AFFIDAVIT OF WILLIAM A. TOBIN

I, WILLIAM A. TOBIN, declare as follows:

Background Overview as Materials Scientist / Metallurgist

1. I have a Bachelor of Science degree in Metallurgy from Case Institute of Technology in Cleveland, Ohio, and graduate studies in metallurgy and materials science at Ohio State University and the University of Virginia. While in graduate school, I accepted an offer of employment by the Federal Bureau of Investigation (FBI) as a Special Agent in 1971. After serving approximately 3 1/2 years as a "street Agent," I was assigned to the FBI Laboratory in Washington, D.C., as a forensic metallurgist, where I remained until my retirement as the chief forensic metallurgist in 1998. During my career at the FBI Laboratory, I undertook additional graduate studies in materials science (metallurgy) at the University of Virginia, and also studies for a Master of Arts in Special Studies at George Washington University (GWU), a program sponsored and instructed by both the Forensic Science Department and Law School at GWU.

2. Included in my academic background are various courses typical of a metallurgy/materials science curriculum, at both an undergraduate (U) and graduate (G) level. Most directly or indirectly relate to production and functioning of firearm components and cartridge cases (not all inclusive and generally in reverse chronological order):

- Manufacturing Processes & Materials (G)
- Statistics for Scientists & Engineers (G)
- Structure & Properties of Materials (G)
- Shaping & Forming of Metals (G)
- Engineering Metallurgy (G)
- Physical Metallurgy (1 G, 1 U)
- Advanced Materials Laboratory (U)
- Properties of Materials (U)
- Engineering & Mechanical Properties of Materials (U)
- Relaxation Properties of Solids (U)
- Engineering Applications of Materials (U)
- Foundry Metallurgy (U)
- Diffusion Processes Laboratory (U)

- Diffusion Principles (U)
- Plastic[1] Flow Laboratory (U)
- Dislocation & Plastic Flow (U)
- Metallurgical Processes Laboratory (U)
- Fundamental Metallurgical Processes (U)
- Behavior of Materials (U)
- Production Metallurgy (U)
- Thermodynamics (U)
- Heat & Mass Transfer (U)
- Structure of Crystals (U)
- Introduction to Materials (U)

3. By congressional mandate, the FBI Laboratory is charged with providing "assistance to all duly-authorized law enforcement agencies" throughout the U.S. Because no forensic metallurgy component existed in any state, local, or other federal law enforcement entity in the United States, or even in most federal regulatory (non-law enforcement) entities such as the Occupational Safety and Health Administration (OSHA), Food and Drug Administration (FDA), or Department of State, *inter alia*, the FBI Metallurgy Unit provided requested assistance for all federal, state, and local criminal, civil, and non-legal matters, and periodically for the international community in foreign police cooperation matters. From the retirement of the former FBI Chief Forensic Metallurgist in 1986 until my own retirement in 1998, my unit was personally responsible for virtually all forensic metallurgical examinations requested of the FBI by all local, state, federal, and foreign agencies. Such assistance included my participation with the National Transportation Safety Board (NTSB) in determination of the causes of the TWA 800 midair explosion disaster over Long Island, N.Y., the nation's worst rail disaster ("Sunset Unlimited" in Mobile, AL), the nation's second worst environmental disaster (oil spill by the "Emily Berman"), and numerous other high profile incidents. Because of the volume of high profile cases for which I was responsible, my scientific work product has been subject to substantial public scrutiny in the United States and internationally throughout my career as a forensic metallurgist/materials scientist.

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[1] It should be noted that the term 'plastic' in the above listing does not refer to the common usage as the synthetic amorphous polymer solid, but rather describes the non-reversible behavior (deformation) of metals and materials reacting to applied stresses.

4. During my metallurgy studies and my tenure as an FBI forensic metallurgist, I visited many metal manufacturing and processing plants throughout the United States and Taiwan to observe a wide variety of industrial manufacturing practices in detail. I also served as a plant metallurgist in both the copper and aluminum industries, and as a research metallurgist in the field of aerospace and nuclear metallurgy.

5. Part of my responsibilities as a plant metallurgist included evaluating tribological regimes operative during production, and toolmarks imparted by tools and dies during fabrication and production, in efforts to insure efficacy of operations and production continuity, while reducing product variability and breakdown of production tooling. Additionally, I am very familiar with the current practice and methodology of firearm and toolmark examinations inasmuch as I used the same comparison microscopy instrumentation and methodology in my capacity as a forensic metallurgist. I have also functioned as a consultant in the ammunition manufacturing industry.

6. I was asked, and accepted, to serve as a scientific reviewer for the draft final report of the National Research Council of the National Academy of Sciences (NAS), Committee on Bullet Lead Analysis.

7. I reviewed the following documents, provided by the Arizona Justice Project, in preparing this affidavit:

a. Transcript of December 20, 1976, testimony of Robert W. Sibert (misspelled as "Siber" through transcript), FBI Laboratory firearms examiner;
b. Transcript of January 3 and 4, 1977, closing arguments in Petitioner's trial;
c. September 18, 1974, Report by Robert W. Sibert of his examination of the firearms evidence in Petitioner's case;
d. Transcript of phone call between Robert W. Sibert and Bedford Douglas, Public Defender for Petitioner during trial;
e. September 9, 1974 Maricopa County Sheriffs Office Departmental Report, and attached cable from FBI.

8. A copy of my *curriculum vitae* is attached to this affidavit.

9. I have not been compensated for any work in Petitioner's case, including for this affidavit.

Specific Qualifications Applicable to Forensic & Firearms/Toolmarks Issues

10. The domain of metallurgists and materials scientists includes material behavior in virtually every phase in the life of a metal - regardless of form - from its extraction as an ore to the use and functioning of a finished product. Each stage of product development, including for firearms and consumer tools, involves important metallurgical considerations, from material selection and process design to bulk metal forming, shaping, heat treatment, finishing, and related production processes.

11. It is imperative that the underlying scientific phenomena affecting material behavior and interactions with, for example, forming tools and dies, in various conditions and environments of both production and consumer use, are understood. The need to understand the scientific principles governing material behavior and their interactions also patently extends beyond production processes. Clearly, interactions of both the product with its environment, and of product components with each other in service (ultimate consumer use), are important considerations for efficacy of product function and for failure analysis both in production and in user service.

12. The heart of virtually every metal forming/shaping operation is the tool/die responsible for changing the shape of the metal work piece under pressure (forced contact). This is true regardless of the actual product produced, such as the barrel, ejector, extractor, firing pin, breech face of a firearm, ammunition cartridge cases, screwdrivers, aerospace components, wire, tubing, *etc.*, or the function that the product is intended to serve in the consumer market.

13. A critical aspect of production continuity, and a seminal issue for forensic toolmarks comparisons, is the material behavior of both the metal product/component and the tool/die during metal-to-metal contact under pressure during production. Material responses to applied stresses during fabrication frequently result in formation of striations and/or impressions on the work piece component surface from forced contact with the forming tool or die. These characteristics are used as the basis for firearms/toolmarks comparisons. The formation of these striations and impressions depends on numerous parameters, including, but not limited to, manner of fabrication, regime of tribological interaction, cleanliness of lubrication system operative, component alloy, mechanical properties (*e.g.*, tensile strength),

temper, speed of processing, temperature of process, *inter alia*.

