

Mr. EDGAR. Thank you. Let me just ask each of you as panel members: Is there anything related to the rifle or either of the two revolvers relating to any of the testimony that has been given today that you would like to comment on or make any extra explanation of?

Mr. CHAMPAGNE. No, sir.

Mr. EDGAR. Let me ask you one final question, then. In your expert opinion, did the FBI do an adequate job in their ballistics test after the death of President Kennedy and for the Warren Commission?

Mr. CHAMPAGNE. I would say, considering the pressures at the time, the FBI did a very good job.

Mr. EDGAR. Are there any tests that you would have done at the time that were not done?

Mr. CHAMPAGNE. No, sir.

Mr. EDGAR. Thank you. Mr. Chairman, I have no further questions.

Chairman STOKES. The time of the gentleman has expired. The Chair recognizes the gentleman from Indiana, Mr. Fithian.

Mr. FITHIAN. Thank you, Mr. Chairman. I wonder if the panel, any one of all of you, would comment on what has been on the panel, widely written about and discussed features of the actual shooting. As I understand it, the distance from the window where Oswald was supposed to have been located to the President was 165 feet. With that weapon which you now have inspected and test fired, how difficult a shot is it with the scope or without the scope, sort of from left to right?

Mr. LUTZ. The answer I would give, I believe, would be that it would not appear to be a difficult shot with either device with reasonable training or a reasonable capability of a firer that was familiar with that firearm.

I personally feel that the iron sights would have provided a better capability because of the problems of sighting through the other device, through the telescopic sight, but I feel that it could have very easily been accomplished from that distance with that rifle.

Mr. FITHIAN. And with the car moving at the estimated speed? Mr. LUTZ. From the data I have about the movement of the vehicle and the speeds involved, I still feel that it would not have been a difficult target at that distance.

Mr. FITHIAN. Is there any other member of the panel who believes that it would be somehow an exceptional feat to have hit the target from that range?

Mr. BATES. I don't believe so, no.

Mr. CHAMPAGNE. No, sir.

Mr. FITHIAN. Mr. Newquist stated, I believe, that the panel could not match their own test-fired bullets with either the FBI's tests from 1963—maybe I misunderstood this—or the so-called pristine bullet that has been so much talked about and the bullet fragments removed from the limousine?

One of the reasons theorized that a match could not be made was that the rifle had been fired too often, somehow destroying or altering the land-and-groove markings. Does anyone on the panel know how many times the weapon was fired by the FBI?

Mr. BATES. No; I do not.

Mr. CHAMPAGNE. Are you referring just to the FBI firing it or the number of times it was actually fired?

Mr. FITHIAN. I was just going in the order I thought it was fired once it was acquired by the FBI and then by the committee panel and by anybody else. I was trying to get at how much actual wear and alteration there has been.

Let me rephrase the question. I am informed by our counsel that the weapon has been fired over 100 times. Is that sufficient wear that it would significantly alter the markings and the identifications?

Mr. CHAMPAGNE. Yes; I think with this type of weapon and the type of bullets involved, that it is. I think that probably the weapon has been fired more than 100 times.

Mr. FITHIAN. Mr. Chairman, I have no other questions of this panel.

Chairman STOKES. The time of the gentleman has expired.

Gentlemen, any witnesses appearing before this committee are entitled, after they have concluded their testimony, to 5 additional minutes in which to explain, amplify, or in any manner expand upon their testimony. On behalf of the committee I at this time extend to you 5 minutes in which any of you may make any comments you so desire.

Mr. LUTZ. I don't believe there is any further expanding on the examinations that we have conducted. I think we feel that they have been as thorough as could have possibly been done. We have been given the opportunity to examine every piece of evidence that we asked for. We didn't have any restrictions. We weren't bound to come up with a particular finding. So I think in that respect we have been very fortunate to conduct an objective examination.

I also would like to express on behalf of the entire panel the thanks to our own employers, the State of Wisconsin, the State of Florida, the State of Iowa, the State of New York, and the Metropolitan Police Department of the District of Columbia for allowing us to participate in this panel. I would like further to extend on behalf of the entire panel our appreciation to the staff of the committee, for the assistance they have given us and especially to thank the committee itself for the privilege and the honor of appearing before it.

Chairman STOKES. We certainly deem ourselves fortunate to have had such a distinguished panel of experts lend their services to this cause. We appreciate all the time that you have expended on behalf of the report that you have brought to the committee and the testimony you have given us here today. We express at this time our very deep appreciation to each of you for the services that you have rendered. Thank you.

The Chair recognizes Professor Blakey.

NARRATION BY G. ROBERT BLAKEY, CHIEF COUNSEL AND STAFF DIRECTOR

Mr. BLAKEY. Thank you, Mr. Chairman. Mr. Chairman, there have been several prior attempts to analyze missiles and fragments recovered from the assassination from the standpoint of their m-

falling makeup to determine, for one possibility, if they have a common origin.

In November and December 1963 the FBI applied to the evidence samples a technique called emission spectrography. It is a process in which the samples are subjected to intense heat and their metallic composition is determined by the color of the gas that is then emitted. Emission spectrography, however, is not highly sensitive and the tests were deemed by the FBI inconclusive.

In May 1964 the FBI also performed neutron activation analysis on some of the samples. That is a nuclear method to determine the elements present. An analysis of trace elements found in the sample of similar materials—for example, bullet lead—enables a highly trained scientist to come to a conclusion as to the probability of the samples having a common origin.

