TECHNICAL NOTE

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Automated Firearms Evidence Comparison: A Forensic Tool for Firearms Identification—An Update*

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ABSTRACT: The Bureau of Alcohol, Tobacco and Firearms (ATF) laboratories is applying the new technology of computerized image analysis for the identification of bullets and cartridge casings recovered in open cases, and to a database of test fired weapons. The Integrated Ballistic Identification System (IBIS) accomplishes these comparisons in minutes, when the same task using conventional microscopical techniques would require weeks to carefully sort through the firearm evidence. The networking of remote Data Acquisition Stations (DAS) can build a regional firearms evidence database, making the IBIS a powerful resource for the investigation of violent firearm crimes from multiple jurisdictions. A technical overview of the IBIS image acquisition hardware, image storage, case data input, ''surface signature'' analysis, and correlation scoring to an image database is reported.

KEYWORDS: forensic science, Integrated Ballistic Identification System (IBIS), computerized bullet comparison, computerized cartridge casing comparison, automation, firearms identification

The Bureau of Alcohol, Tobacco and Firearms (ATF) is charged with the responsibility to develop, implement, and oversee the national strategy for the use of modern technologies in the field of firearms to combat violent crime. With increasing violent crime rates and the use of firearms in those crimes, the workload of firearms laboratories has increased dramatically. ATF is taking a proactive role by utilizing tools that will enhance the firearms examiners' ability to manage this increasing workload. Firearms examiners are often requested to compare a bullet fired at a shooting with a bullet from a recovered firearm, or from another shooting, to show common origin. Traditionally, firearms examiners have been limited to manually comparing only one bullet at a time to a potential match using a comparison microscope. ATF contracted with Forensic Technology, Inc. (FTI), of Montreal, Canada, for the delivery and deployment of BULLETPROOF®, a fully automated projectile comparison system and BRASSCATCHER™, a fully automated cartridge casing comparison system. Together the system is known as IBIS, the Integrated Ballistic Identification System. IBIS gives firearms examiners the ability to screen virtually unlimited numbers of bullets and cartridge casings for possible matches.

The IBIS consists of a Data Acquisition Station (DAS) and a Systems Analysis Station (SAS). The system uses menu-driven graphical interfaces, with radio buttons and drop-down menus. The operator interface consists of CRT display, keyboard, and a mouse. All images captured are available to the operator in real time, for manipulation during comparisons.

Specimen images are digitally captured on the DAS. The SAS derives a mathematical ''signature'' based on characteristics of the captured image. These ''signatures'' are placed into a database where they are correlated and compared, resulting in a ''candidate list'' showing the relative scores for the image correlations. After reviewing the ''candidate list,'' the operator selects the indicated potential matches to be displayed on screen for visual comparison. ''High Confidence'' candidates (likely hits) are referred to a firearms examiner for examination on a comparison microscope. The system operation requires minimal skill and can be operated by a technician, freeing the firearms examiner for the other duties such as court presentation and additional firearm comparisons. The system acts as a guide, providing suggested potential matches of firearms evidence where the actual identification for court presentation is made by the firearms examiner. IBIS is a tool for the firearms examiner that rapidly correlates images, making bullet and cartridge casing comparisons that would be impossible using traditional methods. Networking IBIS instruments allows comparison of evidence from geographically separated areas. This changes the role of the examiner from verifying investigative information (e.g., gun from suspect linked to bullet in victim) to providing investigative leads to the field by linking otherwise unrelated crimes through physical evidence.

Traditional Firearms Examination

Firearms examiners routinely determine if a fired bullet or cartridge casing was fired by a specific gun. The bullet may have been recovered from a victim's body, or fired cartridge casings (most often from a semi-automatic or fully automatic firearm) may

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be found at a shooting scene. Traditionally, these examinations are performed using a comparison microscope. After some preliminary examination, a recovered bullet, for example, is mounted on one microscope stage and a test fired bullet from a suspect's firearm is mounted on the second stage. An optical bridge allows both bullets to be viewed simultaneously. The firearms examiner carefully adjusts the lighting, focus, and orientation of each bullet for proper viewing. The examiner then begins to evaluate the bullets, looking for similar identifying marks called ''striae.'' This approach, using the comparison microscope, has not changed in the past 70 years.