14. Tribology, for purposes of this affidavit, is the science of friction, lubrication and wear, of metals in contact and in relative motion. It is such an important consideration during all metal-to-metal contact that it is a sub-discipline of metallurgy/materials science and mechanical engineering, and is included in various academic metallurgical, materials science and mechanical engineering studies/courses. Metal-to-metal contact involving tribological considerations is patently unavoidable during production and/or consumer use of most wrought metal products. Such forced contact in relative motion occurs both in production (in the metal forming and shaping processes for firearm components), and in service use (a bullet traveling under pressure against the lands and grooves of a barrel, cartridge case against breech face, firing pin contact with primer cup, extractor and ejector contact with the cartridge case, *inter alia*). Thus, the most appropriate and relevant true scientific discipline to address issues of metal-to-metal interactions is metallurgy/materials science.

Metallurgical Origins of Toolmarks, Relevant Considerations of Formation, and Forensic Practice

15. The nature, quality, and number of characteristics imparted to a metal product are dependent upon the type(s) and magnitude(s) of stresses (among many other parameters such as process speed, tooling material, product material, lubrication regime, *inter alia*) during the fabrication process. For plant metallurgists, tribological considerations are critical to production continuity, production costs, quality control, safety and, quite subtly, potential civil litigation against a metal product manufacturer. Accordingly, they are crucial considerations for fabrication tool and die design, the heart of most metal manufacturing operations, and are the very tools (known in the industry as 'tooling') used to form the various components of a firearm that impart the toolmark characteristics used by firearms and toolmarks examiners for source attributions.

16. When two metals are in forced contact with each other, the 'softer' material typically acquires characteristics from the 'harder' material (although, generally unknown outside the metallurgy/materials science field, and counterintuitively, hardness is not always the sole metallurgical determinant). As previously alluded, such forced contact occurs during the cycling of a cartridge through a firearm when the cartridge case is impacted

(struck) by the firing pin, the cartridge head is forced (in compression) against the breech face, the bullet is propelled through the barrel, the expended cartridge case is extracted from the chamber, and the case is ejected from the weapon. Comparisons of striations and/or impressions imparted during these forced contacts are the basis of examinations and conclusions by firearms examiners.

17. It is sometimes claimed, with various phrasing, that cartridges are "…cycled through a gun the same way every time…" and "…cartridges are cycled through firearms the same way…". While this claim is true regarding the macro-mechanical process of firing a cartridge, it is not true with regard to the critical physical process parameters that influence the transfer of characteristics (striae and impression) on a microscopic level. Differences attributable to variability in combustion pressures, eccentric loading, exogenous debris, and other parameters, can result in variations in characteristics imparted from shot to shot. The National Research Council of the National Academy of Sciences recognized this variability with their observation that, "...the firing of a firearm and the subsequent generation of ballistic toolmarks are the end results of processes that are simultaneously characterized by high uniformity and great variability... Likewise, the firing of a gun depends on the rapid and repeated performance of numerous mechanical steps that is designed to produce combustion, done in a controlled manner yet still not creating exactly identical conditions in repeated firings."[2] In short, the toolmarks left on bullets and cartridges can differ, even for bullets and cartridges sequentially cycled through the same weapon.

18. In their evaluations of forensic evidence submitted for examinations, firearms examiners rely on the markings ('toolmarks') left on bullets and cartridge casings during the contact (described above) while in relative motion by firearm components such as the barrel, firing pin, extractor, ejector and/or breech face of a gun during operation ('cycling') of the weapon. For conclusions of individualization (also known as "specific source attribution"), one of two crucial premises upon which firearms examiners rely is that each firearm imparts individual characteristics (generally striations or striae, and impressions) to bullets and cartridge cases

[2] "Ballistic Imaging" Report of the National Research Council, National Academy of Sciences (2008), at 30. Available online at:
http://www.nap.edu/openbook.php?record_id=12162&page=30

cycled through the firearm that are purportedly unique to that firearm. Scientific acceptance of the uniqueness premise is problematic for reasons that will be discussed below.

Class, Subclass, and Individual Characteristics

19. In the pattern-matching process of evaluating toolmarks used as the basis for purported individualizations, the forensic toolmark examiner profession defines three groups of characteristics: class, subclass and individual. Class characteristics are considered common to every member of a relatively large group of items or product, typically originate in the design stage, and are deliberately imparted as part of the manufacturing process. Class characteristics include, for example, the number and direction of lands and grooves on a bullet that are common to numerous weapons of similar or different models. Comparisons of class characteristics as an early stage phase of forensic evaluation serve to filter the universe of all possible products to a manageable population with general comparability.

20. Subclass characteristics are fortuitously produced during the manufacturing process by a tool that can leave virtually identical markings on a number of products produced, including firearms, during the tool's useful life in which it typically produces lots over many months, depending on the process and product. The number of products bearing the subclass characteristics can be very large and can exist across many production lots spanning months. However, that number is a subset (smaller) population of items or products within the class defined, hence the term 'subclass.'

21. Individual characteristics are, by definition in the Association of Firearms and Toolmarks Examiners (AFTE) community, unique to one firearm or tool. However, it should be noted that the premise of uniqueness has not been scientifically established.[3]

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[3] See "Strengthening Forensic Science in the United States: A Path Forward", Report of the National Research Council, National Academy of Sciences (2009) at 154, where they observe, "A significant amount of research would be needed to scientifically determine the degree to which firearms-related toolmarks are unique or even to quantitatively characterize the probability of uniqueness.", and at 7, "With the exception of nuclear DNA analysis, however, no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source." See also NRC report "Ballistic Imaging" (2008), "*Conclusions drawn in firearms identification should not be made to*

22. The stage of forensic evaluation that is generally the least difficult is assessment of class characteristics. Even in this stage, however, errors are known to occur and have been documented in the literature.[4]

23. The most seminal, but problematic, obstacle for toolmarks examiners, however, is discerning subclass from purported 'individual' characteristics. This fact is repeatedly acknowledged in the AFTE literature.[5] The importance of this distinction cannot be overstated. If the toolmark examiner is to claim that a specific firearm is the source of features observed on a bullet or cartridge case, then it is axiomatic that the features imparted *must be individual* characteristics, and not *sub-class* characteristics. But one palpable question arises: how does a toolmark examiner discern sub-class from individual features? In a group of features (striations, for example) observed under a microscope, how does the toolmark examiner know which lines are sub-class in nature and which are purportedly individual? Is it 'all or nothing': 100% sub-class or 100% individual? How does the toolmark

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imply the presence of a firm statistical basis when none has been demonstrated. Specifically, as described in Section 3–B.4, examiners tend to cast their assessments in bold absolutes, commonly asserting that a match can be made "to the exclusion of all other firearms in the world." Such comments cloak an inherently subjective assessment of a match with an extreme probability statement that has no firm grounding and unrealistically implies an error rate of zero." [italics in original]

[4] See, for example, *Williams v. Quarterman*, 551 F.3d 352 (Dec. 9, 2008) (Westlaw 10_48_42), where F/TM examiner originally testified that bullet was fired from .25-caliber pistol but was later concluded to be a .22-caliber bullet fired from different pistol. See also, *Trotter v. Missouri*, 736 S.W. 2d 536 (Mo. App. 1987), where F/TM examiner testified at defendant's trial that .357 magnum revolver was used to fire bullet killing police officer but later changed opinion to conclude it was a .38 caliber bullet fired from different weapon.