Nevertheless, "inconclusive" was also the term used by the FBI to describe its neutron activation analysis. The report it submitted to the Warren Commission stated that the tests would not, quote, "permit positively differentiating among the larger bullet fragments and thus positively determining from which of the larger bullet fragments any given small lead fragment may have come," unquote.

The Warren Commission did not divulge that the neutron activation analysis had taken place in its final report. Indeed the fact did not become public until the early 1970's.

Hopeful that new tests might succeed where old efforts had failed, the committee engaged as a consultant Dr. Vincent P. Guinn, professor of chemistry at the University of California at Irvine. Dr. Guinn had no relation to the Warren Commission. Dr. Guinn analyzed the assassination evidence samples as well as the bullet allegedly fired at General Walker.

In his experiments, Dr. Guinn used a high resolution lithium-drifted germanium detector, a device that is far more sensitive, and hopefully accurate, than the one used for the FBI test in 1964.

Dr. Guinn received an A.B. and an M.S. degree in chemistry from the University of Southern California in 1939 and 1941 and a Ph. D. in physical chemistry from Harvard University in 1949. Dr. Guinn studied radioisotopes at the Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn., in 1952. He is a fellow of the American Nuclear Society, the American Academy of Forensic Scientists, and he is a member of the American Chemical Society.

Dr. Guinn has published numerous scientific articles in the area of activation analysis and forensic chemistry. He has served as an adviser to such agencies as the Atomic Energy Commission and he has made a training film on neutron activation analysis which is in wide use today.

It would be appropriate, Mr. Chairman, at this time to call Dr. Guinn.

Chairman Stokes: The committee calls Dr. Guinn.

Sir, would you please stand and raise your right hand and be sworn.

Do you solemnly swear the testimony you will give before this committee is the truth, the whole truth and nothing but the truth, so help you God?

Dr. GUINN: Yes, I do.

Chairman Stokes: Thank you. You may be seated. The Chair recognizes committee counsel Jim Wolf.

TESTIMONY OF DR. VINCENT P. GUINN

Mr. WOLF: For the record, could you please state your full name?

Dr. GUINN: Vincent P. Guinn.

Mr. WOLF: Where are you currently employed?

Dr. GUINN: As a professor of chemistry, University of California, Irvine campus.

Mr. WOLF: Are you familiar with the technique of analysis of evidence samples known as neutron activation analysis?

Dr. GUINN: Yes; I have been involved in such work for over 20 years.

Mr. WOLF: When did you first personally perform this technique?

Dr. GUINN: About 1956.

Mr. WOLF: Have you testified in legal proceedings before on the applicability of neutron activation analysis to evidence samples?

Dr. GUINN: Yes, on many occasions.

Mr. WOLF: Did you testify in the capacity as an expert witness?

Dr. GUINN: Yes.

Mr. WOLF: In your capacity as an expert witness did you both testify as to samples you had analyzed and performed the analysis on as well as an evaluation of analyses that other people had done?

Dr. GUINN: Yes, both of them.

Mr. WOLF: Approximately how many times have you testified in your capacity as an expert witness?

Dr. GUINN: I would say approximately 50 times.

Mr. WOLF: Generally, Dr. Guinn, why would one subject an evidence sample to neutron activation analysis?

Dr. GUINN: It depends on the kind of evidence sample, but for many kinds the purpose is to detect various elements in the samples and compare specimens to see if they are sufficiently similar in composition that it indicates a high probability of common origin or, if they differ widely, a definite probability of noncommon origin.

Mr. WOLF: So it may be possible, by neutron activation analysis, to determine if two or more unknown evidence specimens are from the same batch or item, is that correct?

Dr. GUINN: That is correct.

Mr. WOLF: To use an example, if a crime had been committed and the victim hit over the head with an ax, and metal fragments were found in the skull of the victim, might you be able to analyze the metal fragments found in the skull to see if they matched the type of ax that was found in a particular person's house who is accused of that crime?

Dr. GUINN: Yes; if one found the same elements at approximately the same concentrations in both, you could establish that there was a good probability that it came from the same type of ax. It wouldn't identify that particular ax because there might have been a hundred or so made of the same batch of metal but it would establish that particular brand and production lot perhaps.

Mr. WOLF: Is it easier for you to state your conclusion that two objects are alike or is it easier to establish the conclusion that two items are not alike?

Dr. GUINN. It is much easier to exclude; if you find two samples that differ markedly, it is easy to say definitively they did not have a common origin. If they look similar in composition, then your first statement is: "They may have a common origin," and you have to look more carefully and look at background data that you have obtained on such materials to try to even estimate a probability that they really do have a common origin.

Mr. WOLF. Briefly, Dr. Guinn, I would like to ask you a few general questions about procedures one would employ to do a neutron activation analysis. If, for example, you had a metal specimen to test, what would you do to that metal specimen to prepare it for testing?

Dr. GUINN. On many kinds of samples it is necessary to remove, as best you can, any external contamination, dust, moisture, or salt from handling and perspiration. You may have to wash them, or salt dry them, and so on, just to get rid of external, extraneous contamination that would otherwise change the measured composition from what the real material was. That is quite common.

Mr. WOLF. After preparing the sample, you would then insert that sample in a nuclear reactor, is that correct?

Dr. GUINN. You normally place the individual samples in small plastic (polyethylene) vials as a container and, of course, you put that into the nuclear reactor.

Mr. WOLF. And the sample would be made radioactive after it was placed in the nuclear reactor, is that correct?