When a cartridge is fired in a firearm, the generated forces act on both the casing in the firearm's chamber and the bullet being driven down the barrel. The microscopic imperfections made during the manufacture of the firearm's barrel, breech face, firing pin, and action leave toolmarks on the softer bullet and cartridge casing metals. The land impression areas on the bullet (Land Engraved Area {LEA} in IBIS terminology), and the breech face and firing pin impressions found on an expended casing, are primary areas for comparisons of identifiable microscopic marks. Experience has shown that for bullets, the most reproducible marks are normally found in the land impressions near the base. This is the area firearms examiners concentrate on during their microscope work, and is the area where the majority of IBIS projectile acquisitions are captured. For the firearms examiner to say that two bullets match, and were fired from the same gun, he/she must be able to align striae around the available circumference of the bullet. This is complicated by using high magnification to examine the fine striae, working with damaged bullets that have mushroomed or fragmented on impact, and the challenge of determining where to start the microscopical search on each bullet. Breech face and firing pin impressions found on the primer of expended cartridge casings also must show sufficient agreement before it can be determined that there was a common firearm source. Many firearms have firing pins that can rotate in the breech between firings, and the impressions produced may have different orientations respective to the breech face impressions. The examiner must consider this possibility during microscopical comparisons (see Figs. 1 and 2).

Using this traditional approach, only one pair of bullets or cartridge casings can be compared at a time, and can typically take 30 min (in an ideal situation) to hours or days for difficult comparisons. Most city forensic labs maintain an open bullet and cartridge casing file where test fires and exhibit cartridge components from open investigations are filed for later comparison with firearms recovered in connection with future crimes. It is not normally feasible to be able to link cases beyond a few weeks or months unless investigative intelligence otherwise links the cases. Human memory or selected bullet or cartridge casing photographs are the only

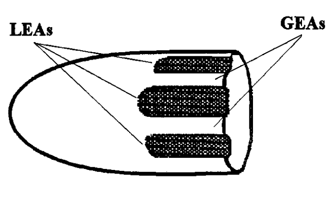

FIG. 1—*The land impression, or Land Engraved Area (LEA), is the impression left on the bullet's surface by the lands in a gun barrel. The groove impression, or Groove Engraved Area (IBIS term—GEA), receives impressions from the grooves of a firearm barrel.*

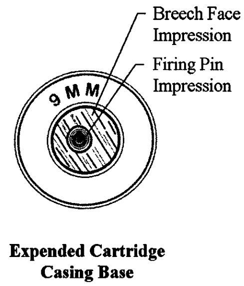

FIG. 2—*The primer in the base of a cartridge is impressed by the firearm's firing pin and breech face during firing.*

tools normally available. As the open case files and number of exhibits grow, the examiner's ability to connect open cases plummets because the traditional approach relies on the human element to make microscopical observations, interpret the observations, and decide if two bullets match. It is dependent on the proper use of the microscope, the brain's ability to correlate hundreds of data points, and consistency to repeat the tasks. As the forensic workload has grown, firearms examiners have not been able to keep up with the increased number of cases. Also, while the work has increased, the number of fully qualified firearms examiners has not proportionally increased. It is not likely that training more examiners to use traditional tools completely addresses the increased burden in casework.

Automated Bullet and Cartridge Casing Comparisons

The IBIS standardizes a number of the steps that normally consume a firearms examiner's time. Specimens are automatically kept in focus by the laser diode system, lighting is fixed and optimized to view bullet striations, and the computer/image capture system consistently (and tirelessly) compares the bullets' images. In a similar manner, IBIS aids the user in cartridge casing image acquisition by automatically determining the margins of firing pin and breech face impressions on the cartridge casing primer, by gaging the lighting for more consistent images, and has precise magnification settings for an additional measure of consistency of images in the database. The system can be run by a technician, freeing the examiner for more complex and skilled tasks.

Instrumentation and Materials

The IBIS equipment comes in two configurations, a stand-alone unit consisting of a DAS and SAS, and a remote workstation known as a DAS-remote (DAS/r). Both image capture and correlations can be done on the stand-alone unit. The stand-alone unit serves as a hub for DAS/r units in other locations. The DAS-SAS units are networked using Novell Light software. Remote DAS units will be able to more efficiently conduct correlations with an upcoming system upgrade to a multitasking server at hub sites using Silicon Graphics servers and Oracle database software.