[5] For one example, see Rivera, Gene C., "Subclass Characteristics in Smith & Wesson SW40VE Sigma Pistols," *AFTE Journal*, Vol. 39 No. 3 (Summer 2007), at 247, where he observes, "The spectre of subclass characteristics has loomed over the field of firearms identification for a number of years… This article documents an alarming example of subclass characteristics that could easily be mistaken for individual characteristics, and might lead an examiner to make a false positive identification. A number of articles regarding the presence of subclass characteristics on various parts of a firearm have been published over the years, including those that specifically dealt with toolmarks produced as a result of the manufacturing process" and proceeds to describe the existence and persistence of subclass carryover through repeated firings that could be easily mistaken for individual characteristics and lead to a false positive identification.

examiner know where sub-class ends and individual begins? For example, the fabrication tool or die may (or may not) have individual characteristics, but when those characteristics are transferred to a work piece (product), do they suddenly become individual to the particular firearm? How many of them remain sub-class and how many, if any, suddenly become 'individual'? The AFTE theory provides no guidance on this question.

24. *It has been my experience as both a plant metallurgist and forensic metallurgist that most metal forming operations generally impart characteristics of forced contact on the work piece (firearm components in this case) that are overwhelmingly subclass in nature,* although it is not uncommon for some individual characteristics to be present as well. The probative significance of these markings depends on, among other factors, the particular alloys involved, manufacturing processes used to produce the part(s), type and nature of the lubrication process(es) operative during production, equipment maintenance practices, production lot sizes, product distribution, and circumstances of subsequent service. The predominant presence of subclass characteristics is particularly true for 'cleaner' operations where, for example, the lubricating medium has been recently changed, effectively removing the majority of suspended particulates unintentionally functioning as abrasives during product/die contact.

25. In part for the above reasons, and because the manufacturing processes *and specific conditions existing during particular product runs* are too myriad, and existing studies too limited, improperly designed, and/or not supportive of the conclusions rendered by study authors, the universal assumptions and premises currently underlying AFTE practice are without scientific foundation. Specific source attributions, such as were asserted in the *Macumber* matter, are inherently probabilistic statements and, without scientific foundation, are unacceptable to the scientific community. The National Academy of Sciences (NAS) agrees, as will be discussed in the following paragraphs.

Influence of Metallurgical Considerations and Fabrication Methods

26. Different fabrication methods, using a variety of forming and shaping techniques, are available for production of barrels and other components of a firearm, such as the extractor, ejector, firing pin, and breech face. For example, rifling techniques for barrels include swaging over a fluted mandrel, rotary hammer forging over fluted mandrel, broaching, and carbide

button rifling. Some processes effect rifling by metal removal (*e.g.*, broaching), and others by metal displacement (swaging, forging, carbide button). Other metal forming, shaping, treating, and finishing processes are used for other components in each firearm. From ore to finished product, the production of a firearm requires a multitude of metallurgical considerations, from evaluation of material properties for anticipated product use, cost, ease of fabrication for each stage of processing (including casting, bulk forming, workability, machining, joining, heat treatment, finishing processes), and process control throughout the manufacturing process, to failure analysis in the aftermarket, for each component.

27. Alloys used can vary for each component in a firearm and among manufacturers, although it is not uncommon for the same alloy to be used for different components in the same product, such as both the barrel and receiver. For example, one manufacturer generally uses a cold-rolled 4140 resulfurized steel and 414 free-machining stainless steel for barrel and receiver production, respectively; another uses 416 grade resulfurized stainless steel for both.

28. To a plant metallurgist, probably the most critical consideration for many manufacturing operations in full production is tool and die wear, for several reasons. Tooling is a significant consideration in production costs, and various techniques are used to eliminate or reduce tool and die costs. Tooling breakdown, caused by die wear, malfunctions or failures, also results in production "down time" and is a costly concern for many, if not most, production processes. Accordingly, efforts to maximize die life have been a dominant concern for plant metallurgists for many decades. As previously alluded, it is such an important consideration that much scientific research has been, and is being, conducted in the field of tribology.

29. The primary metallurgical consideration for the selection and design of tool and die materials, such as for the rifling tool surfaces, is that the materials selected remain chemically, thermally and mechanically stable under production operating conditions. Relative hardness of tool and die material is a significant consideration in die longevity but, generally unknown to toolmark examiners, material hardness alone is not dispositive, and is sometimes not a sufficient indicator of wear resistance or wear performance in specific situations.

30. In general, the use of lubricants in production tends to reduce tool and

die wear by one to two orders of magnitude. However, there are some situations in which they can increase wear such as inhibiting formation of a beneficial tribofilm. They can also act as a carrier of indigenous abrasive chips and exogenous debris if not properly filtered or maintained. Further, lubricants tend to break down over various periods of time, in part depending on the nature of the production process.

31. For some processes, particularly where primarily compressive stresses are involved, a die can last from many hours to many months (even in processes such as common nail production on a "header bench", where 400-600 nails are made per minute) depending, in part, on production rates that are, in turn, dependent upon various parameters such as alloys involved, material temper, type of forming process, percent of cold work, lubrication, product demand, product specifications, and numerous other considerations. The general metallurgical principles involved in how subclass and individual toolmarks are transferred to bullets and casings are no different in relevant aspects in the firearms industry and in firearm user service than they are for marks imparted to metals such as steels, copper, aluminum, *etc.*, during manufacturing processes for other products such as nails, tubing, *etc.*

32. To summarize, it is almost always economically beneficial for a manufacturer to obtain the longest die life possible, not only out of concerns for production continuity (elimination/minimization of production "down-time"), but also because of the costs of purchasing and reworking various tool and die materials such as tool steels and tungsten carbide. Additionally, a strong trend has existed in almost all metalworking industries to reduce variability in manufacturing processes. The effect of these motivating concerns has been increasingly larger production lots before tooling changes are required. This consequently means that the *subclass characteristics (toolmarks) imparted to work pieces such as barrels, extractors, ejectors and breech faces during production have tended to exist in larger production lots over time.*

33. Due to the manufacturing processes and considerations described above, a number of firearms can be expected to exhibit significant concordance in manufacturing subclass characteristics. It is economically undesirable for plant metallurgists manufacturing gun barrels, extractors and ejectors, for example, to accept such high rates of tool and die wear that a rifling broach, mandrel, or a blanking, piercing or coining die is required to be rehabilitated or resurfaced by grinding, or a change of carbide inserts,

after only a few items are fabricated. Persistent tool and die surface characteristics, in turn, will likely impart such concordance of subclass characteristics onto bullets and shell casings that, based on the current subjective protocol and practice for rendering forensic "matches" by toolmark examiners, it can be expected that consecutively formed components could readily be confused in specific source attributions, particularly when the examinations are temporally isolated. Due to the properties and behavior of both work piece (product or component) and die materials, and to the manufacturing processes, it is possible, even probable, that a significant number of weapons may be sufficiently similar in matchable features that are wrongly thought to be individual characteristics, to be declared "matches".

Unfounded Assumption, Uniqueness & 'Individual' Characteristics

34. Firearms/toolmarks examiners' repetitive assertions of various forms of uniqueness, such as "unique signature", "particular weapon", and "no other weapon in the world", *inter alia*, are unfounded assertions. They are unfounded because the assumption of uniqueness has not been scientifically established[6] and constitutes nothing more than subjective belief (speculation). They are also misleading because the tools and dies involved in many fabrication processes involving primarily compressive and shear stresses are not sufficiently volatile over time as to change so quickly due to wear that most toolmarks transferred to firearms components are "individual." In reality, the overwhelming majority of toolmarks imparted in various production processes are subclass in nature, not "individual" characteristics. It is paradoxical because it would appear that the position of practitioners is that fabricating tools (many of which use tungsten carbide inserts) change so quickly as to leave "individual" toolmarks on each work piece fabricated, but that the component surfaces of barrels, breech faces, firing pins, ejectors, and extractors (significantly more vulnerable to wear than tungsten carbide and most tool steels) virtually never change. That position is irrational without consideration and comparison of operating stresses, "feeds and speeds" in production, lubrication regime(s) operative, and numerous other metallurgical and tribological considerations, some of which have been previously discussed.

