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Striation Evidence in Counterfeiting Cases

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ABSTRACT: There has been little information of recent vintage that deals with those unique striation mark identification criteria normally associated with paper cutting tools. Occasionally, forensic science laboratories have been provided with striation evidence where improper collection and transmittal procedures have hampered subsequent edge comparison analysis. This paper has been written in an attempt to bridge the generation gap with more recent tool mark evidence processing procedures. There are a variety of identification factors that are important in striation comparisons and should be considered by both the field investigators and administrative personnel in the transmittal and collection of pertinent evidence. The following factors are discussed in the paper: (1) production of striation markings, (2) variation in striation markings, (3) importance of clamp impression markings, (4) proper preservation and transmittal procedures for tool mark evidence, (5) collection of tool mark standards, and (6) a recent U.S. Secret Service counterfeiting case illustration.

KEYWORDS: questioned documents, tool marks, striations

The U.S. Secret Service Identification Branch was recently requested to conduct appropriate tool mark examinations of the striations present along the edges of some counterfeit $20 Federal Reserve notes in an attempt to determine whether or not a suspect 940-mm (37in.)[2] Challenge® paper cutting blade had cut the seized currency. A preliminary examination by oblique lighting indicated there was a possibility that the same cutting blade had been used to trim both the counterfeit notes and the submitted specimen notes. Because of the presence of some unexplainable subtle differences existing between the submitted questioned and known striation marks, additional research was conducted into those wear-and-tear factors that might contribute to the presence of subtle irregularities sometimes noted in photographs depicting the extent of striation mark agreement (Fig. 1).

A 1953 paper prepared by Purtell [*1*] did discuss some of the identifying anomalies associated with blade-produced striation examinations, although there has been little information of recent vintage that deals with those unique striation mark identification criteria normally associated with paper cutting tools. This paper has been written in an attempt to bridge this generation gap with processing procedures for more recent tool mark evidence (especially as related to paper edge comparisons often confronted by the document examiner).

Occasionally, identification laboratories have been provided with striation-type evidence where improper collection and transmittal procedures have hampered subsequent edge comparison analysis. In one case, for example, the field investigators had erroneously assumed

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[2]Original data were given in inch-pound units.

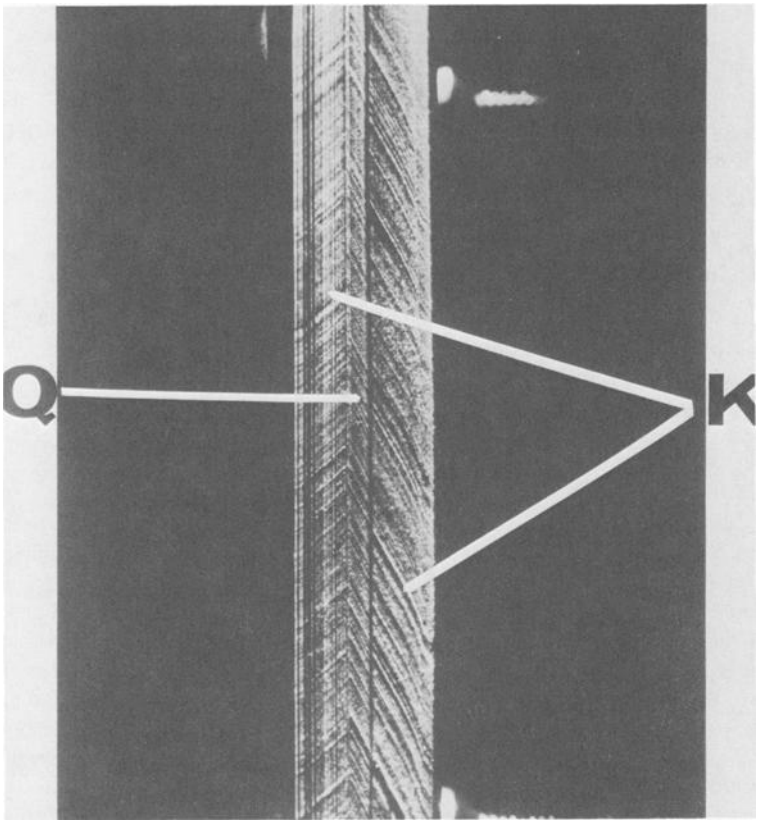

FIG. 1—*Tentative match of counterfeit notes* (Q) *and test cut standards* (K).

that no subsequent tool mark matches could be effected if several weeks had elapsed between the production and cutting of seized counterfeit notes and the obtaining of test mark standards. In another case, the investigator had improperly marked the test cut standards, which had inadvertently altered the evident striations occurring on the note edges.