The DAS/r is primarily a data entry terminal with the ability to upload images and data to the hub. Captured images can be viewed on the DAS/r. The DAS/r uses the same hardware as the DAS-SAS hub, plus a modem (Fig. 3).

DAS—Nikon MM-11C Stereoscopic Microscope

The microscope is modified to house a laser auto-focusing system, radial and axial illumination, stepper motors to rotate the

FIG. 3—*IBIS hub unit (DAS-SAS). The System Analysis Station (SAS) is on the left. The Data Acquisition Station (DAS) with its modified Nikon microscope is on the right. Photograph by Robert Thompson, ATF Laboratory, Walnut Creek, CA.*

bullet specimen during image acquisition, and automatically adjust the focus.

—Sony Video Camera CCD Module Model XC-75
The CCD module is mounted on the stereo-microscope and is used to capture the bullet images.
—Zoom Microscope Sony CCD camera assembly
This assembly is mounted to the microscope for the acquisition of cartridge casing images.
—DEC 486 DX-2, 66MH EISA Computer running Microsoft DOS 6.0
20Mb RAM, 170 Mb hard drive, 525 Mb tape cartridge backup system;
Digital VRC 16 for the graphical interface; and
NEC MultiSync 6FG Monitor Lens—high resolution monitor for image comparison.
—Hewlett Packard 1300T Optical Disk Drive Model C255OT—uses 1.2 Gb removable disks to store the bullet and cartridge casing images.
—Digital VRC 16 Graphical Interface Monitor.
—NEC Multisync FGp Series High Resolution Monitor.

SAS—DEC 486 DX-2, 66MH EISA Computer Running Microsoft DOS 6.0

—20Mb RAM, 170 Mb hard drive, 525 Mb tape cartridge backup system;
IGb hard drive—stores bullet and cartridge casing ''signature'' information;
Digital VRC 16 for the graphical interface; and
NEC MultiSync 6FG Monitor Lens—high resolution monitor for image comparison.
—Uninteruptible Power System (UPS), Liebert UPStation GX UPS model RT2100, 2100VA/1500W output.
—Hewlett Packard 1300T Optical Disk Drive Model C255OT—uses 1.2 Gb removable disks to store the bullet and casing images.
—Hewlett Packard LaserJet 4 Printer.
—Mitsubishi Color Video Copy Processor Model CP11OU, Cypress, CA.
—US Robotics 14,400 Sportster FaxModem.
—Digital VRC 16 Graphical Interface Monitor.
—NEC Multisync FGp Series High Resolution Monitor.

System Operation

Acquiring Projectile Images—DAS Operation (1,2)

The bullet is mounted on a specially designed stub using a hot melt glue gun which is facilitated with a ''C'' clamp-type jig that ensures the bullets are in proper coaxial alignment during rotation. The mounted bullet is placed on a bullet manipulator on the microscope that allows manual positioning and computer-controlled rotation. Using the video image, the operator positions the bullet to begin capturing the first Land Engraved Area (LEA). Proper focus and alignment are accomplished with the aid of the laser diodes. The operator marks the top of the LEA, rotates the bullet, and marks the bottom of the LEA with anchor lines which delineate the land engraved area. The bullet is rotated back to the top of the LEA and the system begins stepping through the delineated area, capturing overlapping images of that LEA (Fig. 4).

Relatively high magnification (fixed perifocal 5× objective and 1×/16 relay lens) is used to compensate for the limitations of the machine vision camera and to capture sufficient striae detail. This requires the system to take multiple images of each LEA (≈ 40 depending on the width of the LEA) and splice them into a single 256 grayscale mosaic image. This process is accomplished in real time. The system automatically overlaps the images and displays the mosaic for operator review before storage. Once the image is approved by the operator, the procedure is repeated for each LEA. During acquisition the operator is prompted if intervention is required. The operator can manually control all parameters from lighting to focus, if needed. A skilled operator can enter a marginally damaged bullet, or test fire, in 10 to 15 min. Deformed bullets with six land impressions may take up to one hour to acquire.