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[6] See "Strengthening Forensic Science...", Report of the NRC, National Academy of Sciences (2009) at Fn 4, *supra*.

35. Characteristics claimed as "individual" and observed on a cartridge case or bullet, the basis by which toolmarks examiners claim specific source attributions (individualizations), are considered to derive from any of several sources: during manufacturing, subsequent materials handling/processing, and/or during service. Even assuming that discernible individual characteristics are introduced in the fabrication process, it is difficult to understand, especially as a former plant metallurgist, how a forensic examiner far removed from the production process can reliably assess the difference between "individual" characteristics and subclass characteristics imparted during production for the majority of metallurgical processes available. *Without personal knowledge of the individual and subclass characteristics produced by a particular manufacturing run, an examiner cannot generally distinguish the two* for most forming processes. Except for certain processes, such knowledge must be specific to a particular production run and/or even to aftermarket events. While some examiners have a general knowledge of how firearms are produced, such general knowledge does not provide any information in a significant number of circumstances about whether a particular mark(s) on a bullet or casing is individual or subclass in nature. As a plant metallurgist, I frequently observed that some of the characteristics imparted by a die and/or during production were intermittent over various runs, or even during a single work piece run, such that even if a firearm does not share particular subclass, or what would likely be interpreted as individual, characteristics with a consecutively manufactured firearm, it may share the characteristics with earlier or later work pieces (firearms components in this case) manufactured with the same tooling.

Subjectivity of Forensic Firearms/Toolmarks Practice

36. Firearms and toolmark examiners do not have objective criteria for declaring a match, a fact that the Association of Firearms and Toolmark Examiners (AFTE) organization and toolmarks examiner community concede. The focus of a firearms/toolmark examiner is generally on finding *similarities,* and dismissing or rationalizing non-matching (dissimilar) characteristics as irrelevant, without compelling objective evidence or scientific explanation to support rejection, in effect selecting the data they wish to use to support identification. They do not employ the 'single dissimilarity exclusion rule' employed in other forensic areas, such as DNA, and even the now-defunct comparative bullet lead analysis (CBLA), where a single dissimilarity required exclusion. The quality of both agreements and

disagreements can be difficult to assess, particularly given that the characteristics used for comparison are a generally low combination (3 to 5 in many cases) of non-unique geometric form (lines). Firearms examiners generally do not make exclusions based on dissimilarity of individual characteristics within a field of view under the theory that bullets or casings fired from the same gun may pick up a number of dissimilar individual characteristics. It should be noted that, according to one study, the toolmark examiner typically encountered 15-20 percent matching striations between bullets fired from different firearms of the same manufacturer and type, and 36-38 percent on bullets fired from the same firearm.[7] A more recent work indicates that "...up to 25% of the striae in a non-match and more than 75% of the striae in a match will show concordance."[8]

37. Inasmuch as firearm examinations are largely subjective in nature, each examiner must decide whether the non-matching characteristics viewed should preclude declaration as a match. As noted by one scholar of forensic science, "[disagreements among toolmarks examiners] stem from one examiner ascribing too much significance to a small amount of matching striae and not appreciating that such agreement is achievable in known non-match comparisons."[9] Notwithstanding the number of AFTE studies, and even if control samples acquired contemporaneously to fabrication were made available to each examiner for a specific examination, inferences of specific source attribution (individualization) would not be generally accepted among materials scientists and forensic scholars given the lack of objective criteria for calling a match.

38. As critical as the skill is in discerning between subclass and individual characteristics, there is no articulated technique purporting to guide examiners in that regard. To rationalize the absence of articulated protocol, literature, and research for such a purported skill, practitioners repeatedly claim that the skill derives from 'training and experience' and that it cannot be explained, hence no articles in the public domain, peer reviewed or otherwise, articulating how to discern purported 'individual' characteristics from subclass characteristics. Such an explanation raises the question as to

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[7] *See* Biasotti, "A Statistical Study of the Individual Characteristics of Fired Bullets," 4:1 *J.For.Sci.* 34, 34-50 (1959).

[8] *See* Heard, *Handbook of Firearms & Ballistics: Examining and Interpreting Forensic Evidence* (1997).

[9] Faigman, D.L., Saks, M.J., *et al.*, *Modern Scientific Evidence: Forensics*, 5:10 at 426: Thomson-West (2008), ISBN 978-0-314-18415-3.

how toolmark trainers communicate behind closed doors with trainees to recognize the difference between subclass and individual characteristics if instructors cannot articulate such differences in published articles. This is particularly problematic given the numerous acknowledgements by experienced examiners in the literature that "subclass characteristics can be easily mistaken for individual characteristics" and "...features that produce markings on bullets which may be mistaken as individualizing marks when in fact they are really a more restrictive form of class characteristics."[10]

39. In my reviews of underlying benchnotes and/or worksheets of firearms/toolmarks examiners, I most frequently see no discussion or reference to subclass characteristics or "subclass carryover" but, rather, observe a direct leap from class characteristics to presumed "individual" characteristics. In virtually every other case I've reviewed with firearms/toolmarks benchnotes and worksheets, this suggests an "all or nothing" approach, where the examiner presumes that the fabrication process left no subclass characteristics whatsoever and that all the characteristics used for comparison are "individual" characteristics. Such a leap of faith is not unexpected in view of the fervent belief by practitioners in the unproven premise of uniqueness.

40. A subtle, and easily overlooked, consideration rendering the practice of toolmark associations even more subjective than is already immediately apparent is the issue of line (striae) quality to which I previously alluded. Line quality is quite significant but is also unquantifiable and inherently subjective. Because of the lack of scientifically acceptable parameters and descriptors to describe 'lines', toolmark examiners frequently resort to ascribing nebulous and unquantifiable terms in frustrated efforts to give lines some 'character.' In one trial of another defendant, the toolmarks examiner described how he matched lines: "Just one or two fine lines is never going to make it, but if they have some character to them, there is some design to them, and there are no significant differences between those two areas, then - - [sic]."[11] From the perspective of a metallurgist/materials scientist, representations that a line can have 'character' or 'design' are nonsensical.

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[10] Moran, Bruce, "Firearms Examiner Expert Witness Testimony: The Forensic Firearms Identification Process Including Criteria for Identification and Distance Determination," *32(3) AFTE Journal*, 231 (2000), at 239.

[11] Testimony of firearms/toolmarks examiner Jon Kokanovich, Dec. 3, 1992, in *re State of Arizona v. Anthony Spears*, Maricopa County Superior Court Case CR92-90457, T.tr. at 855.

They are subjective descriptors with meaning only to the observer. They are not quantifiable, reproducible data that can be conveyed for peer review, nor are they falsifiable, a critical element of the scientific method.