There are a variety of identification factors that are important in striation comparisons and should be considered by both the field investigator and administrative personnel in the transmittal of pertinent evidence. These include, but are not limited to, the evidence marks found on the seized currency and also those striae appearing within the test cut standards. The proper collection, preservation, and transmittal of the evidence blade can also preserve its integrity for subsequent laboratory analysis. Each of these areas will be discussed, especially as they relate to typical U.S. Secret Service counterfeiting investigations.

Production of Striation Markings

One laboratory manual defines a tool mark as "any impression, cut, gouge, or abrasion that results when a tool is brought into contact with an object" [*2*]. In the case of paper cutting knives, the evident striation marks are caused by the impressing of the blade outline (containing its own unique combination of identifying irregularities) into the paper product. The resultant irregular scraping marks are known as *striae*, while the paper edges are characterized as being *striated*, with the parallel striations indicating the tool's direction. It is the

arrangement of the striae and their spacing and depth characteristics that bear a direct correlation with the condition and individuality of the evidence blade edge [*3*].

The cutting of commercial paper stock is still accomplished in much the same manner as described by Purtell. Essentially, the stack is cut and trimmed by large guillotine-type blades, with a manual or automatic clamp descending into position to hold the paper while a hollow ground blade is brought through the stacked paper at varying degrees of pressure. The stroke of the cutting knife has a sidewards motion as it descends [*1*, p. 266].

Variation in Striation Markings

The question often arises as to the effects of sharpening on the identifying value of a cutting blade. Certainly the type of cutting edge under consideration, together with the extent of use or abuse the blade is subject to, will in some degree affect its evidentiary value. Of course, as the edge undergoes continual change (thus acquiring greater individuality), or if it is resharpened, it can lose its old identity and gain a new one [*4*]. The manner of handling, storing, and mounting of the cutting knife will also affect what final defects or impressions the blade is subjected to.

In a counterfeit case, the document examiner is normally faced with evidence marks produced on a blade considerably longer than that of the specimen cut. In such cases, it is necessary to test the full length of the blade before a conclusion can be reached from comparison of test cuts and evidence marks. Because a paper cutting blade's angle of application is considerably restricted, the main cutting edge has a fixed position and angle with respect to the plane of the cutting surface, thus eliminating many of the tilt and rotational angle changes commonly associated with other types of tool marks. This factor of variation and application of the tool can be controlled in obtaining standards. Standards of comparison should therefore be prepared in sufficient numbers and variety to permit several test cuts to approximate the position of the tool at the time of the original application.

As Purtell [*1*] has noted, many of the wear characteristics affecting the blade's integrity will be due in part to the loading of a cutter by the operator and the type of paper product subjected to the cutting process:

> Newsprint, bond, ledger, book, and onionskin papers can be loaded to nearly the full lift of a cutter without harming the blade. Boards and coated and gummed papers (including heavy clay content paper) are very hard on the edge of a blade. Most of the papers following in this latter class often are trimmed in small lifts and cut with a very sharp knife. This type of paper will nick and dull a knife very readily . . . It is also recommended that a knife be sharpened before each shift or day's work begins . . . A paper cutting knife is usually made up of two different types of steel, each having its own purpose. A low to medium carbon steel is used in a mounting portion of the knife, while a high speed tool steel is used on the blade (p. 264).

Because of the variation-producing influences of wear, damage, and sharpening on the identifying blade characteristics, an exact match of corresponding striae is rarely possible, especially where a considerable number of striae are present for comparison purposes. Such factors as different lighting conditions or different rotational and tilt angles produced by the cutting surfaces may produce what initially appear to be different marks. It is essential therefore that the illumination of the test and standard marks be as nearly identical as possible.

> Photographs should then be taken of the separate marks, enlarged to the same size, and the striae compared on the final prints. Where striations are quite large, they may be visible to the unaided eye in a comparison made by holding test and evidence in juxtaposition where the similarities can be viewed together. Here again, photographs of the separate specimens may be used to demonstrate identities [*5*].

