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JFK Assassination: Bullet Analyses

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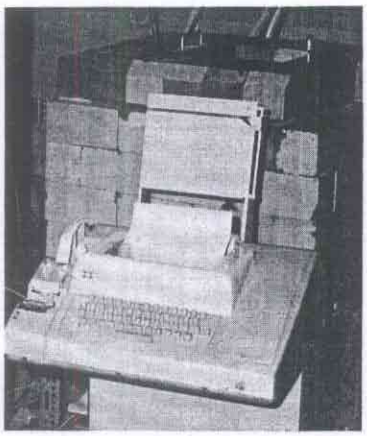


The world was shocked on November 22, 1963, when President John F. Kennedy was assassinated by rifle fire in Dallas, Tex. It rapidly became clear that either some or all of the bullets were fired at the President's motorcade limousine from a corner room on the sixth floor of the Texas School Book Depository, just after the motorcade turned onto Elm Street in Dealey Plaza. Within about 2 h after the shooting, Lee Harvey Oswald was captured a few miles away, but only after he had fired four revolver shots into Officer J. D. Tippit, killing him instantly. Initially arrested for the killing of Officer Tippit, it soon became evident that Oswald was probably also the assassin of President Kennedy. A search of the Book Depository sixth floor room resulted in the finding of three spent Western Cartridge Co. (WCC) 6.5-mm Mannlicher-Carcano (MC) cartridge cases on the floor of the room, and an Italian-made Mannlicher-Carcano military rifle with one unfired cartridge of the same type still in the gun. Oswald, an employee of the Book Depository, had been seen there that morning and also a few minutes after the assassination—disappearing soon thereafter.

During the next 48 h, Oswald was interrogated repeatedly, but consistently denied having killed either the President or Officer Tippit. While the investigation was still in progress, Oswald was shot and killed by Jack Ruby while Oswald was being transferred to other quarters.

Warren Commission Investigation

Within days, numerous rumors were afoot that Oswald was part of a conspiracy to assassinate the President, and that he had one or more confederates, firing from the same location or from another location. The facts, soon unearthed, that Oswald was an avowed Marxist, had recently lived for about three years in the Soviet Union where he married a Russian (Marina), and was an outspoken supporter of Fidel Castro's Cuba, led many people to suspect an international conspiracy. To investigate all of these possibilities in depth, and to provide the American public with a factual analysis of the assassination, the new President, Lyndon B. Johnson, appointed a Presidential Commission to conduct a thorough investigation of all aspects of the assassination. Headed by then Chief Justice Earl Warren, the 7-member Commission became known as the Warren Commission. Constituted only one week after the assassination, it conducted a 10-month investigation assisted mainly by the FBI, and published its findings in September of 1964 in the famous Warren Commission Report.