Reliability of Specific Component Comparisons in the *Macumber* Case

41. The purported individualization in the *Macumber* case was based solely on ejector marks. As the photographs below illustrate, the ejector in the 1911A1 (the model of weapon in question) is approximately one inch long, and the only part of the ejector that makes contact with a cartridge is a portion of the edge at the end of the forward profile of the ejector (see *fig.* 1), the width of contact of which is roughly the same as that of the thickness of a dime (see *fig.* 2). As a result, the ejector mark produced on a cartridge is only a tiny fraction of a square inch. The characteristics transferred during fabrication of the ejector are very limited because of the small surface area of the component and, thus, any characteristics transferred during firing are even more limited because of the tiny surface area in contact with the cartridge case. As a result, comparisons based on ejector characteristics are generally known to be the *least reliable* upon which to base an inference of individualization, in part because of subclass carryover (discussed previously), but also because of the very small surface area of the ejector mark itself.

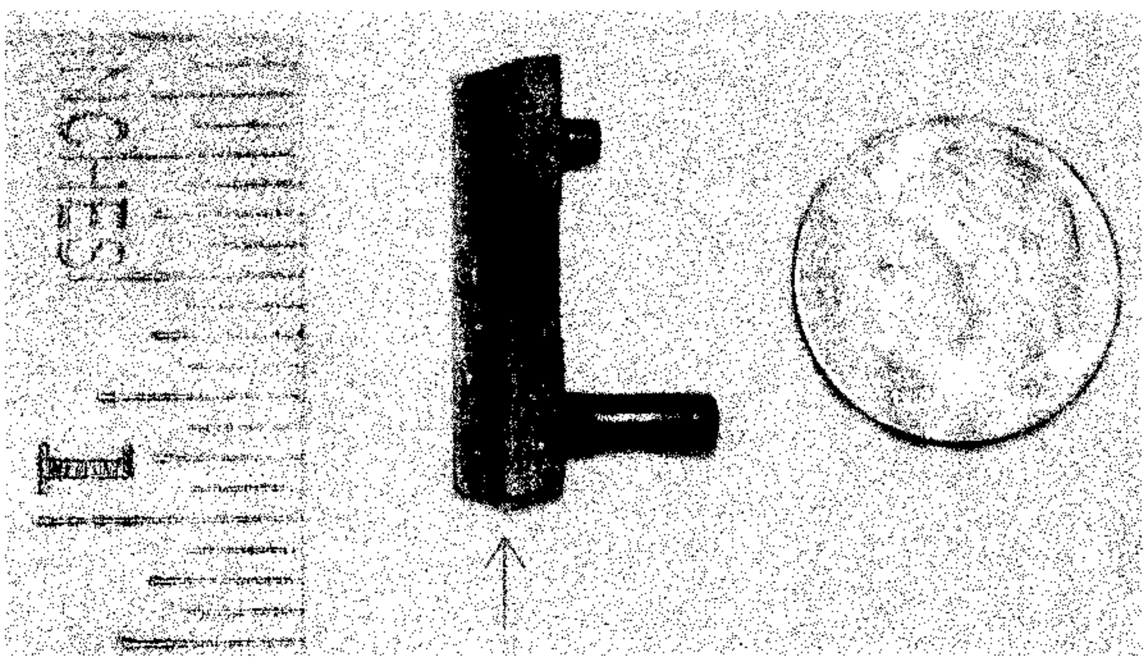

fig. 1. Side profile of 1911A1 ejector. Point and direction of contact indicated by arrow.

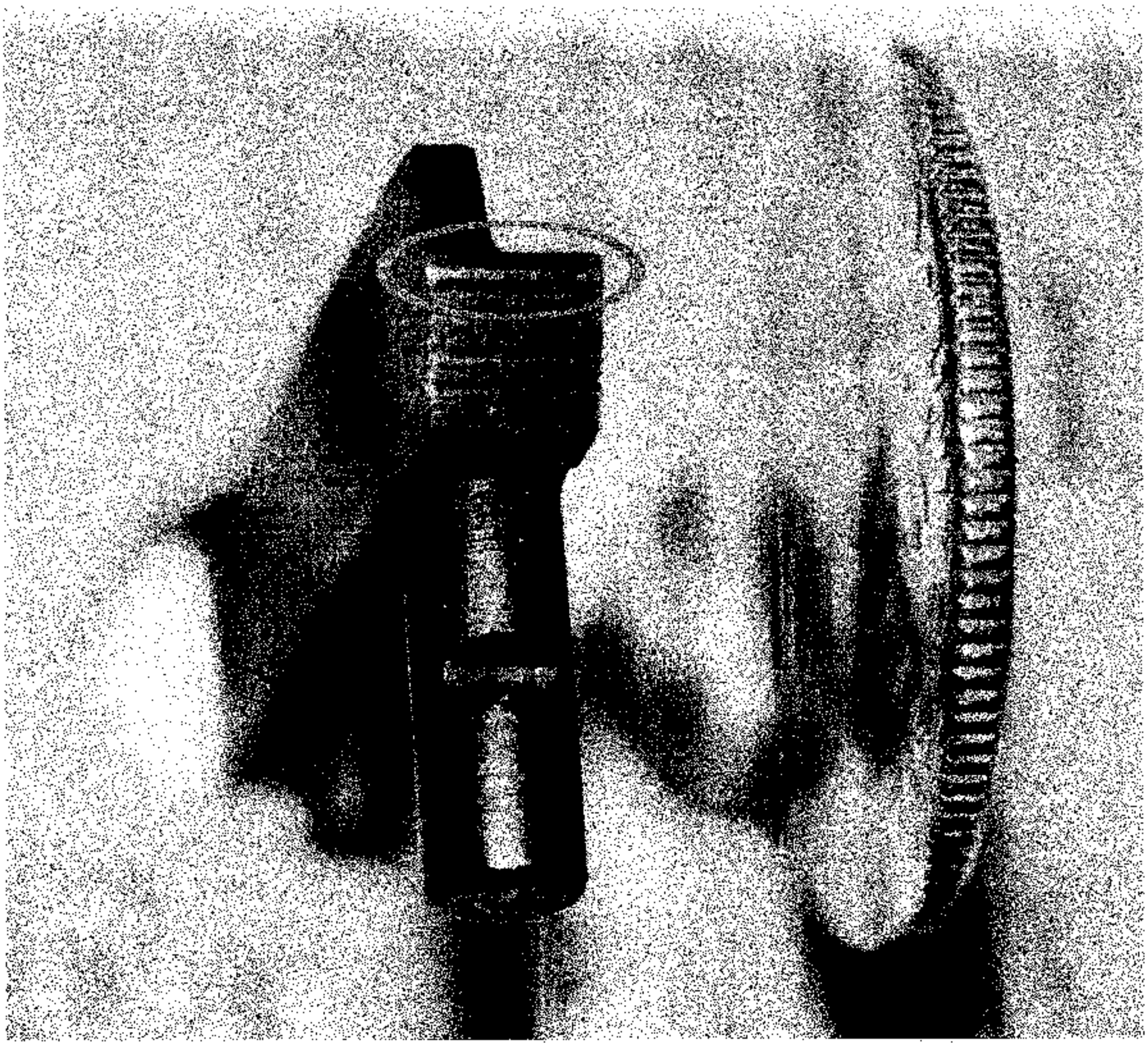

fig. 2. Forward profile of 1911A1 ejector. Area of contact indicated by circle.

42. Furthermore, the fact that the breech face and firing pin marks on the evidence cartridges were inconsistent with the Petitioner's weapon strongly suggests a misattribution, that the Petitioner's weapon was not, in fact, the murder weapon. The breech face and ejector are components that are not typically swapped out of weapons by users. Therefore, it would be expected that these marks should be consistent when comparing evidence cartridges to test cartridges. The fact that they were not should at the very least have raised a red flag to Agent Sibert of the possibility, indeed probability, of misattribution, or at least the exercise of caution in his conclusions, particularly given that he based his entire conclusion on a single, very limited surface.