Clamp Impressions

As the character of the blade changes with each sharpening, there is one part of the machine known as the clamp, which is rarely replaced and therefore contains significant identifying information. The clamp is a cast material with a two-sided polished face, of which the leading edge is solid and square while the rear section is normally made up of fingers approximately 51 mm (2 in.) long and 12.7 mm (½ in.) wide. As Purtell has noted:

> The leading edge of a clamp may become scored by the same types of defects on the blade which have earlier been mentioned. When the clamp is brought down at great pressure on a pile of paper, the marred part of the leading edge will impress its form into the top few sheets of the pile of paper. The fingers of the clamp will also lend themselves to a similar type of identification. Here we have the marks left by the edges as well as the form of the figures from which to work. Such markings imposed by the clamp are greater when applied with the grain of paper than against the grain. These marks of the clamp are not as dramatic as the marks left from the knife but are still of practical identifying value [*1*, p. 268].

It should be noted that during the recent U.S. Secret Service counterfeiting case, clamp or pressure bar impressions present on the test specimens contained characteristics that could have possibly identified the Challenge machine used in the production process. It is not unusual in counterfeit note investigations for the blade to lose its identifying characteristics and hence evidence potential through either use, sharpening of the blade, blade transport or alignment defects, or removal of the blade. The advantage of identifying the clamp impressions as having been produced by a specific paper cutting machine is that because the clamp is a functional and permanent part of the cutting apparatus, the machine itself has now been identified with the counterfeiting operation.

As discussed in the following sections, any clamp mark impressions should be obtained on paper stock of a similar weight and texture as that bearing the evidence impressions. Sufficient adjustment of the standards' position within the clamping device should also be accomplished, thus allowing for some minor variation in the angle of application of the clamp marks or finger impressions.

Preservation and Transmittal of Tool Mark Evidence

Objects bearing tool marks should always be handled and packed in such a manner as to guard against needless alteration or contamination of evidence markings. If handled carelessly, it is possible for a tool mark to develop additional striations, thus destroying the evidentiary value of the markings:

> Protect the mark by wrapping or covering it with paper or some other soft, dry material, and pack the object to avoid friction or pressure over the marked area. As with all other types and forms of evidence, the containers or packages should be sealed and marked with all appropriate information . . . When tools are recovered, the investigator should mark each one, taking care not to lose any trace material such as paint, grease, or ink components. *Never clean a tool.* Send it, as found, to the laboratory for examination purposes. Each tool should be wrapped in a piece of paper and sealed. After the tool is completely wrapped, an additional protective covering should be placed on the outside of the package to cover the cutting or marking end of the tool. This is to protect the tool in case it is accidentally dropped. The necessary identifying information is then placed on the outside of the container. Never place tape or other sticky material in direct contact with the tool. When the tape is removed it will also remove any trace material that may be present [*2*, p. 105].

It has been observed that sometimes the seized counterfeit currency is removed from the crime scene and later transferred from its original container to a different size box for subsequent postal shipment. There exists again the potential for destruction of evidence impressions by note sequence disturbance. The original containers should also be forwarded to the labora-

tory for analysis as they may contain not only critical fingerprint impressions but also important trace evidence materials that are susceptible to identification.

As previously noted, the primary causes of the production of identifying striae on the edges of paper are the irregular contour characteristics of the blade edge. This is most dramatically affected by two primary causes: (1) sharpening of the blade and (2) wear-and-tear dulling of the blade, produced primarily by cutting heavily loaded or high clay content paper products. As was recently demonstrated in the counterfeit investigation noted at the beginning of this paper, knowledge of both the sharpening schedule of the blade and the types and amount of paper product cut by the suspect Challenge paper cutter had a significant impact on the expert's ultimate identification of the blade. It is therefore recommended that in all striation examinations, when possible, the case agents attempt to obtain such pertinent forensic science information.