The original image is stored on the DAS 1.2 Gb optical drive. A compressed image (JPEG) is stored on the SAS optical drive. A bullet with 6 LEAs requires about 2.1 Mb of storage space. Approximately 500 to 600 bullets can be stored on each DAS optical disk. The computer extracts significant features (''signatures'') for future correlations against the database. The compressed image and ''signature'' (from a DAS or DAS/r) is then transferred to the SAS. The compressed image is stored on the SAS optical disk (currently up to 6000 JPEG images) and the ''signature'' is stored on the SAS 1 Gb hard disk (up to 50,000 projectile ''signatures'' and associated case data).

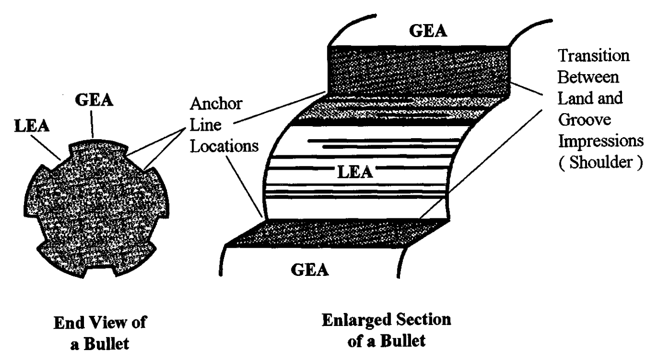

FIG. 4—*Enlarged section of a bullet. This enlarged section of a bullet's surface illustrates where the operator places the anchor lines that locate the image acquisition area. Drawing courtesy of FTI.*

Acquiring Breech Face and Firing Pin Impression Images—DAS Operation (3)

The fired cartridge casing is placed, without regard to orientation, into a specially designed holder attached to the microscope stage. The magnification is selected and the image is centered within the acquisition box displayed on the high resolution viewing monitor by using the microscope stage adjustments. The image is then manually brought into focus and the lighting is adjusted by aid of a bar graph depicting light intensity on the Data Acquisition Station (DAS) user monitor. Once the parameters of lighting, focus, and magnification are set, the operator activates an automated function to define the circular limits of the recording area on the specimen image. For the breech face limits, the software excludes the firing pin impression and the outside margin of the primer. The operator, at this stage, may also ''manually'' designate the image margins to acquire the maximum individualizing detail available. The image is then acquired and processed to extract a signature, which is stored permanently on an optical disk.

The images of the breech face and firing pin impressions are separately acquired. In this manner, images from firing pin impressions made by firearms having firing pins that can rotate within a breech block are independently correlated without respect to firing pin orientation. The two separate magnification settings available for use during image acquisition affords the examiner the opportunity to find matches when either the firearm's breech face or firing pin may impart a smooth, unremarkable impression on the fired cartridge casing. Approximately 1800 cartridge casing images can be stored on a DAS optical disk, and approximately 10,000 compressed images and ''signatures'' can be stored on a SAS optical disk. Database storage on the SAS is virtually unlimited since additional capacity can be installed if needed.

Database Correlations and Comparisons—SAS Operation

To initiate a search, the operator selects a case file and designates it as the ''reference.'' During the search, the database can be filtered using keys that are built around the general rifling characteristics (GRC) of firearms. Such things as caliber, number of lands, and direction of rifling twist can be selected by the operator. In a similar manner a cartridge casing can be compared with the database. In this instance the GRC data entry is simply the caliber and firing pin shape (circular, rectangular, or Glock-type).

A correlation is then run comparing image signatures using the selected filtering keys. It takes approximately five seconds to correlate two bullets. The size of the database subset with the characteristics defined by the filters determines the total correlation time. At the end of the correlation, the system produces a candidate list ranking what the system projects to be the best matches. In addition to displaying ranking information, case identification and other relevant case information are displayed. For bullet comparisons the examiner uses the scores designated Max LEA, Phase Peak, and Max Phase presented in a relative ranking by the SAS, to determine which pairs of projectiles should be viewed on the high-resolution monitor, or further evaluated on a comparison microscope. The ''Max LEA'' is the highest score given to one of the LEA-to-LEA comparisons between a bullet pair. The ''Max Phase'' is the sum of all the LEA-to-LEA scores in a given orientation (phase) of a bullet pair. The ''Phase Peak'' is the highest LEA-to-LEA score for the highest scoring phase orientation (Max Phase). For example, if the Max Phase score of one projectile is sufficiently above the Max Phase score of other projectiles on the list, this projectile might be considered a ''primary candidate.'' Max LEA scores would be studied for bullets with obliterated surfaces, or fragments. These candidates would have depressed Max Phase scores, but may have superior LEA-to-LEA correlation scores (Fig. 5).