Summary Opinion

43. Metallurgy is the most appropriate scientific discipline to address issues of metal-to-metal contact, such as occurs during cycling of a firearm. This metal-to-metal contact produces the toolmarks on which firearms examiners base their conclusions. These toolmarks are the result of various manufacturing processes and the microscopic characteristics imparted on firearms and their components that these processes create, which are subsequently transferred to bullets and cartridges when a firearm is discharged. It has been my experience as both a plant metallurgist and forensic metallurgist that most metal forming operations generally impart characteristics of forced contact on the work piece (firearm components in this case) that are overwhelmingly subclass in nature. These subclass characteristics are shared by many tools, and thus cannot be used to make specific source attributions. However, the firearms examination community has not developed any objective criteria or technique for identifying subclass characteristics, nor do examiners have personal knowledge of the subclass characteristics present, from most production processes, on any particular firearm.

44. It is thus my opinion that there is no basis for a firearms examiner to conclude – as in Petitioner's case – that a particular mark was made by a particular weapon "to the exclusion of all others in the world." Furthermore, not only was the language Agent Sibert used in his conclusion scientifically unsupported and misleading, but also it is my opinion that the evidence does not support an inference that the Petitioner's weapon was, in fact, the murder weapon.

SWORN this 23rd day of February, 2011.

William A. Tobin

William A. Tobin

SUBSCRIBED AND SWORN to before me this 23rd day of February, 2011.

MARGARET J. ADKINS
Notary Public
Commonwealth of Virginia
111028
My Commission Expires Jul 31, 2011

Margaret J. Adkins
Notary Public – Virginia

My Commission Expires: 7-31-2011

Curriculum Vitae of

William A. Tobin

-- Educational --

Bachelor of Science, Metallurgy, Case Institute of Technology
Master of Arts, Special Studies, George Washington University
Graduate studies, Materials Science & Engineering, University of Virginia

Additional Courses & Symposia
Physical Metallurgy, Ohio State University
Shaping, Forming of Metals, Ohio State University
Engineering Metallurgy, Ohio State University
Principles of Failure Analysis, American Society for Metals (ASM)
Fractography: Practical Applications in Failure Analysis (ASM)
Metallographic Interpretation (ASM)
Energy Dispersive X-ray Fluorescence, Kevex Corporation
Statistics I, Northern Virginia Community College
Statistics II, Northern Virginia Community College
Detection and Recovery of Human Remains, FSRTC
Calculus I (refresher), Northern Virginia Community College
Calculus II (refresher), Northern Virginia Community College
Applied Statistics for Engineers and Physical Scientists, Va. Commonwealth Univ.
Structure and Properties of Materials, University of Virginia
Fastener Characterization by Mechanical & Metallographic Methods
Manufacturing Processes & Materials, University of Virginia
Applied Electrochemistry, University of Virginia
Explosion Effects & Structural Design for Blast

-- Professional Experience --

Battelle Memorial Institute, Research Metallurgist
Chase Brass and Copper Company, Plant Metallurgist
National Aeronautics and Space Administration, Research Metallurgist
Monarch Aluminum Company, Manufacturing/Production Process Control
U.S. Marine Corps, Platoon Commander, Republic of South Vietnam
Federal Bureau of Investigation, Supervisory Special Agent
FBI Laboratory, *de facto* Chief Forensic Metallurgist
Forensic Engineering International, Principal

-- Court Appearances and Depositions --

Testified as an expert witness in 231 local, state and federal criminal and civil matters, in 44 states (excluding Congressional testimonies and grand juries).

-- Commendations --

- Bronze Star with Combat 'V', U.S. Marine Corps
- 2 Crosses of Gallantry, Republic of South Vietnam
- 20 additional military combat decorations

Numerous letters of commendation, including:

- Personal commendation from U. S. Attorney General William French Smith
- Three commendations with cash awards, from FBI Director William H. Webster
- Two commendations and cash award from FBI Director William S. Sessions

-- Professional Affiliations --

Fellow, American College of Forensic Examiners Institute (ACFEI)
Diplomate, American Board of Forensic Engineering & Technology (ABFET)
Managing Board, Institute for Studies in Science and the Law (ISSL)
Diplomate, American Board of Law Enforcement Experts (ABLEE)
National Association of Corrosion Engineers (NACE)
American Society for Testing and Materials (ASTM)
American Society for Metals, International (ASM)
Advisory Board, Forensic Justice Project (FJP)
The Minerals, Metals & Materials Society (TMS)
National Fire Protection Association (NFPA):
NFPA Section Memberships: (1) Fire Science & Technology Educators, (2) Building Fire Safety Systems, (3) Research, (4) Aviation, (5) Rail Transport Systems, (6) Electrical
International Metallographic Society (IMS)
American Foundry Society (AFS)
1st Marine Division Association

-- Literary Acknowledgments / References / Media --

And The Sea Will Tell, Vincent Bugliosi, Ballantine Books, 1992; former prosecutor of Charles Manson and author of *Helter Skelter*.

Bones, Dr. Douglas Ubelaker (Smithsonian Institution) and Henry Scammell; Harper Collins Publishers, 1992, New York, NY.

Hard Evidence, David Fisher, Simon & Schuster, 1995; author of bestsellers *Gracie With George Burns*, *What's What*, *Killer*, and *The Umpire Strikes Back*.

"60 Minutes", CBS televised interview November 18, 2007; re-aired Sept. 14, 2008

-- Other --

Referee for *Fire Technology*, NFPA
Editorial Advisor, *The Forensic Examiner*, ACFEI
Requested by UNSCOM to serve as U.N. Weapons Inspector, Iraq (1998)

Evidentiary Comparison of Plastic Materials and Products Based Upon Fabrication Characteristics (Toolmarks), F.S. DeRonja and W.A. Tobin, *Proceedings of the International Symposium on the Analysis and Identification of Polymers*, July 31 to August 2, 1984, FBI Academy, Quantico, Virginia.

Collapsed Springs in Arson Investigation: A Critical Metallurgical Evaluation, W.A. Tobin and K.L. Monson, *Fire Technology*, Volume 25, Number 4 (November 1989), National Fire Protection Association.

Arson Investigations, W.A. Tobin, *Law Enforcement Bulletin* ('Focus' feature), February 1990, Federal Bureau of Investigation.

What Collapsed Springs Really Tell Arson Investigators, W.A. Tobin, *Fire Journal*, Volume 84, No. 2 (March/April 1990), National Fire Protection Association.

What Collapsed Springs Really Tell Arson Investigators, W.A. Tobin; course instructional material, *Fire/Arson Investigation Resident Course*, October 1994, U.S. Fire Administration, National Fire Academy; requested and reprinted with permission.

Noninvasive Evaluation of Vehicular Lampbulbs, W.A. Tobin, *Crime Laboratory Digest*, Volume 21, Number 1 (January 1994), Federal Bureau of Investigation.

Noninvasive Evaluation of Vehicular Lampbulbs, W.A. Tobin, *Forensic News*, April-June 1994, Arizona Identification Council, Division of the International Association for Identification; reprinted with permission.

FBI Investigates Aircraft Corrosion (submitted as "Aircraft Corrosion in Law Enforcement"), W.A. Tobin, *Materials Performance*, Volume 33, Number 6 (June 1994), National Association of Corrosion Engineers (NACE).