Collection of Tool Mark Standards

Test materials are selected on much the same basis as tests for impression markings—that is, they must be sufficiently like the material upon which the evidence exists to permit valid comparison, yet soft enough that extensive testing will not damage the tool. Whenever obtaining standard cut impressions in the field, the investigator should ensure that the entire length of the blade surface is used. In the case of the Challenge paper cutter, the blade is a bit skewed, with the right side being a bit higher than the left. Starting at the right side of the cutting board (next to the alignment bar), three sets of standards should be taken by the investigator, gradually moving down the blade surface from right to left (heel to toe), thus obtaining all recorded striations on the blade. Each of the three specimen stacks should be marked and would correspond to either the right side, middle, or left side of the cutting blade. After the standards are obtained, the case agent should initial and date each specimen stack, thus ensuring that the exact sequence of cutting of the standards is maintained and recorded. All identifying marks should be placed on a nonessential edge of each stack and should never interfere with or alter the evidence striations occurring on the paper edges. Consideration should also be given to employing an appropriate writing instrument when identifying the questioned and known specimens, as a hard-tipped fiber pen or sharp writing instrument can damage existing striae and thus hamper any subsequent examination.

It is also strongly recommended that following seizure of counterfeit currency, the case agents should not under any circumstances disturb either the sequence of the currency in its stacked position or make any attempt to conduct an exact count of the seized currency. As has been demonstrated on numerous occasions, disturbing the integrity of the originally found questioned exhibits can not only cause needless contamination of possible latent fingerprint evidence, but can also cause irrepairable harm to any striation examinations or comparisons subsequently attempted at the laboratory. Rather, it is recommended that photographs of the counterfeit currency in its original configuration be taken at the crime scene and only an approximate count of the specimen notes be attempted by the field investigator. This procedure has been followed successfully by most federal law enforcement agencies that are responsible for processing tool mark/striation type evidence. The courts are generally aware of the possible damage that disturbance of note integrity can cause and are sympathetic to the field investigator computing only an approximate count of the seized currency recovered. The generally accepted method of approximating the amount of seized currency is to use measurement of the individual stack heights rather than conducting an exact count of the individual sheets. Thus, the seizure and subsequent transmittal of a box containing 20 stacks of counterfeit $20 Federal Reserve notes should reflect 20 178-mm (7-in.) stacks (or whatever height relationships are appropriate) of counterfeit currency. The approximate amount of seized currency could then be computed by measuring a similar height stack of genuine currency of known value and multiplying the total heights involved times the value of the seized denomi-

nation(s). If an insufficient amount of genuine currency is available, it is recommended that attempts be made to obtain the same or similar weight paper as that used in the production of the counterfeit currency for making the approximation. Counterfeit currency is often printed on a high quality rag content paper bearing an appropriate watermark, and the same paper can often be located within the subject print shop by examination for the same distinctive watermark. Agency contraband inventory forms should therefore reflect the use of the word "approximate" whenever describing the amount of seized currency forwarded for striation examination purposes.

Exact counts of seized counterfeit currency can always be made later at the receiving evidence laboratory or by appropriate headquarters personnel charged with chain-of-custody or inventory counting responsibilities. Indeed, it is recommended in striation examinations that appropriate oblique photographs first be taken of the note striations, before any attempt at counting the individual specimens. Only after proper photographs have been taken and a visual or microscopic comparison of the questioned and known striae is conducted should an exact count be made.

Case Illustration

The previously mentioned counterfeit currency investigation conducted by the Secret Service developed important tool mark (striation) evidence that subsequently led to a guilty plea being entered at the time of trial by the defendant, who was the owner of a commercial printing shop. The investigating case agents were able to establish that the seized $500 000 in counterfeit $20 Federal Reserve notes had been produced on or about 1 July 1981, although the printing press and paper cutter were not seized until approximately two weeks later. At that time, standards were obtained on the print shop's cutting machine, a 940-mm (37-in.) Challenge paper cutter.

Following a tentative conclusion that the suspect notes may have been produced by the same cutting blade used in the production of the standards, sidelighted photographs of the tentatively matched stacks were produced (Fig. 1). An examination of the questioned and known striations showed a marked similarity in numerous striae existing between the two specimen stacks, although some minor irregularities were apparent. As most of the major striae defects were being reproduced in the standards and the apparent differences were possibly caused by wear and tear, it was deemed advisable to submit the evidence to another document examiner familiar with tool mark comparison techniques for clarification of any striae discrepancies.

It was now apparent that more specific information was required concerning the operating characteristics of the Challange paper cutter, together with specifics regarding its composition, manufacturing processes, or any data that would assist in explaining those factors that might cause striae variation.