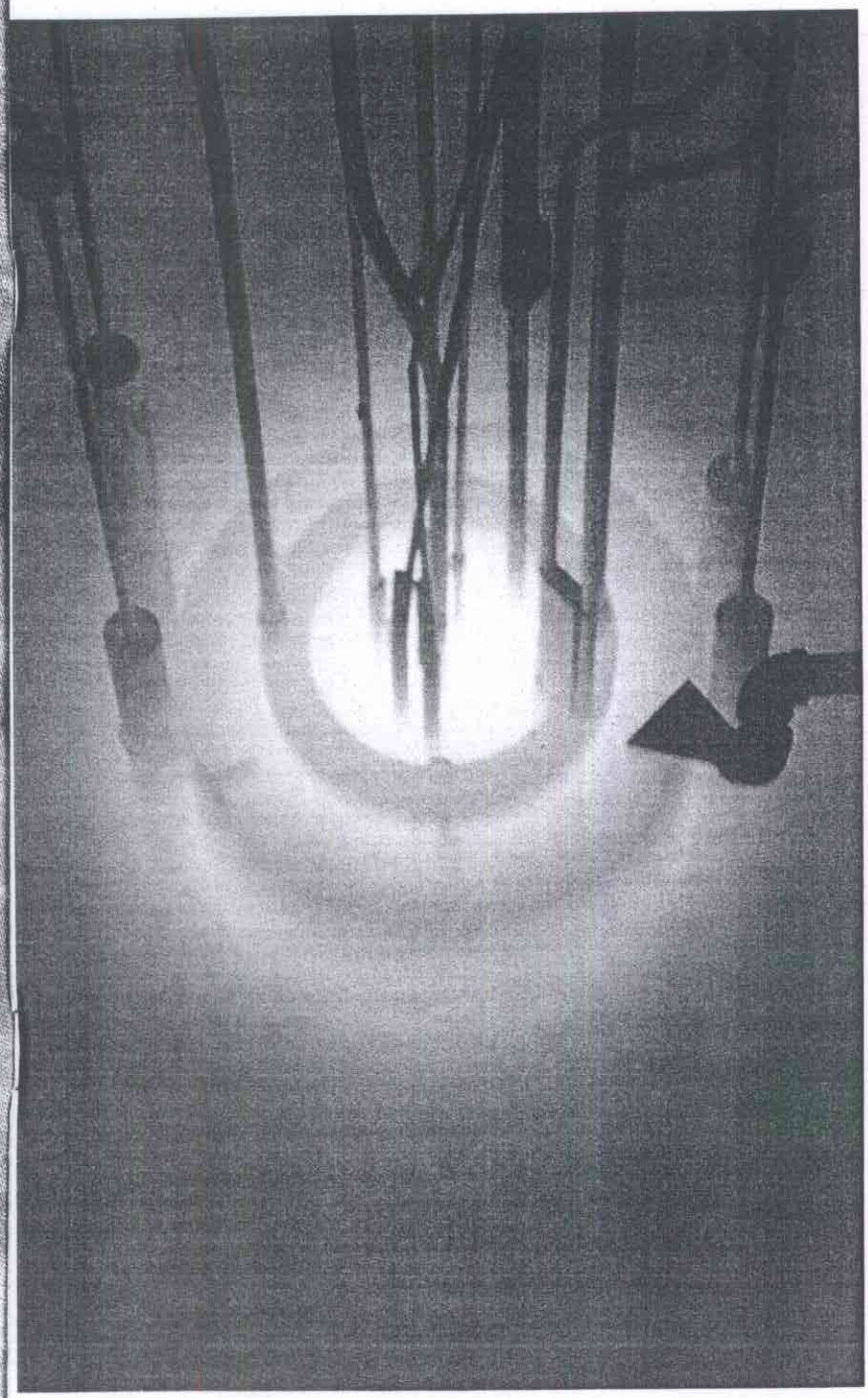
In this investigation, the Mannlicher-Carcano rifle was definitely proved to belong to Oswald (his palmprint was found on it), the three recovered cartridge cases were proved to have been fired from it, and the almost undamaged copper-jacketed bullet found on Governor Connally's stretcher at the Parkland Memorial Hospital in Dallas and two large pieces (a nose portion and a base portion) of copper-jacketed bullet(s) found in the President's limousine were all shown to have been fired from that particular rifle. Clearly, Oswald appeared to be either the lone assassin or at least one of the assassins.

1963–1964 Analyses

All of the analytical measurements conducted by the Dallas police (inconclusive dermal nitrate tests run on paraffin casts taken of Oswald's hands and his right cheek soon after he was apprehended) and by the FBI Laboratory shed very little light on the subject. The FBI took the Oswald paraffin casts to the Oak Ridge National Laboratory and analyzed them by neutron activation analysis (NAA) for the possible presence of primer residue (barium and antimony) (*1*) still there even after the Dallas dermal nitrate tests. This effort was thwarted by the fact that the casts were badly contaminated, essentially as much Ba and Sb being found on the outside surfaces of the casts as on the inside surfaces—which had been in contact with Oswald's skin. The right cheek cast, if it had not been contaminated by improper previous handling, might have established that Oswald had very recently fired a rifle. The FBI Laboratory also analyzed the various bullet fragments recovered from the Dallas limousine, President Kennedy's brain, and Governor Connally's wrist plus the bullet recovered from his stretcher. These specimens were analyzed by emission spectrography. The results showed that all of the bullet-lead specimens were qualitatively generally "similar" in elemental composition,

The Analytical Approach

Edited by Claude A. Lucchesi



The core of the U.C. Irvine TRIGA Mark I nuclear reactor

and "could be" all of the same brand of ammunition. That was all of the chemical analysis work cited in the Warren Commission Report.

