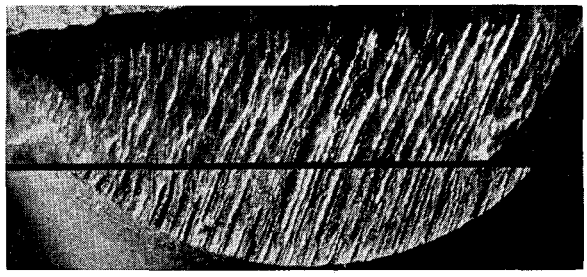

Figure 3.
Comparison photomicrograph of cut mark on padlock hasp of burglarized gasoline station (top) and test cut on iron nail made with bolt cutters (bottom).

for repairs after it broke down on the highway. In making a routine check of the automobile owned by the arrested man, a bolt cutter was found. This bolt cutter was turned over to the police department in the city in which the gasoline station burglary occurred. They, in turn, requested that a laboratory comparison be made to determine whether or not the bolt cutter had been used to cut the hasp from the lock. Test cuts were made on an iron nail with the questioned tool and compared microscopically with the cuts on the lock hasp. These comparisons proved that the bolt cutter was used to cut the lock hasp submitted and one of the photomicrographs taken is shown in Figure 3. The suspect was convicted of auto theft and is still serving time, but at the time of writing has not been tried on the burglary charge.

6. Bolt Cutter Marks on Iron Rods, Wire, and Padlock. In another similar case three stores were broken into by cutting open an iron rod over a window at one, a padlock at another, and cutting a heavy wire window covering at a third store. Two tools which might have been used were compared with the cut articles from the three stores. In all cases, tests were made with the cutters on sheets or rods of lead. The comparisons showed that one of the bolt cutters submitted was the tool used to cut the exhibits from the three stores. The defendant was convicted at his trial where testimony concerning the examinations was given and the photomicrographs shown to the jury.

7. Tire Iron Mark on Mail Chute. In order to gain access to a business establishment in the commission of a burglary, a flat metal tool such as a tire iron or jack handle was used. Entry was gained by enlarging the opening of a mail chute so the burglar could reach through the door and open the night latch. In the automobile of a suspect was found a combination tool (a tire iron, jack handle, lug wrench) capable of causing the damage

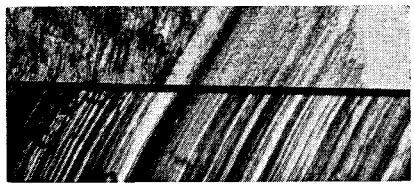

Figure 4.
Comparison photomicrograph of tool mark on aluminum mail chute (top) and test mark made with tire iron on lead (bottom).

found on the mail chute. The tool marks around the opening in the chute were principally pressure marks but, because of the elasticity of the sheet aluminum of which the chute was constructed, did not appear to be readily identifiable. There was also one small spot that had the distinct striations characteristic of abrasion marks. From the shape of this mark, its relation to other marks in the opening and the location of traces of aluminum visible on the suspected tool, it was possible to determine with considerable accuracy what spot on this tool produced the mark. A test abrasion mark was then made with the suspected area of the tool on a piece of lead. Figure 4 shows the result of matching test and questioned marks under the comparison microscope.

8. Pocket Knife Marking on Pencil Lead. As an illustration of the value of tool marks where least expected, the following case is of interest. A killing occurred in a jungle camp as an aftermath of a drunken holiday celebration. Two suspects of Indian descent were immediately apprehended, and the clothing of one was found to be extensively blood stained. These suspects would admit no knowledge of the crime and denied ownership of a bloody knife, a coat and jumper found near the body. The investigation developed a third suspect, a white man, who was alleged to be the owner of the knife and the abandoned clothing. When he was apprehended his clothing was submitted to the laboratory to be examined for blood. While small spots of human blood were found on several garments the suspect would admit nothing. In an effort to establish ownership of the knife found beside the body, a comparison was made of fibers and other debris from the knife and material from the suspect's trouser pockets. This fiber comparison clearly indicated the white man as the owner of the pocket knife.