Cartridge casing images and their signatures are similarly exported to the System Analysis Station (SAS) for correlations. The SAS is designed to correlate a reference cartridge casing to a database of candidates in two phases. The first phase occurs when a screening correlation of the breech face signature is performed on each cartridge casing that conforms to the search parameters such as caliber and firing pin shape. The scores are stored within the computer's memory and ranked in descending order. The top 10% of the candidate's signatures are then correlated in the second and final phase. In this manner, the phase-one screening helps to discriminate between likely matching and obvious nonmatching candidates prior to the more extensive correlations. During this process, the software compares the cartridge casings in many different orientations by rotating the screened casings 360 deg to find the best matching positions. When the scores are requested for examination, they can be viewed in ascending or descending order for the breech face or the firing pin. The ranked score list produced after the correlations are performed represents a significant aid to the operator. By evaluating the scores, the operator selects candidate images from that list for comparison on the high-resolution monitor. The best candidates ''stand out'' on the basis of their scores so that less qualified candidates may be discounted. One way that the operator's selection is assisted by the recognition of a large score difference between the top scoring candidate(s) compared with the remainder of the correlated database. Therefore, since the matching algorithm produces a score that is much higher for closely matching cartridge casings compared with nonmatching casings, much of the operators work is minimized at the onset (Fig. 6).

For cartridge casing comparisons, the examiner notes both the breech face and firing pin score rankings. When the pair of candidates for comparison is selected, the examiner may select either breech face or firing pin impressions to compare. The computer then presents the best ''matching'' orientation for viewing on the high-resolution monitor. The examiner can then ''move'' and ''rotate'' the images in much the same manner as used in the comparison microscope stages.

Once the operator has viewed the digital images in the comparison mode, and there is sufficiently good visual agreement between the reference image and the image that the candidate list produced, that bullet or cartridge casing is now considered a ''High Confidence'' candidate. ''High Confidence'' candidates are those cartridge components that would be referred to the comparison microscope for further examination.

Discussion and Observation

The greatest initial concern using this technology was whether or not different examiners could enter projectile and cartridge casing images in a sufficiently consistent way for the database to be able to locate a match. The equipment's image capturing system and its robust algorithm have all but eliminated operator variability as a concern (Figs. 7,8).

The modified microscope's features reduce the potential for operator error. Laser diodes are used to help the operator place the anchor lines. They also aid in automatically adjusting the focus, in combination with the stepper motors, to ensure that the bullet is in focus as each image is taken. The light levels are monitored

IBIS BULLETPROOF SYSTEM
REFERENCE

CASE ID : OAK96002625
EXHIBIT : EX/p3,2
DATE : Jan 08, 1996
MACHINE : OAKLAND
CAPTION : 9mm
NB LEA : 6

Database Correlation results

Number of correlated cases : 92

CASE ID	EXHIBIT	CAPTION	MAX LEA	PEAK PHASE	MAX PHASE	R-T LEA	STR	OFF
OAK92124687	EX/p5,9-6	9mm	94	94	284	1-3	7	-8
OAK96004845	TF/P1,1/T1	9MM/BERETTA	67	67	230	1-1	18	-16
CCC9600355B	TF B-1	9mm/NORINCO	71	53	215	6-6	-18	7
OAK94115244	EX/p3,4	9MML (OR 380 AUTO)	59	55	197	2-3	-16	14
OAK95089188	EX/p2,1	9mm	56	56	192	1-5	-20	13
OAK94111188	EX/p2,6	9MM	61	57	184	3-5	4	-18
OAK93086003	EX/p2,1	9mm	57	57	183	4-1	5	-17
CCC9508719C	EX B5	9MM	61	61	180	2-3	-6	-1
OAK93022950	EX/p2,1	9mm	57	57	178	1-3	7	-16
OAK94108977	EX/p1,1	9MM	45	43	176	1-4	0	-18
OAK93061188	EX/p1,5	9mm	52	52	174	2-5	-6	-12
OAK93090772	EX/p3,7	9mm	53	40	172	2-3	-4	-15
CCC9508838A	EX 60	9MM	45	42	171	2-4	2	0