Dr. GUINN. Yes; in the reactor the purpose is to bombard the sample with neutrons. The neutrons—some of them get captured by the nuclei of the different kinds of atoms in the sample, and that makes some of these radioactive. So when the sample comes out—particularly metal samples—there is no change in weight that you can measure, there is no change in appearance, but the sample is now radioactive and you can then test it with suitable counting equipment.

Mr. WOLF. Now, radioactive materials decay, is that correct?

Dr. GUINN. Yes. Different radioisotopes have different rates of decay.

Mr. WOLF. Can you explain in layman's terms what "radioactive decay" means?

Dr. GUINN. "Radioactive decay" means that an event occurs in the nucleus of an atom resulting in it releasing energy and penetrating radiation and/or a particle such as a beta particle, which is a high-energy electron. In the process, it changes normally to a stable isotope, of the next element in the case of beta-minus emission. The process of that decay is called "radioactivity" or "radioactive decay."

Some elements have a number of different radioisotopes that have been made in the reactor with neutrons. Some of them will only form one radioisotope; some will form two or three. The radioisotopes of different elements are characterized by the energies of the radiations that they emit in the process of decaying and also by their half-lives, which is a measure of how rapidly they decay away.

Mr. WOLF. You are telling us different elements have different radioactive half-lives and, by detecting the radioactive decay of the

unknown sample, you would be able to identify the elements present in that sample, is that correct?

Dr. GUINN. Yes, particularly, in practice, by looking at the energies of the gamma rays that are emitted by the sample, rather than actually measuring the half-life. We make use of the half-life but we don't usually actually measure it.

Mr. WOLF. What are some of the different types of materials you have tested by neutron activation analysis for the purpose of comparison?

Dr. GUINN. Well, almost all the kinds of materials you can think of that may get involved in some kind of criminal case—gunshot residues, bullet lead, glass, paint, paper, cloth, oil, greases, and so on and on.

Mr. WOLF. How many different types of bullets have you examined by neutron activation analysis?

Dr. GUINN. Approximately 165 different actual, known brands and known production lots of bullets.

Mr. WOLF. Were these of different calibers as well as manufacturers?

Dr. GUINN. Yes; they covered the full range of calibers as well. Mr. WOLF. What elements have you found were the most distinct to distinguish among different brands of bullets?

Dr. GUINN. Looking over all of the data that we have obtained and also other people have obtained who have been using the same general approach, we find there are three elements that commonly show up in bullet leads but at widely different concentrations, depending upon which bullet lead it is. These three elements are antimony, silver, and copper.

And I would say that that is about the approximate order of importance—that is, antimony being perhaps the most informative or the most critical element to measure; silver, very close to it; copper, somewhat less, though, mainly because copper wouldn't be so bad in and of itself but, in criminal cases, you very frequently are looking at little bits and pieces of bullets, and the original bullets were copper-jacketed and that means some of the fragments you get may have a little bit of copper imbedded in them physically so that you can't see and yet it will show up markedly in the analysis. So the copper numbers can often bounce around.

Mr. WOLF. Are other elements found to be present in bullets when you analyze them, apart from antimony, silver, and copper?

Dr. GUINN. Well, many times in bullets, under the conditions that we normally use, you will just see those three. Very often, unless you very carefully clean them, you will find a little bit of sodium and a little bit of chlorine, coming from salt, which may be from perspiration if anybody has handled the specimens, or salt spray in the air if it is anywhere near the ocean, for example. Often you will find a little trace of manganese, not so much that it is common but we happen to be extremely sensitive for manganese. The main reason for using the activation analysis method is that it is an extremely sensitive method. It will detect very small concentrations, but it doesn't have the same sensitivity for all elements. Some are far more sensitive than others. So we sometimes see a little manganese, occasionally a little aluminum, once in a while some arsenic or tin.

That about covers all of the elements that we have ever seen in all bullet leads.

Mr. Wolf. Have you analyzed Mannlicher-Carcano bullets produced by the Western Cartridge Co. (WCC)?

Dr. Guinn. Yes, I have.

Mr. Wolf. When did you do these analyses?

Dr. Guinn. A number of years ago. I believe I started doing the first analyses about 1973. A colleague, not at Irvine but at the University of Kansas, Dr. John Nichols, had been interested in the President Kennedy case for quite some time and he contacted me and said he had been able to acquire boxes of Mannlicher-Carcano ammunition from the four production lots that had been produced by the WCC, and he was wondering if I would be interested in doing analyses on them since I had earlier analyzed a lot of other kinds of bullets. I said yes, and I did, and we found some unusual features about WCC Mannlicher-Carcano ammunition that showed it was different from most kinds of bullets.

Mr. Wolf. Prior to getting into those features, did you examine bullets from every lot produced by the Western Cartridge Co.?

Dr. Guinn. Yes. The Western Cartridge Co. reportedly made 1 million rounds of each of 4 production runs, lots 6,000, 6,001, 6,002, and 6,003. They were made at different times in 1954, and reportedly those are the only lots they ever produced, and we had boxes from each of those lots.

Mr. Wolf. Addressing your analyses, did you find WCC Mannlicher-Carcano bullets differed from most other bullets you had analyzed?

Dr. Guinn. Yes; they did.

Mr. Wolf. How did they differ?

Dr. Guinn. Well, as of the time that I first measured them, they had a lower antimony content than I had encountered prior to that in most other bullets, because a very large percentage of bullets you do look at, commercial ones, are hardened lead, where they deliberately add anywhere from half a percent up to perhaps 4 or 5 percent antimony to make the lead much harder. A very large percentage of commercial bullets do have hardened lead. So we have usually found much higher antimony levels than in the WCC Mannlicher-Carcano bullets.