Contact with Mr. Jack Underhill, a ceramic design engineer and president of American Custom Metals in Cincinnati, OH, disclosed that the primary wear factor responsible for the deterioration of a smooth blade cutting surface is the clay content of the paper stock being cut.[3] A higher clay content paper, although providing durability to the product, likewise causes excessive wear to the blade edge, thus producing increased striations on the cutting surface. A high clay content paper is also referred to as *hard* paper, while one possessing lesser concentration is known as *soft* paper.

Further research indicated that the Challenge paper cutter (which is used by the majority of commercial printing firms) is manufactured without the cutting blade. Almost all domestic cutting knife blades are, instead, produced by American Custom Metals, which sells the

[3]Jack Underhill, private communication, American Custom Metals, Cincinnati, OH, 1981.

various lengths and types of cutting blades to the individual paper cutting machine companies. The Challenge paper cutter is available in both a hydraulic (automatic) mode and also in a manual mode.

In both systems the paper stock is first aligned by means of an alignment bar located on the right side of the cutting board surface. After alignment, the cutting blade is activated (either hydraulically or manually) and travels in a swinging sideways motion through the paper stock. As most cut paper stock is shorter in overall length than that of the blade, most of the identifying striations are normally found on the heel side of the blade—in the case of Challenge paper cutter, on the right side of the blade, extending from the alignment bar toward the toe or the left side of the blade.

Also noted was the presence of clamp impressions on the topmost two sheets of cut paper stock. The bottom side of the paper resting on the cutting board is spared any form of scoring or impression because of the presence of a neoprene plastic (or wood) pad resting on the cutting board directly under the blade. Standards produced on another Challenge paper cutter disclosed evidence of the clamp mechanism becoming scored by misalignment of the blade, causing it to change the facial effect on the clamp face. In the manually operated Challenge paper cutter, a pressure bar assembly is activated by the cutter, which produces characteristic pressure bar impressions in the topmost sheets of cut paper. Examination of the ghost impressions caused by the hydraulic clamp (or manual pressure bar mechanisms) dis-

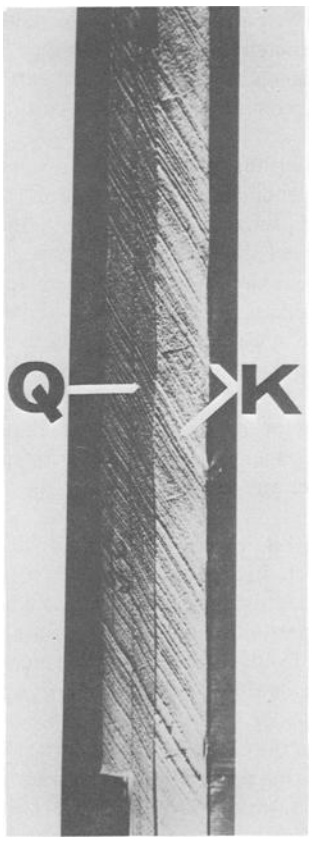

FIG. 2—*Court photograph depicting positive identification of striations present on counterfeit notes* (Q) *and test cut standards* (K).

closed the identifying value of these mechanical impressions, which deteriorate dramatically below the topmost sheets of cut paper stock.

For trial purposes, additional photographs were taken of the tentative striation identification noted in Fig. 1 that enhanced the clarity of the agreeing questioned and known striae (Fig. 2). Additionally, at the time of trial, the suspect blade was recovered from the print shop and photographed both in its overall aspect and in close-up perspective to reveal the microscopic gouges and other surface irregularities found in a cutting blade that had experienced sufficient wear to produce identifiable striae (Figs. 3 and 4). Photos depicting the pressure bar and blade surfaces of a Challenge paper cutter are also attached (Figs. 5 through 8). Additional field testing over a period of a week disclosed that sufficient additional striae were produced on the blade surface that it was not possible to match even the standard impressions produced on the first day cuttings to those recorded on the last day of the testing period. Again, the increased wear was most likely a result of the higher volume of hard paper stock being cut by the test paper cutter. The importance of this observation is to alert the investigator to the benefits of attempting to determine the sharpening schedule of the suspect blade and the importance of expediting procurement of any standards for subsequent striation analysis.