Inferring Duration of Exposure to a Hostile Environment Based on Measurement of Corrosion Product Thickness, W. A. Tobin, *The Customs Laboratory Bulletin*, Volume 7, Number 1 (1995), U.S. Customs Service, S. M. Dyszel, Ed., Washington, D.C.

A Metallurgical Review of the Interpretation of Bullet Lead Compositional Analysis, E. Randich, W. Duerfeldt, W. McClendon, W. Tobin, *Forensic Science International*, Volume 127, Issue 3 (September 2002), pp.174-191, Elsevier Science Publishing.

How Probative is Comparative Bullet Lead Analysis?, W. A. Tobin, W. Duerfeldt, *Criminal Justice*, Volume 17, Number 3 (Fall 2002), pp.26-34, American Bar Association.

Comparative Bullet Lead Evidence (CBLA): Valid Evidence or *Ipse Dixit*?, E. J. Imwinkelried and W. A. Tobin, *Oklahoma City University Law Review*, Vol. 28 No. 1 (2003), pp.43-72.

Comparative Bullet Lead Analysis: A Case Study in Flawed Forensics, Tobin, W.A., *The Champion*, July 2004, pp.12-22, National Association of Criminal Defense Lawyers.

A Retail Sampling Approach to Assess Impact of Geographic Concentrations on Probative Value of Comparative Bullet Lead Analysis, S.A. Cole, W.A. Tobin, L. Burgess, H. Stern, *Law, Probability & Risk*, Vol. 4, No. 4 (2005), Oxford University Press.

Evaluating and Challenging Forensic Identification Evidence, W.A. Tobin, W.C. Thompson, *The Champion*, July 2006, pp. 12-21, National Association of Criminal Defense Lawyers.

Expert Opinion: Evidentiary Value, Chapter 8: "Evaluating and Challenging Forensic Identification Evidence", W.A. Tobin, W.C. Thompson, reprinted with permission, pp. 137-160; The Icfai University Press, Hyderabad, India (2007).

Chemical and Forensic Analysis of JFK Assassination Bullet Lots: Is A Second Shooter Possible?, C. Spiegelman, W.A. Tobin, William D. James, Simon J. Sheather, Stuart Wexler, D. Max Roundhill, *The Annals of Applied Statistics*, Vol. 1 No. 2, 287-301 (2007); Institute of Mathematical Statistics. http://dx.doi.org/10.1214/07-AOAS119 or http://arxiv.org/abs/0712.2150. Winner of "2008 Statistics in Chemistry Award" of the American Statistical Association with cash award.

-- Noteworthy / Sample Cases --

TWA 800 Aircraft Disaster: Mid-air explosion of flight TWA 800 enroute from New York's Kennedy Airport to Paris, France, on July 17, 1996.

Mid-air Breakup of Missouri Air National Guard F-15C: Crash of F-15C from longeron fatigue failure resulting in nationwide grounding of all F-15A/B/C/D aircraft.

U.S. v. [Blackwater Worldwide personnel]; Incident involving Blackwater Personal Security Detail (PSD) in September 2007 escorting convoy of U.S. State Department vehicles en route to meeting in western Baghdad with USAID officials, resulting in 17 Iraqi civilian fatalities in Nisour Square, Baghdad.

U.S. v. Aafia Siddiqui; Trial of Dr. Aafia Siddiqui for attempted murder with M4 rifle; trial in NYC, NY. Terminal ballistics issue from shooting reconstruction: evaluation of wall damage claimed to be bullet holes from high velocity impact of M855 (SS109) projectiles (bullets).

Olympic Park Bombing: Pipe bomb explosion at Centennial Park, Atlanta, GA, during 1996 Olympics.

Charles Stuart: National notoriety and local racial strife in Massachusetts resulting from incident where Stuart and his pregnant wife were shot in their vehicle; Stuart called "911" from his vehicle while wounded. Notoriety resulted in TV movie "Good Night, Sweet Wife" (CBS) and several books.

U.S. v. Walter Leroy Moody: Defendant sentenced to 7 life terms plus 400 years for mailing package bombs that killed U.S. Appellate Court Judge Robert S. Vance and civil rights attorney Edward Robinson.

USS Iowa: Explosion aboard ship that killed numerous sailors during training operation.

Susan B. Anthony silver dollar recovery. Developed technique for U.S. Mint to recover thousands of mis-minted silver dollars embedded in lucite for collectors.

U.S. v. Joseph Earl Meling; Product tampering of SUDAFED capsules; defendant convicted of contaminating capsules with sodium cyanide to murder his wife, and of causing the deaths of several consumers purchasing SUDAFED.

Girl Scout Cookie Tampering; Nationwide alert for contaminated Girl Scout cookies.

Train Derailment, Panama City, FL; 129 car derailment releasing chlorine gas which killed 8 people. Incident featured in *Newsweek* and numerous other news periodicals.

Wilberg Coal Mine Explosion, Orangeville, UT; coal mine explosion of such severity that it took approximately two years to recover bodies of 27 miners who died in the mine.

Scaffold Collapse, Willow Island, WV; Wire rope failure that caused collapse of scaffold used in construction of nuclear facility, resulting in 51 deaths.

U.S. v Buck Walker & U.S. v. Stephanie Stearns; "Hippie" couple alleged to have murdered Malcolm ("Mac") and Eleanor ("Muff") Graham on Palmyra Island in the South Seas. Skull found by beachcomber on deserted beach in the South Seas 12 years later, depicted on the cover of *And The Sea Will Tell* by Vincent Bugliosi (author of *Helter Skelter* and prosecutor of Charles Manson); also subject of popular TV movie "And The Sea Will Tell" (CBS).

Lt. Colonel William Higgins, Commander of U. N. Forces, kidnapped and killed, Beirut, Lebanon.

Achille Lauro Cruise Ship; Terrorism aboard cruise ship.

Judge Alcee Hastings; impeached Federal judge accused of misconduct and obstruction of justice.

Train Derailment, Mobile, AL; Derailment of the "Sunset Limited," worst rail disaster in U.S. history, resulting in the deaths of 47 passengers on September 23, 1993.

Environmental Disaster; Oil spill, San Juan, Puerto Rico, January 7, 1994, involving motorized vessel (M/V) Emily S. (tug) and barge Morris J. Berman, with 662,000 gallons of #6 fuel oil.

UNABOM; Sixteen package bombs sent to/opened by various technical personnel.

Oklahoma City, OK; Bombing of Murrah Federal Building on April 19, 1995.

Patent Infringement Litigation: *Brunswick v. U.S. Army*; materials design of radar-scattering camouflage netting used by U.S. Army in Kuwait-Iraq conflict. Devised unique testing technique to determine spatial relationship of critical component fibers for U.S. Justice Department.

Auto Accident Due To Roadway Debris; Tragic automobile accident caused by 50-lb. steel plate falling from commercial truck under tow, nearly decapitating victim driver in vehicle behind tow, September 2000, causing massive I-95 traffic stoppage. Cause: poor maintenance and defective weldment on battery compartment of truck under tow.

Dogwood Elementary School Fire, Reston VA; Elementary school fire resulting in total destruction of school ($17 million loss), November 2000. Unsolved by fire investigators for months. Forensic metallurgical assistance provided to Fairfax County Fire & Rescue attributed cause of fire to defective ceiling-hung clock.

COLLAPSE OF BUCKET TRUCK BOOM ARM; bucket truck boom arm, used to trim and clear tree limbs from vicinity of electrical power lines in Warrenton, Virginia, collapsed during use, November 2000. Failure attributable to defective manufacturing technique (weldment).