Mr. Wolf. And WCC Mannlicher-Carcano bullets are considered unhardened bullets. Is that correct?

Dr. Guinn. They are definitely unhardened bullets. That puts them down much lower in antimony than most bullets.

Subsequently we—in looking at a lot more brands in the interim—did find some others that were also low, some of them lower yet in antimony, but that was one unusual feature.

The other unusual feature of the WCC Mannlicher-Carcano is that there seems to be no uniformity within a production lot. That is, even when we would take a box of cartridges all from a given production lot, take 1 cartridge out and then another and then another and then another, all out of the same box—boxes of 20, these were—and analyze them, they all in general look different and widely different, particularly in their antimony content.

This is not true of most bullet leads that we have ever looked at before, which are very uniform. In general, if you take most boxes

of ammunition—and we published on this, it is in the literature—take a bunch of them out, you can't tell one from the other. They all look like little carbon copies even to activation analysis, but not so with the Mannlicher-Carcano.

Mr. Wolf. Did any of the 165 known brands and lots of bullets you have previously examined have constituent ranges that were the same as the WCC Mannlicher-Carcano bullets in their antimony and silver characteristics?

Dr. Guinn. Yes; the range of the WCC Mannlicher-Carcano, especially in the antimony content, is so wide that it does encompass some of the others which are down at that low end, and out of 165, there were 4 different groups, 1 U.S. made and 3 foreign made, that fell somewhere in that range.

Mr. Wolf. Addressing the work you did for this committee, Dr. Guinn, where did you obtain the evidence samples that you examined for this committee?

Dr. Guinn. Well, it was during last year. First of all, we made the arrangements in advance, and then in September of last year Mr. James L. Gear of the National Archives brought the samples out. He flew out with them and brought them down with a couple of Federal guards, down to the laboratory, my laboratory at Irvine.

Mr. Wolf. All the samples you examined for this committee were obtained from the National Archives, is that correct?

Dr. Guinn. Yes.

Mr. Wolf. How many items were brought to you from the National Archives for you to first examine?

Dr. Guinn. There were 10 different specimens that had CE numbers and/or FBI Q numbers attached to them—10 different ones.

Mr. Wolf. Did you test all these 10 different items by neutron activation analysis?

Dr. Guinn. No. The first thing we did was for me to look over the samples to see if they were suitable for analysis—if there was anything left there to analyze for one thing, if an analyzable sample could be obtained. Three of them were not suitable.

Mr. Wolf. Which three items were not suitable for analysis?

Dr. Guinn. Let me just check so I can get the proper numbers for them. One was the so-called Dallas curbing sample.

Mr. Wolf. Is that FBI No. Q-609?

Dr. Guinn. Yes; the FBI number was Q-609. That was a piece of curbing that was cut away in Dealey Plaza because it appeared there was a smear that might be from a grazing bullet, and that was brought out to the laboratory. But after looking at it, it was quite apparent that there would be no way—it was just hardly a visible smudge. To get a sample removed from it, you would have to scrape it and you would end up with a sample that was mostly cement.

You might be able to detect a little antimony or something like that, but you could never relate it to a particular kind of bullet lead. This had been scraped before by FBI to take their samples for emission spectrography, and that is why practically nothing was left.

Mr. Wolf. What are the other samples that were not suitable for analysis?

Dr. GUNN. Another one was FBI Q-8, which has a Commission number, CE-569. That was reportedly a fragment recovered from the front seat of the Dallas limousine.

Mr. Wolf. Why was that not suitable for analysis?

Dr. GUNN. That was a sizable fragment, but it was only the jacket material. The lead that had been inside of it was all gone and, since I was trying to analyze bullet lead, not jacket material, there was nothing left in that one to analyze.

Mr. Wolf. The third item that was unsuitable for analysis was what?

Dr. GUNN. FBI Q-15, which also has CE No. 841. That was reportedly some very tiny particles scraped from the inside surface of the windshield of the Dallas limousine. Apparently in the previous FBI emission spectrographic examinations that little bit of material had been completely used up. We opened the container but we could find nothing in there, noting in there at all, even with magnification.

Mr. Wolf. Addressing the items you did analyze for the Committee, could you describe where the two items in what you have characterized as group 2 were found, Commission exhibit 573 and Commission exhibit 141?

Dr. GUNN. Yes, just for convenience of discussion I have grouped the seven specimens that were analyzed—that I did analyze—into these two groups. Group 2 consisted of just two specimens: FBI Q-8, which also has the Commission No. CE-141. That is what has been referred to recently here, too, as the complete, unfired Western Cartridge Co. 6½-millimeter cartridge reportedly found in the chamber of the Mannlicher-Carcano rifle found in the Texas School Depository Building on November 22, 1963.

Mr. Wolf. And Commission exhibit 573?

Dr. GUNN. Yes; Commission exhibit 573 is the other one, which has an FBI number of Q-188 also. It is a mashed bullet still in the jacket, and it is the one that was reportedly fired at Gen. Edwin Walker in April of 1963. I took samples of both of those, of the bullet lead, and analyzed them.

Mr. Wolf. Addressing the five evidence fragments which you examined in which you called group 1, all of which were allegedly found in or near the occupants of the President's limousine, could you give their Commission exhibit numbers and state where they were found, please?