Surprise Letter Found in the National Archives

For a number of years after publication of the Warren Commission Report, the author, several other forensic scientists, and various critics of the Commission urged that the Dallas bullet-lead evidence specimens should be examined in more quantitative detail by some more powerful method, such as NAA, to test the Commission's conclusion that all of the specimens recovered were fired only by Oswald. The FBI, under J. Edgar Hoover, declined or ignored all such suggestions. And then a great surprise occurred late in 1973, almost 10 years after the assassination—a letter from J. Edgar Hoover to the Warren Commission, dated July 8, 1964, turned up in the National Archives. This hitherto unknown letter disclosed the fact that, after the generally not very informative emission spectrographic analyses, the bullet-lead specimens had been analyzed by the FBI, using the NAA method. The letter contained no numerical results at all, but merely stated that the NAA results were also inconclusive, and did not allow one to discern how many bullets were represented by the various recovered fragments, although it did state that some compositional differences were found. Why Mr. Hoover chose not to reveal that these NAA measurements had been made, and why there is no mention of them in the Warren Commission Report, is still a mystery.

1964 FBI NAA Data

Working with John Nichols, a forensic pathologist at the University of

Kansas Medical School, I joined in efforts to obtain a copy of the 1964 NAA data obtained by the FBI on the bullet-lead specimens. This also proved to be a slow uphill battle. Finally, and only by taking legal action under the amended Freedom of Information Act, Dr. Nichols succeeded in obtaining a copy of the FBI data—in April of 1975. Dr. Nichols immediately flew out to California with the data, and I began a detailed examination of the 70 pages of the raw NAA data and calculated results that had been obtained at the Oak Ridge National Laboratory in May 1964 by John F. Gallagher of the FBI Laboratory (now retired). The author's initial examination of these data tended to agree with Mr. Hoover's statement that the results were inconclusive. But I will discuss more about these data later.

WCC Mannlicher-Carcano Bullet Lead

At this point, Dr. Nichols and I urged a reexamination of the bullet-lead evidence specimens—this time using nondestructive instrumental neutron activation analysis (INNA) with a high-resolution Ge(Li) semiconductor gamma-ray detector instead of the low-resolution thallium-activated sodium iodide [NaI(Tl)] scintillation detector that had been used in 1964. During the period 1972–1976, I had analyzed a number of samples of WCC/MC 6.5-mm bullet lead, from all four of the production lots made by WCC, using instrumental NAA with Ge(Li) gamma-ray spectrometry. These known samples were supplied by Dr. Nichols and gave surprising results. The results showed that this type of ammunition was quite different from virtually all other brands of bullet lead I had ever analyzed before (*2, 3*). Although individual bullets were fairly homogeneous in their antimony and silver contents, they exhibited a great heterogeneity from bullet to bullet—even within the same production lot and even within an individual box of 20 cartridges. The range of Sb values was especially large, all the way from around 20 ppm up to 1200 ppm Sb. Although still in the range of unhardened lead, they clearly were not made from virgin lead but instead obviously contained appreciable and variable amounts of recycled lead—some of which was antimony-hardened lead. The silver levels ranged from about 5 ppm to around 15 ppm Ag. These background results showed that a more detailed analysis of the Dallas bullet-lead specimens, by INAA with Ge(Li) gamma-ray spectrometry, might be able to establish whether all of the specimens were or were not in the range of WCC/MC bullet lead, and whether they corresponded to two, or more than two, bullets.

The Warren Commission, it should be noted, had concluded that Oswald fired three WCC/MC bullets; that one of them had missed completely; that one of them had struck the President in the back, exited from his throat, gone on to strike Governor Connally in the back (he was sitting in a jump seat right in front of the President), exited from the Governor's chest after fracturing one of his ribs, struck the Governor's right wrist—shattering it, exited from the under side of his wrist, and then came to rest in his left thigh after penetrating the flesh only slightly—finally to fall out on the Governor's stretcher at the hospital; and that a later (or last) one had struck the back of the President's head, exiting near the right front of his head, causing a massive and fatal wound. After issuance of the Commission's Report in 1964, numerous critics scoffed at their conclusion that a single bullet could cause the President's back wound and the Governor's back, wrist, and leg wounds—and still end up with only a slight dent in it and with only about a 1% weight loss. They dubbed it the "Magic Bullet." In addition, partly based on the Zapruder film and on eyewitness accounts of gunfire from a region in front of the limousine (the so-called "grassy knoll"), rather than from the rear, some critics claimed that the fatal head shot did not come from Oswald's location.