Based on the agreement evident in the striations appearing in Fig. 2 and his unique knowl-

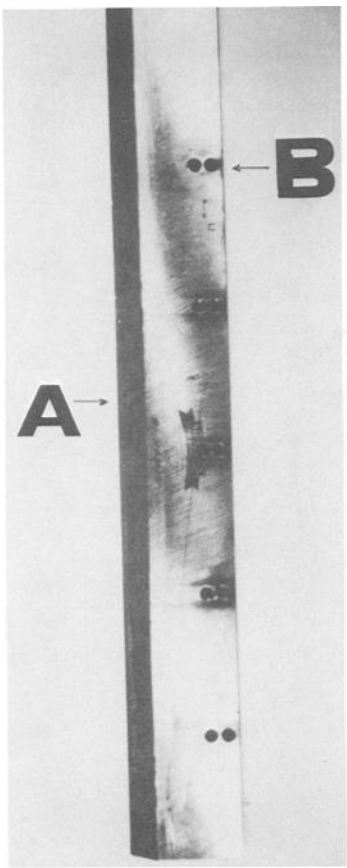

FIG. 3—*Overall perspective of 904-mm (37-in.) Challenge paper cutter blade* (A = *cutting edge*, B = *mounting holes*).

FIG. 4—*Photomicrograph of cutting edge, revealing cutting surface and defects in blade.*

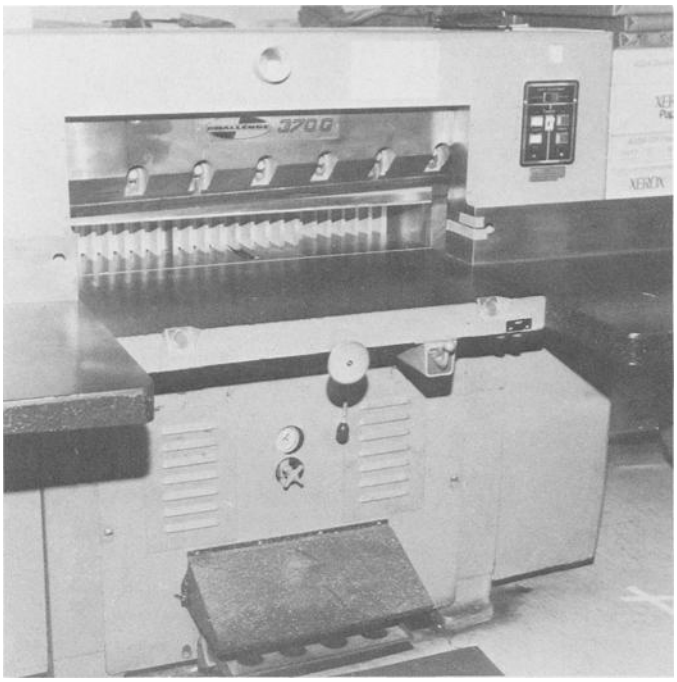

FIG. 5—*Model 370G Challenge Hydraulic Paper Cutter.*

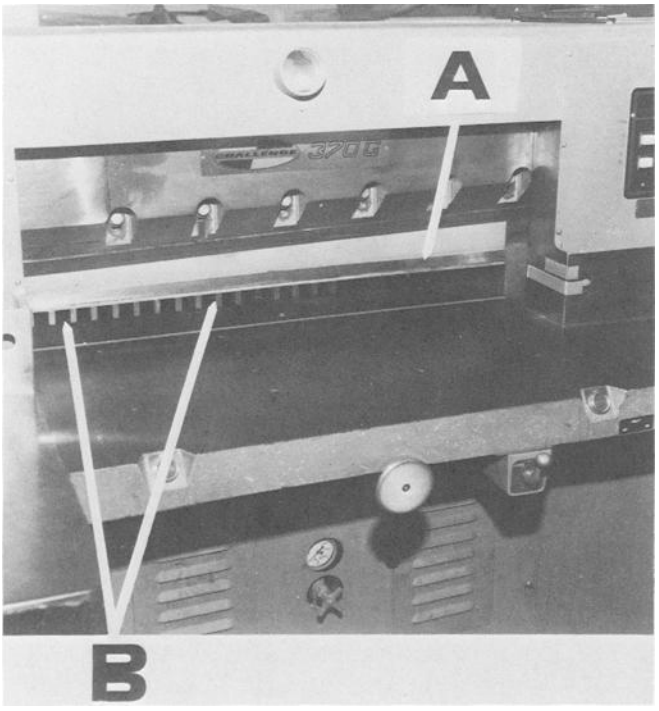

FIG. 6—*Challenge 370G pressure bar* (A) *and finger bar mechanisms* (B).