Dr. GUNN. Yes; the first one would be Commission exhibit 399. That is the specimen often referred to as the pristine bullet, reportedly found on the stretcher at Parkland Memorial Hospital in Dallas that afternoon of November 22, 1963.

[Interruption from the floor.]

Chairman Stokes. The gentleman in the rear of the room is requested to remove himself from the room.

Counsel, you may proceed.

Mr. Wolf. Dr. Guinn, if we could again start with the items that we have placed in group 1 of the items, all found in or near the occupants of the President's limousine, and if you could give their Commission exhibit numbers and the location where they were allegedly found.

Dr. GUNN. The first of the five was CE-399. That is the so-called pristine bullet reportedly found on a stretcher at Parkland Memorial Hospital in Dallas. The second was Commission exhibit 567. That was a mashed large bullet fragment still in its jacket reportedly recovered from the front seat of the Dallas limousine.

The third one, CE-843, consisted of one larger fragment and one smaller fragment reportedly recovered from President Kennedy's brain at autopsy. The fourth one was CE-842, one larger fragment and two smaller ones reportedly recovered from Governor Connally's wrist during surgery. And the fifth one was CE-840, fragments reportedly recovered from the rear floor of the Dallas limousine.

Mr. Wolf. Was there any lead on any of the evidence samples in the National Archives on the clothing of Governor Connally or President Kennedy that you could subject to neutron activation analysis?

Dr. GUNN. Not so far as I am aware, and I did not analyze any materials from clothing at all, just these bullets or bullet fragments.

Mr. Wolf. In addition to the evidence samples, you also made radioactive known standards of three elements, is that correct?

Dr. GUNN. Yes, the normal procedure is to not only detect elements in sample; but to measure their concentrations quantitatively. To do this, you need to know, for one thing, the weight of the sample and, second, you have to compare the radioactivities that you observe in the activated samples with those from standard samples of known weights of the elements that you are detecting.

Mr. Wolf. And the three standards you used were one of copper, antimony, and silver, is that correct?

Dr. GUNN. That is correct.

Mr. Wolf. Mr. Chairman, I would ask at this time to show the witness what has been marked as "JFK exhibit No. F-328," which is a graph of the decay pattern of an antimony standard, and the decay pattern of Commission exhibit 843, reportedly a fragment recovered from President Kennedy's brain during the autopsy, after each had been activated in the nuclear reactor.

Dr. Guinn, did you prepare these graphs?

Dr. GUNN. Yes; I did.

Mr. Wolf. And addressing yourself to the lower of the two graphs, what does that graph illustrate?

Dr. GUNN. What it shows is the peak in the gamma-ray spectrum, the measured gamma-ray spectrum, from radioactive antimony, the radioisotope antimony 122. It has one principal gamma ray with a certain energy, 564,000 electron volts; and that means as we measure it, it should fall in a certain position, horizontally, on the spectrum.

What we see is just an enlarged small portion of the whole spectrum. You may note we have a channel number there and this enlarged portion only ranges from roughly channel Nos. 600 to 700. The entire spectrum goes all the way from channel 1 to channel 4,096. You can see this is just a small part, but any sample that has been activated and counted under these conditions antimony in measurable quantity should show a peak at exactly that location.

Mr. Wolf. And the lower graph, Dr. Guinn, is the graph of the known standard of antimony that was made radioactive, is that correct?

Dr. Guinn. That is correct.

Mr. Wolf. And what does the upper graph illustrate, which is the decay pattern of a fragment reportedly recovered from President Kennedy's brain during the autopsy?

Dr. Guinn. That shows the larger brain sample, which weighed, as it shows there—41.9 milligrams is the sample weight. It was irradiated in the reactor at the same time the standard was, for the same length of time; and then after some time of decay afterward, it was then counted under the same conditions, and you do see you get a peak at the same location—the size of the peak is different because the sample and standard don't have the same amount of antimony, but the location of the peak is the same. That tells us that that sample contains antimony.

Of course, in that spectrum, if you were to look at the entire spectrum, you would see other peaks due to copper and so on as well. But we are just looking at the antimony part of the spectrum here.

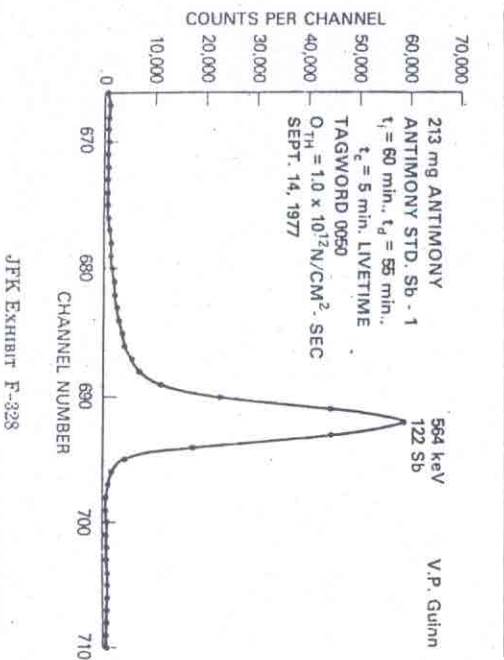
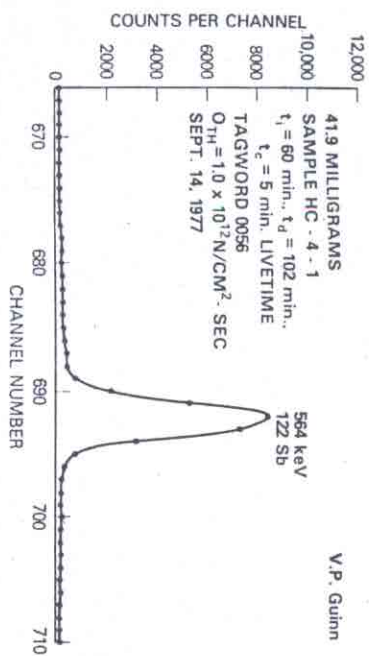
Mr. Wolf. What is the significance of the fact that the peak of the graph above is directly above the peak of the graph below?