FIG. 5—*Portion of a bullet correlation candidate list. A bullet case #OAK96002625 was compared with the database. The top scoring bullet images, case #OAK9214687, were judged after reviewing the images as a ''High Confidence'' candidate. The MAX Phase and MAX LEA were scored well above the ''background'' of the rest of the database. Reference LEA 1 to LEA 3 was selected as the best comparison area between the two bullets (RT-LEA). The STR (Stretch) and OFF (Offset) are a measure of computer adjustment for the best comparison.*

IBIS BRASSCATCHER SYSTEM

REFERENCE

CASE ID : OAK93074726
EXHIBIT : EX/p1,2
DATE : Aug 01, 1993
MACHINE : OAKLAND
CAPTION : 9mm

Database Correlation results

Number of corre:ated cases : 316

CASE ID	EXHIBIT	CAPTION	FIRING PIN	BREECH FACE	THETA	CX	CY
OAK93114544	EX/p1,1-2	9mm	1	66	14	-5	14
OAK95020117	TF/p2,1/T3	9mm/BERETTA	0	13	270	-7	-6
OAK95032217	TF/p1,1/T2	9mm/NORINCO	0	13	9	9	-15
SF931417461	EX BAG 3-4	9mm	1	8	268	10	-15
SF951209000	TFC-B	9mm/KSI	7	7	11	2	-8
SF950497826	TFC-B	9mm/LUGER	3	6	18	-17	-7
OAK95025946	TF/p1,3/T3	9mm/LORCIN	3	6	352	4	-8
SF940200691	TF BAG 6-C	9mm/INTERDYNAMICS MOD KG99	1	6	275	12	12
OAK95002282	TF/p1,1/T3	9mm/NORINCO	0	6	12	10	7
CCC9507557A	EX 905-5 #6	9MM	2	5	209	-4	2
SF951086535	TF/1C	9mm/SMITH & WESSON MOD 39	0	4	194	-12	-5
OAK95038802	TF/p1,1/T1	9mm/INTRATEC	4	3	5	-2	-10
OAK95088714	TF/p1,1/T2	9MM NORINCO	2	2	9	-5	-10

FIG. 6—*Portion of a cartridge casing candidate list. In this case the reference cartridge casing, case #OAK93074726, was most similar to #OAK93114544 in the database. The high breech face score, and image comparisons, determined that the casing was a ''High Confidence'' candidate. THETA, CX, and CY describe the best comparison orientation and position of a casing pair.*

so that the lighting highlights the striae detail. The operator is visually prompted if the light or focus are outside predefined levels. Cartridge casing images have precise magnification settings which virtually eliminate errors produced by less than optimal image sizes in the database. Lighting is also electronically monitored for optimal image quality.

The search algorithm and image acquisition system demonstrated its robust nature during a recent series of tests conducted by the Office on National Drug Control Policy (ONDCP) (4). During a series of stress tests, images were acquired outside the norms any trained operator would use. The tests included reducing and flaring the light sources, misplacing anchor lines, tilting the image during acquisition, incorrectly designating the striae angle, partially masking striae detail, and obliterating striae information by sanding a land engraved area. Even when combinations of mistakes were made, the system located the correct matching bullet among the top five candidates 85% of the time (22 out of 26 tests). A number of the tests included correlations where the images were acquired by two different operators. An Operational Performance Study performed with the *BRASSCATCHER* component at the ATF San Francisco Laboratory Center demonstrated excellent results in the algorithm's ability to correctly find matching cartridge casings in