During this examination some flakes of yellow paint were found, one of which showed traces of silver colored lettering. Indications were that the paint was from a lead pencil. Search of the white suspect's personal property left with the jailer at

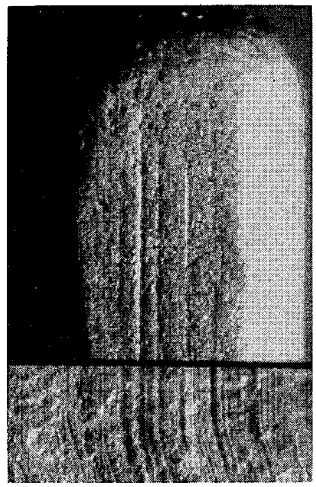

Figure 5.
Comparison photomicrograph of the lead from a pencil found in clothing of suspect (top) and test cut made on lead of carpenter's pencil with knife found near body of murdered man (bottom).

the time of his arrest yielded a short yellow pencil with silver lettering. The pencil had been sharpened at both ends with a knife, but the markings on the wood were very indistinct. Microscopic inspection of the sharpened ends showed two small areas on the pencil lead that bore well defined striations produced by the knife in sharpening it. Test cuts were made with the evidence knife using the large lead from a carpenter's pencil to cover a longer part of the cutting edge than could be tested at one time with an ordinary pencil. The results of the comparison showed a complete reproduction of all of the more prominent lines on the pencil lead in the test cut as shown on Figure 5. Many of the finer marks have, of course, been rubbed from the pencil point as a result of wear since it was sharpened. This evidence clearly established that the murder knife was at one time in the possession of the suspect.

9. Lathe Turning Comparison. A small machine lathe was stolen from its place in a shop. Indications at the scene showed that it had been carried by two men to an automobile for transportation. In a suspect's automobile was found some dried mud containing a few fine brass turnings. This material and sweepings from the floor where the lathe had stood were submitted to the laboratory for comparison. Consideration was first given to spectrographic analysis of the turnings, but miscroscopic examination showed color differences indicating variations in composition. This was also indicated by inspection of small castings

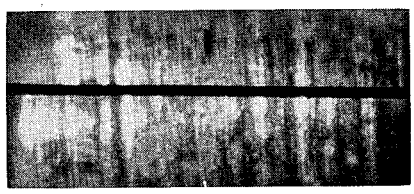

Figure 6.
Comparison photomicrograph of lathe turning from burglary scene (top) and lathe turning found on floor of suspect's automobile (bottom).

being machined before the burglary occurred. It was therefore decided to attempt to match the tool marks on the turnings from the automobile and the shop floor.

Eight small turnings were found in the dried mud that appeared to have identifiable marks on their outer surfaces. A search of the sweepings revealed many turnings with markings corresponding to six of the eight found in the mud from the suspect's car. Figure 6 illustrates one of these microscopic comparisons. At the time of the identification the lathe had not been recovered. The cutter, of course, was not found.

10. Knife Cut on Tree Branch. In committing a highway robbery a blind was built on top of a bank beside a country road. The blind was constructed of small redwood boughs cut from a nearby tree with a pocket knife. A suspect was arrested while attempting to hitch-hike from the scene. He had none of the loot with him, but search of his clothing revealed a pocket knife with which test cuts were made on tree branches similar to those cut

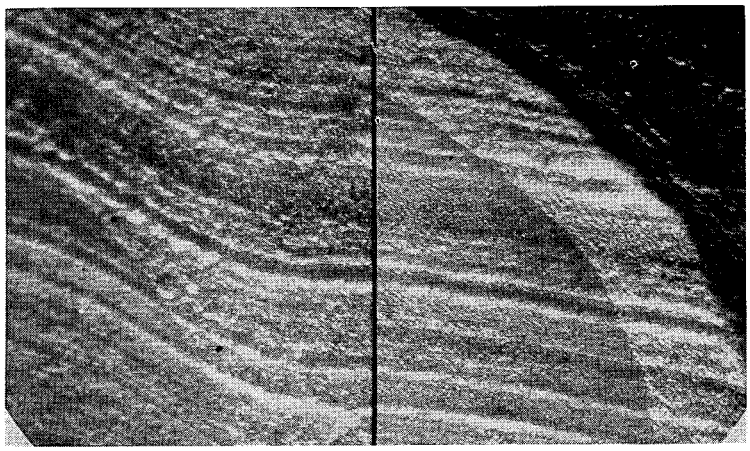

Figure 7.
Comparison photomicrograph of cut mark on tree from which branch was removed for construction of a blind used by a robber (left) and test cut made with suspect's pocket knife on similar wood (right).