A Phone Call from the House Select Committee

In the early summer of 1977, the author received a phone call from a staff member of the U.S. House of Representatives Select Committee on Assassinations—inquiring (1) whether the author thought it might yield new information if the Dallas bullet-lead evidence specimens were reanalyzed, using improved INAA techniques; (2) what kind of information might be generated by such measurements; and (3) whether the author would be willing to conduct such analyses for the Select Committee. To (1) and (3) the answer was "yes," and the answer to (2) was a summary of the information possibly obtainable from such measurements, based upon the author's earlier studies of WCC/MC bullet lead. It was then agreed that the author would reanalyze the Dallas specimens, using the sensitive and nondestructive INAA method, with Ge(Li) gamma-ray spectrometry.

New INAA Measurements

In mid-September of 1977, James L. Gear of the National Archives flew out to California with the Dallas bullet-lead specimens. During a three-day period, the author examined the specimens, prepared them for analysis, analyzed the samples in two reactor runs under different conditions, and returned the samples to him. An amusing aspect was that the measurements had to be conducted under tight security and secrecy—during every working hour of those three days Mr. Gear and the author were accompanied by two armed, uniformed federal guards. Needless to say, speculation amongst the U.C. Irvine students ran high! Later, reading the Ge(Li) pulse-height data from the samples and the Sb, Ag, and Cu standards back from the magnetic tape, I proceeded to calculate the ppm levels of these three elements in each sample.

Preparation of the samples for analysis was itself somewhat of a problem. The various samples ranged in size from about 1 mg on up to one large portion of a jacketed bullet (Q2) on up to an almost whole bullet (the Connally stretcher bullet, Q1). The smaller pieces were taken each in its entirety. From the large Q2 specimen, a piece of the bullet lead free of copper jacket was cut off with a stainless steel scalpel, for analysis. A sample of bullet lead was drilled out from the base of the stretcher bullet (Q1), using a 0.5-mm diameter carbon-steel drill. Each sample was examined under magnification to be sure no specks of imbedded jacket material could be detected. To remove as much as possible of any external contamination from the samples, each was washed three times, alternately, with distilled/deionized water and reagent grade acetone. Each sample was weighed into a specially cleaned small polyethylene vial on an analytical balance. Several small standard samples each of Ag, Sb, and Cu were prepared in the same size vials, the solutions evaporated to dryness, and the materials cemented to the inside of the bottom of the vial by paraffin (using a few drops of 10% paraffin/CS_2 solution, followed by air drying). The conduct of the analyses was somewhat restricted by the security/secrecy requirements, and by the short time available to carry them out (precluding the possibility of doing replicate determinations of each sample, except for the silver determinations, which could be repeated, due to the short half life of ^{110}Ag). Each night, all of the evidence specimens and the analytical samples had to be taken away for overnight security storage at the Laguna Niguel branch of the National Archives.

In the first run, the 1–50-mg samples and the standards were activated and counted one at a time, using the pneumatic-tube facility of the U.C. Ir-

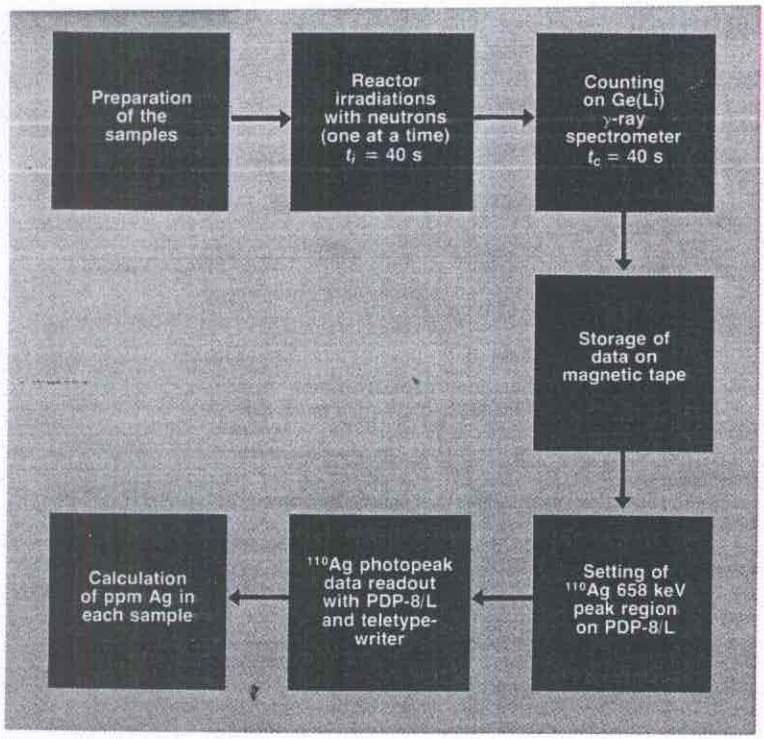


Figure 1. Schematic of INAA determination of silver in bullet-lead specimens via 24.4-s ^{110}Ag