Dr. Guinn. Well, falling in the same channel number means the gamma rays you are measuring have the same energy, within plus or minus about 1,000 electron volts, and that is what helps you identify it.

Mr. Wolf. Mr. Chairman, I would like JFK exhibit No. F-328 admitted into evidence at this point.

Chairman Stokes. Without objection, it may be entered into the record at this point.

[JFK exhibit No. F-328 was entered into the record.]



Mr. Wolf. Mr. Chairman, I would like to have shown to the witness what has been marked for identification as JFK exhibit 329, which is a photograph depicting the decay pattern of a silver standard and a photograph depicting the decay pattern of a fragment removed from President Kennedy's brain during the autopsy, after each had been activated in the nuclear reactor.

Dr. Guinn, the photograph at the bottom indicates the decay pattern of the known sample of silver, is that correct?

Dr. Guinn. That is correct.

Mr. Wolf. And what does the top graph depict?

Dr. Guinn. It is the same sample that you saw on the previous photograph, the 41.9 milligram sample of material removed from President Kennedy's brain, but activated this time under very different conditions, very rapidly, because we were looking for a very short lived isotope here, namely, the radioactive silver 110, which has a half life of only 24.4 seconds. That means it is rapidly disappearing by decay, dropping in half roughly every 24 seconds. So you must look at it very quickly to see it at all.

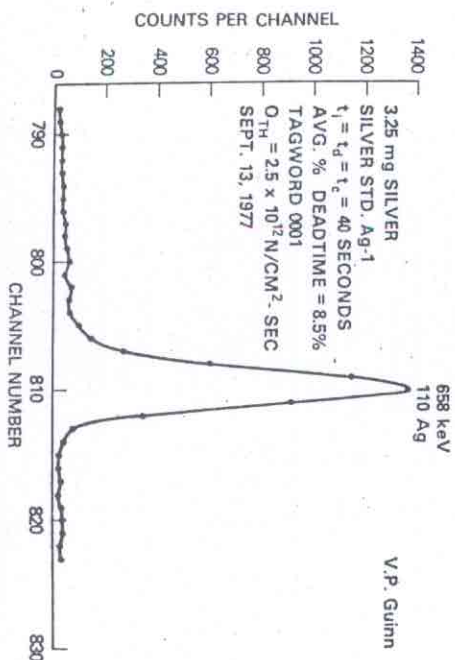
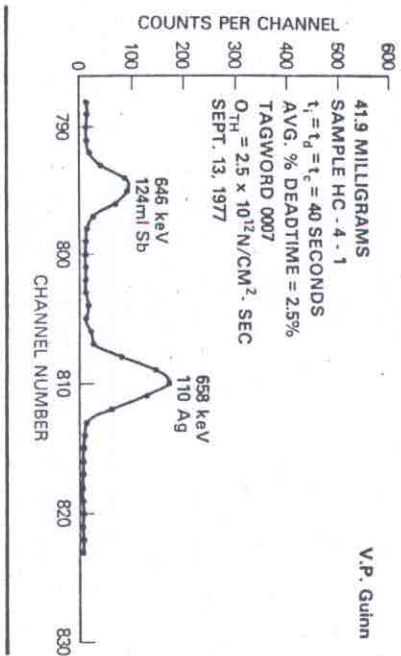
Mr. Wolf. How does the antimony on the photo peak on the right, JFK exhibit F-329, differ from the antimony on the photo peak on the upper left?

Dr. Guinn. I picked this one particularly to illustrate this point, that even with the high resolution germanium detector you will notice that close to the silver peak of the sample, but not of the silver standard, there is a little peak over to the left, and that is also from radioactive antimony, but it is from a different isotope with a different half life. That is antimony - 124 m, which has a gamma-ray energy of 646,000 electronvolts, which brings it close to the 658,000 electron-volt peak of silver - 110. Rather than use this smaller antimony - 124 m, peak, from the short irradiation, to measure the antimony contents quantitatively, I used the much larger peak of antimony - 122, from the longer irradiation, to obtain a more precise measurement. With silver there is really only one choice, the short-lived silver - 110.

Mr. Wolf. I would move that JFK exhibit F-329 be admitted into evidence.

Chairman Stokes. Without objection, it may be entered into the record.

[The above referred to JFK exhibit F-329 follows:]



JFK Exhibit F-329

Mr. Wolf. Dr. Guinn, I would now like to turn to some of the results of the analyses you performed for the committee and some of the conclusions you may have obtained.

Turning to the items in what you characterized as group 2, first, this consisted of the alleged bullet fired at General Walker and the unfired WCC Mannlicher-Carcano cartridge. Was the unfired WCC Mannlicher-Carcano cartridge similar to the previous WCC Mannlicher-Carcano cartridges you had tested?

Dr. Guinn. First of all, I am looking for the table here.

Would you repeat the question, please?

Mr. Wolf. Was the unfired WCC Mannlicher-Carcano cartridge that you tested similar to the previous ones you had tested independent of the work you did for this committee?