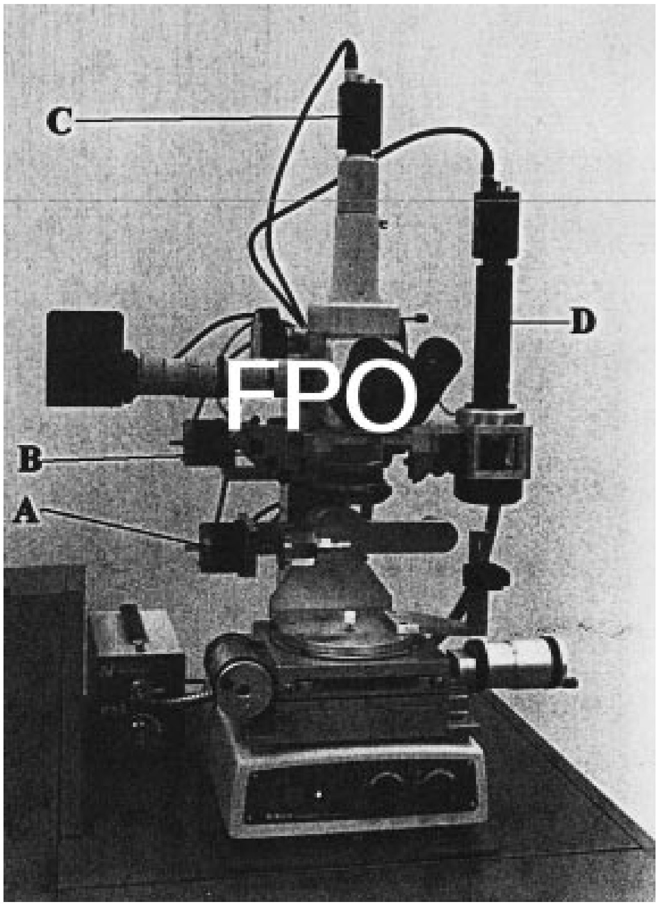

FIG. 7—*Microscope assembly: bullet manipulator and cartridge casing mount. The computer-controlled stepper motor (A) rotates the bullets during image acquisition. Manual manipulation is available when needed. The laser diodes (B) for focusing are located above the bullet at a 45° angle on either side of the ring light. The bullet surface images are captured by the microscope camera (C). At the far right is the cartridge casing acquisition microscope and camera (D). Photograph by Robert Thompson, ATF Laboratory , Walnut Creek, CA.*

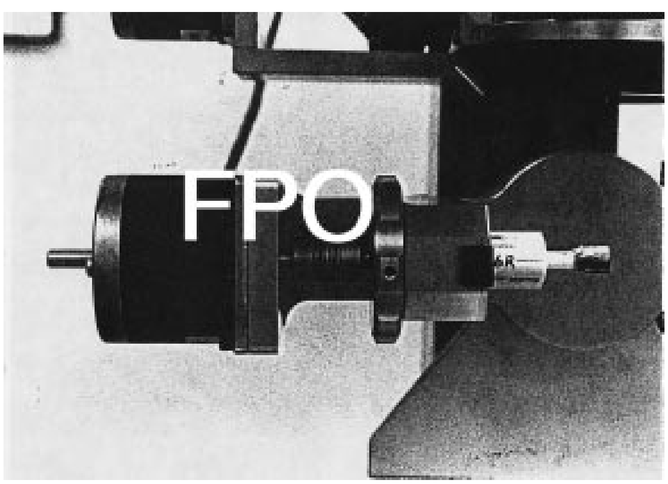

FIG. 8—*Close-up view of a bullet on a mounting stub* (right), *and the computer controlled stepper motor* (left).

a database of 200 pistols where the test-fired cartridge casing pairs *were not prescreened microscopically* for identification. Correct associations were found in 65% to 80% of first position scored candidates representing .25 Auto, .380 Auto, 9 mm Luger and .45 Auto calibers. In a 9 mm Luger caliber database from Glock pistols, the correct association was found in 94% of the first position scored candidates (3).