vine TRIGA Mark I nuclear reactor. The conditions used were those of our rapidscreening method (*4*), giving precision measurements for silver and less precise values for antimony and copper: irradiation, decay, and counting times of 40 s each. The samples were activated in a thermal-neutron flux of 2.5×10^{12} n cm^{-2} s^{-1}, and each was transferred to a fresh polyvial during the 40-s decay period. Each activated sample was counted with a 38 cm^3 Ge(Li) detector/4096-channel gamma-ray spectrometer, and the pulse-height data were promptly stored on magnetic tape. The most prominent induced activities detected were 24.4-s ^{110}Ag, 93-s ^{124m_1}Sb, and 5.10-min ^{66}Cu. Quantitative results were based upon the largest photopeak of each (658, 498, and 1039 keV, respectively). The analytical sequence is shown schematically in Figure 1.

In the second run, the same samples (and standards) were activated and counted again, but this time all together in the 40-tube rotary specimen rack of the reactor—for 1 h at a thermal-neutron flux of 1.0×10^{12} n cm^{-2} s^{-1}. After about a 1-h decay, the samples and standards were counted as before, but this time for 5 min each. The most prominent induced activities were 2.80-day ^{122}Sb and 12.8-h ^{64}Cu, providing more precise values of the antimony and copper levels. Quantitative results were based upon the largest photopeak of each (564 and 511 keV, respectively).

Results of New INAA Measurements

As can be seen in Table I, samples Q1 and Q9 (the Connally stretcher bullet and fragments from Connally's wrist, respectively) are indistinguishable from one another in their Sb and Ag concentrations, but are clearly distinguishable from the Q2, Q4, 5, and Q14 samples (Q4, 5 being fragments

*See correction below

three samples, in turn, being indistinguishable from one another. The results for copper follow the same pattern except that no reliable value for Cu could be obtained for sample Q9, because it was greatly contaminated with Cu from imbedded jacket material. From the induced 66.9-min ^{204m}Pb activities [an (n,n') fast-neutron product of lead] (*5*), it was also established that all of the samples were at least 90% lead. The sample Q designations, by the way, are those originally assigned to the evidence specimens by the FBI. The CE designations, which are also shown in Table I, are the Warren Commission Exhibit numbers assigned to them.

The conclusions derived from these results—interpreted in the context of my earlier measurements on background WCC/MC bullet-lead samples—are definite and straightforward: all of the Dallas samples are in the unusual (though not necessarily unique) concentration ranges of WCC/MC bullet lead; and the specimens show clearcut evidence for the presence of two, and *only* two, WCC/MC bullets—one of a composition of 815 ppm Sb and 9.3 ppm Ag, the other of a composition of 622 ppm Sb and 8.1 ppm Ag.

A Second Look at Earlier FBI Data

After I had obtained these new results, it seemed to me that the presence of two different compositions should have been discernible from the FBI's 1964 NAA data, in spite of the complication of the 20-fold poorer energy resolution of the NaI(Tl) scintillation detector that Mr. Gallagher used [the high-resolution Ge(Li) detector was not generally available in 1964]. My previous examination of the FBI data had revealed that the results had been obtained for silver (via the 24.4-s ^{110}Ag induced activity, as in the newer measurements) under one set of irradiation/decay/counting time conditions. His values for silver agreed closely with the new values. The complication, however, was that Mr. Gallagher measured antimony (via the 2.80-day ^{122}Sb and 60.4-day ^{124}Sb induced activities) under four different sets of irradiation/decay/counting time conditions—unfortunately obtaining four rather widely different Sb values for each sample. The wide spread of Sb values for each sample obscured any distinction between the Q1 and Q9 samples, on the one hand, and the Q2, Q4, 5, and Q14 samples, on the other—if all the results were viewed simultaneously. This confusion

Table I. Author's 1977 INAA Silver and Antimony Results [a]

Sample no.	ppm Ag	ppm Sb	Sample description
Q1 CE-399	8.8 ± 0.5	833 ± 9	Connally stretcher bullet
Q9 CE-842	9.8 ± 0.5	797 ± 7	Fragments from Connally's wrist
Q2 CE-567	8.1 ± 0.6	602 ± 4	Large fragment found in car
Q4, 5 CE-843	7.9 ± 0.3	621 ± 4	Fragments from President Kennedy's brain
Q14 CE-840	8.2 ± 0.4	642 ± 6	Small fragments found in car

[a] The measurement precisions shown in Tables I and II as ± values represent 1 standard deviation. Studies by the author on background samples of WCC/MC bullet lead show that the Sb variability within an individual bullet, particularly, is usually several times larger than the measurement precision on an individual sample.