Dr. GUINN. Yes, sir; the key elements, the antimony and the silver, were in the same range as the other WCC Mannlicher-Carcano samples. The antimony was definitely down at the lower end and the silver was up at the upper end, but it was in the same general range.

Mr. WOLF. And what was the composition you found in your analysis of the Walker bullet fragment?

Dr. GUINN. About 17 parts per million antimony. Each value has a little uncertainty to it, but just stating the numbers, 17 parts per million antimony, and 20.6 parts per million silver, in the Walker bullet.

Mr. WOLF. Was this similar to the composition of the unfired WCC Mannlicher-Carcano cartridge?

Dr. GUINN. Yes, sir; the unfired WCC Mannlicher-Carcano cartridge which we took apart, took a little sample out of the lead, and put back together again, instead of 17 parts per million antimony it was 15, instead of 20.6 parts per million silver, it was 22.4. These are well within the ranges of slight variation that you get from within such materials.

Mr. WOLF. In your professional opinion, Dr. Guinn, is the fragment removed from General Walker's house a fragment from a WCC Mannlicher-Carcano bullet?

Dr. GUINN. I would say that it is extremely likely that it is, because there are very few, very few other ammunitions that would be in this range. I don't know of any that are specifically this close as these numbers indicate, but somewhere near them there are a few others, but essentially this is in the range that is rather characteristic of WCC Mannlicher-Carcano bullet lead.

Mr. WOLF. Turning to what has already been placed on the exhibit board and labeled at table 1 and marked for identification as JFK exhibit F-330, Dr. Guinn, was this chart prepared by you?

Dr. GUINN. Yes, it was.

Mr. WOLF. Does this chart represent the results you obtained during your tests of the evidence specimens?

Dr. GUINN. Yes, for these five evidence specimens, this chart lists all of the information obtained, even for a few traces of elements for which we find no real significance. But, for the sake of completeness they are all listed. There are some eight elements listed for each sample.

Mr. WOLF. I move that JFK exhibit No. F-330 be admitted into evidence.

Chairman STOKES. Without objection, it may be received.

[The above referred JFK exhibit No. F-330 follows:]

Table 1
RESULTS FROM SEPTEMBER 1977 INAA
OF EVIDENCE SPECIMENS AT U.C. IRVINE

Sample Number	FBI Q-1	HC-1	% Lead	Antimony ppm	Silver ppm	Copper ppm	Aluminum ppm	Manganese ppm	Sodium ppm	Chlorine ppm
399	1	101-3 ^b	833.9	7.9-1.4	58.3	ND ^c	0.09-0.02	5-1	19-12	
567	2	95-2	602.4	8.1-0.6	40.1	1.1-0.4	0.10-0.01	9-1	22-6	
843	4.5	91-2	621.4	7.9-0.5	40.2	5.5-0.7	0.10-0.01	134.3	59-10	
842	9	104-2	797.7	8.6-0.3	44.2	8.1-1.4	0.07-0.02	120.4	257-14	
840	14	94-2	638.4	8.6-0.3	44.2	2.7-0.6	0.08-0.01	13.1	38-7	
	14.2	103-2	647.4	7.9-0.5	42.2	2.4-0.5	0.05-0.01	19.1	40-8	

^a The absolute values shown for Al, Mn, Na and Cl are minimum values since these elements were not run, but table values used instead. However, this does not affect their relative values.

^b The 2 values shown for Pb, Sn, Cu, Sb, Ni, and Cr represent one standard deviation on three only on the counting statistics. They were calculated on the usual way of averaging and are the peak photometric counts and the counts in the underlying Compton continuum. For a normal distribution about 98% of the values observed in repetitive measurements should fall within the limits of the mean value ± 1.96 for Ag and Al which were measured twice on each sample; the 2 values shown for Fe calculated either from the counting statistics or from the trend of the two values on silver resulted in the larger value.

^c ND means none detected.

JFK EXHIBIT F-330

Mr. WOLF. Dr. Guinn, addressing your attention to the column labeled "percentage lead," what does this indicate?

Dr. GUINN. Lead is one of the elements that we can detect with activation analysis, but not with great sensitivity. However, if you have dealings with samples that are mostly lead, you don't need great sensitivity to at least detect it, et cetera, but even here the precision of measurement is not great, and if you look at the numbers you will see percent of lead is shown as plus or minus 2, plus or minus 3, or even plus or minus 4 percent. You will note that they all come out about in the range of 100.

All this really shows is that these metal fragments that we were looking at indeed were lead fragments, they weren't steel fragments, for example, or something else; they were lead.

Mr. WOLF. What does the PPM prior to the listing for each of the other elements indicate?

Dr. GUINN. PPM is just the abbreviation for parts per million by weight. One part per million is only one ten-thousandth of a percent.

Mr. WOLF. Dr. Guinn, based on these results, do you have an opinion as to what type of bullets these fragments were from?

Dr. GUINN. Once again, every one of these samples is in the same range, which is an unusual range, as the background WCC Mannlicher-Carcano samples that we have looked at from all four production lots. These five fall right in the midrange, in fact. They are not the highest; they are not the lowest of the antimony range, and the same is true of the silver.

Mr. WOLF. Is it your opinion then that these all are fragments from WCC Mannlicher-Carcano bullets?

Dr. GUINN. I think that is their most likely origin, yes.

Mr. WOLF. Looking at these results, can you determine how many bullets these evidence specimens came from?