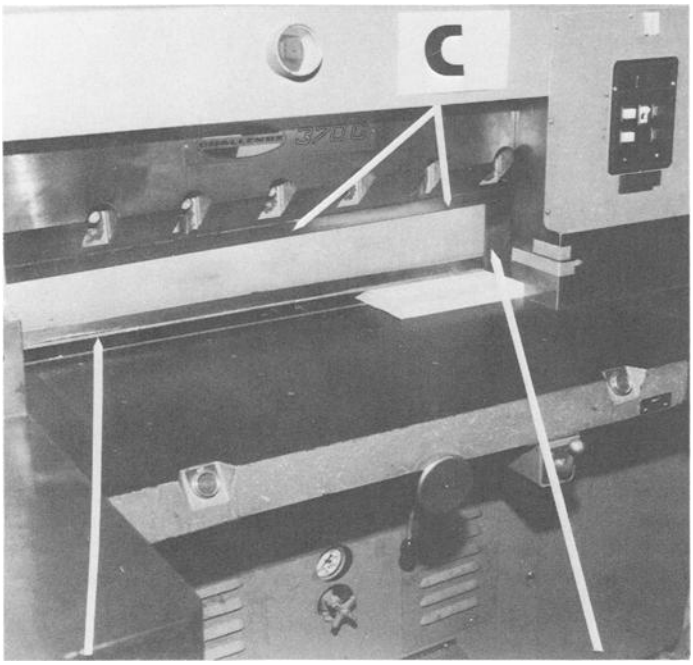

FIG. 7—*Challenge 370G pressure bar* (A), *alignment bar* (B), *and cutting blade* (C).

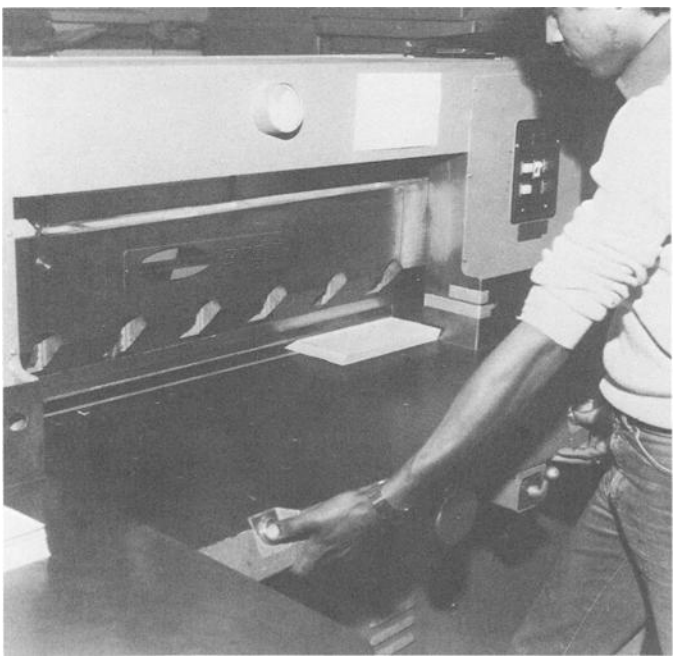

FIG. 8—*Challenge 370G paper cutter in operation, producing various striae impressions.*

edge of the wear characteristics that could be expected through normal use on the subject blade surface, the document examiner was able to render a positive identification, linking the seized cutting blade to the striations appearing on the edges of the seized currency.

The striation evidence provided in this investigation had paramount importance in the eventual guilty plea rendered by the defendant. In the original grand jury testimony, the defendant acknowledged that his fingerprints had inadvertently been placed on some of the seized notes (in fact, three fingerprint impressions were developed on some of the counterfeit notes), but claimed he had initially been shown sample notes but refused to enter into any criminal conspiracy. The defendant steadfastly denied, however, that any of his equipment (including the Challenge paper cutter) was involved in the production of the counterfeit money. Following the trial, the defendant admitted that the striation evidence had been the most damaging evidence against him and was primarily responsible for his guilty plea in the case.

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