Operational Use—Results of IBIS Programs

ATF at its National Laboratory Center has been conducting an IBIS program in cooperation with the Washington, DC Metropolitan Police Firearms Unit since December 1993 (5). In this program bullets and firearms recovered from police precincts, and from all of the city's homicides, are entered into IBIS. An initial pilot study was designed to test all aspects of both the DAS-SAS hub unit and the DAS/r. The hub unit was located at the ATF National Laboratory Center in Rockville, Maryland and the DAS/r at the Metropolitan Police Laboratory in Washington, DC. During the pilot program it has been possible to evaluate the impact of operator variability on image quality and matching, networking limitations, and ease of operator use for data entry, as well as correlations and system maintenance. Operator variability is not a concern, as discussed previously. Significant improvements in ease of use have been made, including the creation of a batch mode process that allows correlations to be queued and run unattended, and an incremental data backup process that saves considerable operation time.

Most important, the effectiveness of the technology in current ATF and local law enforcement IBIS programs has been demonstrated. As of summer 1997, over 41,000 projectiles and 43,500 cartridge casings have been entered in the nation's operational databases. There have been over 75 ''cold hits'' with projectiles, and over 400 ''cold hits'' with cartridge casings reported. (A ''cold'' hit is defined as linking one specimen to another specimen from a separate incident where no investigative/intelligence information associated the events.) When multiple like specimens (i.e., cartridge casing to cartridge casing or projectile to projectile) from the same incident are linked, it is counted as only one ''cold hit'' regardless of the number of specimens.

As IBIS systems are networked, regional databases will be created that allow a broader sharing of investigation and intelligence information. The ATF Atlanta Forensic Science Laboratory is in a partnership with the Georgia Bureau of Investigation Laboratory. The ATF San Francisco Laboratory Center has joined forces with the Oakland Police Department Laboratory and the Contra Costa County Sheriff's Crime Laboratory. In both cases the ATF laboratories have a DAS-SAS hub unit and the state/local has a DAS/r. The labs are cooperating on training, sharing resources, and developing protocols and quality assurance practices.

ATF has worked with the Association of Firearm and Toolmark Examiners (AFTE) and the American Society of Crime Laboratory Directors (ASCLD) on the use of this technology. AFTE is the premier international professional organization for firearms examiners. ASCLD represents virtually all the crime laboratory managers in the United States and a number of foreign countries. ATF has been instrumental in forming a nationwide IBIS users group to ensure consistent standards, terminology, and protocols. The first formal meeting was conducted at the Association of Firearms and Toolmark Examiners Annual Meeting in June 1995. In May 1996 at Walnut Creek, CA, a formalized IBIS National Users Group (IBIS-NUG) was instituted. Currently over 50 Forensic Laboratories are represented worldwide in the IBIS-NUG.

Summary

The Bureau of Alcohol, Tobacco and Firearms, with cooperation and support from Forensic Technology, Inc., and local law enforcement crime laboratories, has demonstrated that IBIS works. The examiner remains in control of all the critical aspects of the identification process and is able to accept or reject the computer's assessment or modify data treatment. This makes it an excellent screening tool, but not a substitute, for firearms examiners. The system is easy to operate and is capable of capturing consistent, high-quality images. This ensures that images can be shared, and compared with data collected at other laboratories. Common standards and protocols have been developed which are the essential steps for creating regional and national databases. ''High Confidence Candidates'' are selected by trained operators, allowing time for skilled firearms examiners to conduct microscopical comparisons, make identifications, and testify. Information about ''High Confidence'' candidates includes which LEAs are a potential match. This gives the firearms examiner a reference point to begin his/her examination ''in phase,'' with the proper land impressions aligned, saving considerable work and time for the examiner. A significant advantage of the system is that it removes some of the subjectivity that an examiner might apply to the microscopical examination as he/she considers the value of weak or strong striae. The software takes into consideration all data in the ''capture zone'' (area near the base of the bullet designated by the operator) of the land engraved area.

BULLETPROOF® and BRASSCATCHER™ (IBIS) technology helps law enforcement agencies to extend investigative resources in firearm-related violent crime. The imaging and correlation capabilities allow intercomparison of projectiles from hundreds or thousands of investigations. Finally, the IBIS technology gives forensic laboratories the ability to generate investigative leads through this physical evidence. When the case involves a ''no-gun'' situation, the listing of possible candidates after a correlation to a database often gives an indication of the most probable manufacturers of the firearm sought. The digital imaging capability of the networked system allows examiners in different jurisdictions (or countries) to examine each other's evidence without the difficulties of physically transferring evidence and cumbersome chain-of-custody procedures.

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