*Correction: Should read "recovered from President Kennedy's brain; Q2 and Q14 being fragments recovered from two different areas in the Dallas limousine)--these latter"

Table II. 1964 FBI Antimony NAA Results from Four Sets of Measurements (and the One Set of Silver Results)

Sample no.	ppm Ag	ppm Sb			
		Set 1	Set 2	Set 3	Set 4
Q1	9.4 ± 0.3	945 ± 16	1002 ± 13	813 ± 43	705 ± 54
Q9	9.2 ± 0.1	977 ± 24	1090 ± 37	773 ± 22	676 ± 14
Q2	7.9 ± 0.9	745 ± 16	747 ± 20	626 ± 57	534 ± 30
Q4, 5	8.5 ± 0.4	783 ± 5	858 ± 46	614 ± 37	561 ± 32
Q14	8.5 ± 0.2	793 ± 10	879 ± 33	629 ± 18	562 ± 21

no doubt led Mr. Hoover to state that the results were inconclusive.

However, my second review of the FBI data (*6*) [benefiting, of course, from the hindsight gained from the newer Ge(Li) results] resolved this anomaly. Although not heretofore realized, the old FBI data also showed that samples Q1 and Q9 were similar to one another in their Sb and Ag contents (Cu was detected, but not measured), and distinct from samples Q2, Q4, 5, and Q14—which, in turn, were similar to one another. This conclusion was reached by examining the Sb results obtained by the FBI for all the samples under all four conditions—but with the data for each condition compared only with one another, rather than intercomparing the results obtained for each sample under all four conditions. Examined in this fashion, it was revealed that, for each of the four FBI measurement conditions, samples Q1 and Q9 matched closely, and were quite different from samples Q2, Q4, 5, and Q14, which in turn matched one another closely. The FBI results are displayed in this fashion in Table II. Apparently, some errors in some of the standards used, and/or in the counting conditions used in the four different measurements led to some consistent (determinate) errors that resulted in four different Sb values being obtained on the same sample. The FBI values for one of their conditions (set 3) agree closely with the newer Ge(Li) values, but their results for the other three conditions are numerically considerably different from the Ge(Li) results.

Presentation of Results Before the Select Committee

After I had submitted a detailed report to the Select Committee on my INAA results and conclusions concerning the Dallas bullet-lead evidence specimens, the Committee requested that I present these at their public hearings in Washington, D.C. On September 8, 1978, I presented a 90-min summary of my findings and conclusions (nationally televised on public service TV), the 90 min including questioning by various of the 12 Congressmen who constitute the Select Committee.

Thus, analytical chemistry—which in 1963–64 had not shed much light on the assassination—finally succeeded in producing significant useful information. The nondestructive instrumental neutron activation analysis results have demonstrated that, to a high degree of probability, all of the bullet-lead evidence specimens are of WCC/MC 6.5-mm brand, that there is evidence for the presence of portions of two—and only two—such bullets, and that the Connally stretcher virtually intact bullet indeed caused the fracture wound of Governor Connally's wrist—a previously hotly disputed part of the Warren Commission's theory. The back wounds of President Kennedy and Governor Connally involved essentially no damage to the bullet (or bullets) causing them, and thus produced no fragments for possible analysis. The new results cannot prove the Warren Commission's theory that the stretcher bullet is the one that caused the President's back wound and all of the Governor's wounds, but the results are indeed consistent with this theory.

And What Now?

In due time, my report to the Select Committee will be made public and available, and I will be submitting a series of several papers to the *Journal of Forensic Sciences* (of the American Academy of Forensic Sciences) that will cover this investigation in greater detail. These papers will also include additional studies in my laboratory, some of them still in progress at this writing, on background WCC/MC bullet-lead samples (further homogeneity studies) that will enable one to calculate actual numerical probabilities.

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