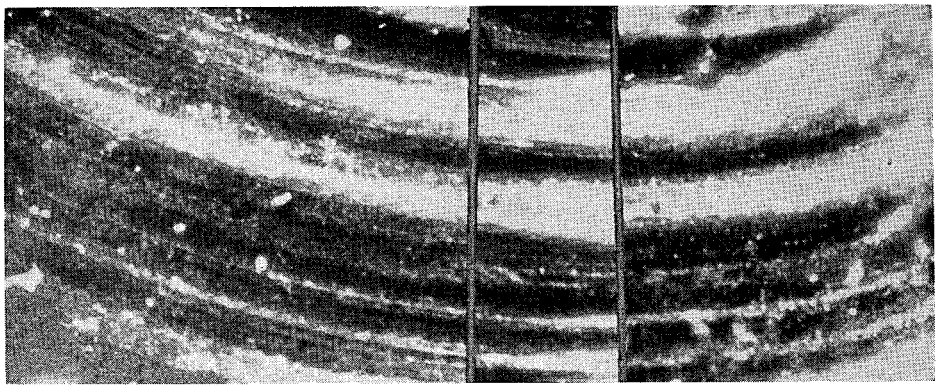

Figure 8.

Composite made from three photographs of can opener marks in arson case. Left: Can opener mark on bottom of soup can used as shield around candle in setting fire. Center: Test made with suspect's can opener on similar can. Right: Can opener mark on top of same soup can shown at left.

for the blind. These showed ample characteristic striations comparing favorably with the ends of the branches from which the boughs for the blind were cut. The cut ends of the branches from the blind itself were not used in the comparison photographs, as illustrated in Figure 7, since these ends were soiled and mutilated when they were pushed into the ground. The defendant when confronted with this evidence entered a guilty plea.

11. Can Opener Mark Comparison. In the investigation of a brush fire on forest land a candle was found to have been used to start the blaze. In order to protect the candle from any breeze that might have been blowing and thus unduly speed its burning or to prevent it from being blown out, it was surrounded by a tin can from which both top and bottom had been removed. In an attempt to link this can with the suspect, a small key type can opener found in his kitchen was submitted with the evidence can for comparison. A similar can was opened with the can opener noting which of the points on the serrated can opener wheel made each of the tiny test marks. Under the comparison microscope it was possible to identify each of the marks on both ends of the evidence can as having been made by a particular point on the serrated can opener wheel. The illustration, Figure 8, was not made under the comparison microscope, but separate photomicrographs were made of corresponding marks on both ends of the evidence can and the test can. Sections of these photomicrographs were then mounted as shown in this illustration. The defendant was tried for arson, but was found guilty of a misdemeanor because of the minor damage that actually resulted before the fire was extinguished.

12. Axe Marks on Wood. In an attempted train wrecking case, a piece of redwood conduit and the enclosed railroad block signal wires were cut. The pieces of cut conduit and an axe belonging to a suspect known to be mentally ill were compared. Preliminary examination directed attention to one side of the axe blade, and with this side of the blade test cuts were made on similar conduit material. Due to the large size of the test and evidence cuts only very small areas could be compared microscopically, and, therefore, it was decided to make the final comparisons photographically. This was done by photographing the test and evidence cuts on the same piece of film to insure equal magnification. Two sections of the photograph of the evidence cut were superimposed on the photograph of the test. On several previous occasions the suspect had been involved in damage done to the railroad which passed close to his home. He apparently disliked the railroad and in particular was bothered by the buzzing of high-voltage power lines which apparently he mistakenly believed were connected with the block signal wires which were cut. The suspect involved was committed to a state hospital.

REFERENCES

1. Soderman, H. and O'Connell, J., Modern Criminal Investigation (1936), page 160.
2. Lucas, A., Forensic Chemistry and Scientific Criminal Investigation (1937), page 158.
3. Burd, D. Q. and Kirk, P. L., "Tool Marks, Factors Involved in Their Comparison and Use as Evidence", J. Crim. Law & Criminol. (Pol. Sci. Sect.), *32*, (6): 679 (1942).
4. May, L. S., "The Identification of Knives, Tools and Instruments", Am. J. Pol. Sci., *1*, (3) : 246 (1930).
5. Mezger, Hasslacher and Frankle, "Identification of Marks Made on Trees", Am. J. Pol. Sci., *1*, (4) : 358 (1930).
6. Koehler, A., Technique Used in Tracing the Lindbergh Kidnapping Ladder, J. Crim. Law & Criminol. (Pol. Sci. Sect.), *27*, (5) : 712 (1937).
7. Wilson, C. M., "Comparison and Identification of Wire in a Coal Mine Bombing Case", J. Crim. Law & Criminol. (Pol. Sci. Sect.) *28*, (6) : 873 (1938).
8. Kirk, P. L., "The Standardization of Criminological Nomenclature", J. Crim. Law & Criminol. (Pol. Sci. Sect.), *38*, (2) : 165 (1947).
9. Hatcher, J. S., Textbook of Firearms Investigation, Identification and Evidence, (1935), page 286.