BICYCLE FATALITY; Moped conversion bike, with caliper hand brakes, became uncontrollable when brakes were applied, causing rider to be ejected over handlebars, resulting in rider fatality. Loss of control attributable to improper bicycle modification.

VEHICULAR FATALITY; Driver stopped on Interstate 95 with mechanical problems was killed by commercial truck while awaiting roadside assistance. Metallurgical examinations confirmed that disabled vehicle's lights, including emergency flashers, were incandescent and visible at time of truck impact.

CORROSION: Premature condenser tubing failures. Well-known construction contractor experienced through-wall corrosion of stainless steel condenser tubing within one year of construction for utility client in Colombia, South America. Three metallurgical entities disagreed as to cause, majority concluding microbiologically induced corrosion (MIC). Indisputable determination of cause: improper heat treatment of tubing, not MIC.

CORROSION: Determination of cause and fault for metal building roof corrosion, installed one year earlier; Wilmington, NC.

CORROSION: Determination of cause & fault for metal building roof corrosion, Annandale, VA.

CORROSION: Determination of cause & fault for multi-million dollar power generating trailers for large-scale emergency power, Wheeling, IL.

EXPLOSION failure of chamber used for demilitarization processes at Army Research Laboratory (ARL), Aberdeen Proving Grounds (APG), Aberdeen, MD.

MISCELLANEOUS: Work ladders; hunter's tree stand; wire rope & cables; fire sprinkler system corrosion; foundry & casting matters; obliterated serial number & identification marking restorations; oil drilling equipment; fasteners (nails, screws, staples, bolts, nuts, *etc.*); missile guidance system components (radar waveguides); aircraft, boat and ship corrosion; automobile accidents & components (fractures, failures, speedometer, headlights, taillights, *etc.*); timing mechanisms (clocks, watches, *etc.*); manufacturing processes; statistical process control; metal building corrosion; mine disasters; transport disasters (maritime, aviation, rail); quality control; standards & specifications; welding; fires & explosions; M4 launch and penetration mechanics with M855 (SS109); gunshot residue (GSR); bullets; firearms; toolmarks.

Various cases featured on "America's Most Wanted", "Unsolved Mysteries", "60 Minutes", "20/20", "Dateline", "Primetime", "Eye to Eye", "48 Hours", "Forensic Files", "FBI Files", "The Discovery Channel", "The Learning Channel", CNN, Canadian Broadcasting Corp.(CBC), British Broadcasting Company (BBC), and National Geographic Channel.

– Speaking Engagements –

ASM, COMS (Central Ohio Metallographic Society), Columbus, OH
Ohio State University
Welding & Testing Technology 8th Annual National Conference (31 professional societies, Knoxville, TN)
ASM, Philadelphia, PA (Liberty Bell Chapter)
MTI (Metal Treating Institute), Secaucus, NJ
ASM, Hartford, CT
ASM, Bethlehem, PA
ASM, New Haven, CT
ASM, Nashua, NH
ASM, York, PA
ASM, Charlotte, NC
ASM, Cincinnati, OH
AWS (American Welding Society), York, PA
University of Pittsburgh
ASNT (American Society for Nondestructive Testing), ASM, Hampton, VA
AWS, ASM, Houston, TX
ASM, Peoria, IL
AWS, Los Angeles, CA
AWS, Baltimore, MD
AWS, Hampton, VA
ASM, Baltimore, MD
ASM, Washington, DC
ASM, Johnson City, TN
ASM, South Bend, IN (Notre Dame Chapter)
AWS, Houston, TX
AIME (American Institute of Mechanical Engineers), AWS, ASM, Beaumont, TX
SCTE (Society of Carbide and Tool Engineers), ASM, Philadelphia, PA
ASM, Portland, OR
ASM, Greensboro, NC
ASQC (American Society for Quality Control), ASM, AIME, Worcester, MA
Metal Treating Institute International Convention, Washington, DC
ASM, Baton Rouge, LA
Florida International Arson Seminar, 46th Annual, Orlando, FL
AWMI (Association of Women in the Metal Industries), Marlboro, MA
AWS, Washington, DC
SAMPE (Society for Advancement of Materials and Processing Engineers), SCTE, ASM, San Diego, CA
Florida International University
ASM, AWS, Miami, FL
MFPG (Mechanical Failures Prevention Group), 45th Session Symposium
AICE (American Institute of Carbide Engineers), ASM, AIME, Kansas City, MO
ASM, Grand Rapids, MI
ASM, Battle Creek, MI
ASM, AWS, ASNT, Rahwah, NJ
ASM, Oak Ridge, TN
ASM, South Bend, IN (Notre Dame Chapter)
Roger Williams College
ASME, ASM, East Providence, RI
ASM, Bethlehem, PA (Lehigh Valley Chapter)
COMS, ASM, ASNT, Ohio State University, Columbus, OH
ASM, AES (American Electroplaters Society), ASQC, Springfield, MA
ASM International, Montreal, Quebec, Canada

TMS (The Metallurgical Society), New Haven, CT
AWS, ASM, Beaumont, TX
AWS, ASM, Houston, TX
AWS, Tampa, FL
Case Alumni Association, Washington, DC
National Thermal Spray Convention (NTSC) '93, Anaheim, CA
26th Annual IMS Symposium, Charleston, SC
ASM, Dayton, OH
ASM, Central Carolinas Chapter, Raleigh, NC
SWE, ASM, Peoria, IL
AWMI, Cleveland, OH
AFS (American Foundrymen's Society), ASM, Saginaw, MI
U. S. Attorney's Office, Dept. of Justice, San Diego, CA
AWS, San Diego, CA
ASM,-Milwaukee, WI
AWMI, Baltimore, MD
AWS, Tysons Corner, VA
ASM, Indianapolis & Muncie, IN
National Engineers Week, Akron, OH: AIIA, ASM, ASCE, ASDPE, ASME, ASHE, IEEE, SME, NAWIC, ASQC, ASHRAE, AIChE, ACESS, Univ. of Akron, Kent State Univ.
ASM, MIT Faculty Club, Cambridge, MA
AWMI, Dallas, TX
ASM, Baltimore, MD
University of Virginia (graduate seminar)
AWMI, Minneapolis, MN
AWMI, St. Louis, MO
Oklahoma City University School of Law
Florida Assoc. of Criminal Defense Lawyers (FACDL), Palm Beach, FL
Wisconsin Assoc. of Criminal Defense Lawyers (WACDL), Madison, WI
American University, Washington School of Law, Washington, D.C. (guest lecturer)
CLE: "Life In The Balance" Seminar, NLADA, Memphis, TN
CLE: North Carolina Association of Trial Lawyers (NCATL), Raleigh, NC.
Joint Statistics Meeting (JSM 2004), Toronto, Canada
CLE: NLADA Conference, Washington, DC.
CLE: NACDL Midwinter Meeting & Seminar, New Orleans, LA
CLE: NCATL Conference, Sunset Beach, NC.
CLE: CPD, Copper Mountain, CO
CLE: TCDLA, Dallas, TX (co-director)
Georgetown University School of Law, Washington, D.C. (guest lecturer)
CLE: DCACDL, Washington, D.C.
CLE (judges only): "Science in the Courtroom", Judicial Institute of Maryland, Annapolis, MD
CLE: TCDLA, Houston, TX (co-director)
CLE: NCAJ, Raleigh, N.C.

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