Dr. GUINN. Yes, that is the really interesting part of this. I don't suppose people in back can see, or you up there can see, the numbers on the chart very well, but you have the report to look at. If you look at these five that are listed up here, and you first of all look at the prime or key element, which is antimony, you find of the five samples, that there are two of them that are up somewhere around 800 parts per million, and you find three others that are down just a shade over 600 parts per million.

Now, after each number there is shown a plus or minus. This is only the uncertainty of that particular measurement from what we call the counting statistics. That uncertainty we can measure.

Mr. WOLF. Dr. Guinn. Before we go into a more technical explanation, can you just from looking at the results, state what is the number of bullets that these evidence specimens came from?

Dr. GUINN. Yes, sir, I can.

Mr. WOLF. What is the number of bullets, in your opinion, Dr. GUINN. These numbers correspond to two bullets. Two of the samples have indistinguishable compositions, indicating that they came from the same bullet, and the other three particles are evidently samples from another bullet.

Mr. WOLF. So it is your opinion that the evidence specimens represent only evidence of two bullets, is that correct?

Dr. GUINN. Yes, sir, there is no evidence for three bullets, four bullets, or anything more than two, but there is clear evidence that there are two.

Mr. WOLF. And which specimens that correspond, respectively, of the two bullets?

Dr. GUINN. Using the CE numbers, the 399 specimen, which is the so-called stretcher or pristine bullet—it has various names—agrees in composition both in its antimony and its silver with CE-842, which are the fragments reportedly recovered from Governor Connally's wrist.

Mr. WOLF. Is it your testimony that CE-399 and CE-842, the so-called pristine bullet, and the fragments removed from Governor Connally's wrist during surgery, both came from the same bullet?

Dr. GUINN. Yes. One, of course, is almost a complete bullet so it means that the 842 fragments came from, in this case, the base of the bullet.

Mr. WOLF. Dr. Guinn, am I correct that technically you cannot today testify to the complete validity of the so-called single bullet theory because there was no lead left in the back wound of the President or around the President's throat that would allow you to examine it and, therefore possibly determine that CE-399 passed through the President?

Dr. GUINN. Yes, reportedly there were no lead fragments found in the back-to-throat wound of the President, and hence no specimens to be analyzed, so I know nothing about that particular wound.

Mr. WOLF. You can, however, today state for the first time scientifically that CE-399 did cause the injuries to Governor Connally's wrist?

Dr. GUINN. Yes sir, those two match so closely that I would say that such was the case.

Mr. WOLF. What is the degree of confidence and certainty with which you can state this conclusion?

Dr. GUINN. I wish that I could put a number on it, as we often can do, that is, calculate a probability, but we really don't have the background information to make a numerical calculation in this case. One can only show what information we do have, and that is that you simply do not find a wide variation in composition within individual WCC Mannlicher-Carcano bullets, but you do find wide composition differences from bullet to bullet for this kind of bullet lead. Thus, when you find two specimens that agree this closely, you can say it looks indeed like they are pieces from the same bullet.

Mr. WOLF. Would you state that your conclusion is more probable than not, highly probable, or what is the degree of certainty of your conclusion?

Dr. GUINN. I would say highly probable, yes. I would not want to say how high, whether it was 99 percent or 90 percent or 99.9 percent. I can't make a calculation like that.

Mr. WOLF. You would state it is highly probable that the injuries to Governor Connally's wrist came from the so-called pristine bullet?

Dr. GUINN. That is correct.

Mr. WOLF. Were you present yesterday during the testimony of Dr. Wecht?

Dr. GUINN. Yes, sir, I was.

Mr. WOLF. Did you hear Dr. Wecht testify, in response to questions from counsel, that in his opinion it was impossible for CE-399 to have caused the injury to Governor Connally's wrist, even if it hit nothing else, because CE-399 would have had to show more deformity?

Dr. GUINN. Yes. I heard him make that statement.

Mr. WOLF. Dr. Guinn, on the basis of your scientific analysis, do you believe Dr. Wecht to have been correct?

Dr. GUINN. Well, I think that is his opinion, but like many opinions and many theories, sometimes they don't agree with the facts.

Mr. WOLF. Dr. Guinn, have you prepared a report for the committee which completely describes your work for the committee and your conclusions?

Dr. GUINN. Yes, sir.

Mr. WOLF. Do you have that report with you?

Dr. GUINN. Yes, sir. It is right here.

Mr. WOLF. Mr. Chairman, I move that Dr. Guinn's report be marked as JFK exhibit No. F-331 and introduced into evidence. Chairman Stokes. Without objection it may be introduced at this point.

[The above referred to JFK exhibit F-331 follows.]

JFK Exhibit F-331

A REPORT TO THE HOUSE OF REPRESENTATIVES
SELECT COMMITTEE ON ASSASSINATIONS

on the subject of

1977 NEUTRON ACTIVATION ANALYSIS MEASUREMENTS

ON BULLET-LEAD SPECIMENS INVOLVED IN THE 1963 ASSASSINATION

OF PRESIDENT JOHN F. KENNEDY

by

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Vincent P. Quinn
Sept. 8, 1978

September, 1978

I. INTRODUCTION

This report is a presentation of the results obtained and their interpretation, in a September 12-14, 1977 instrumental neutron activation analysis (INAA) study of bullet-lead specimens involved in the November 22, 1963 assassination of President John F. Kennedy in Dallas, and of a specimen from a bullet allegedly fired at General Edwin Walker in April of 1963.

The author has been engaged in neutron activation analysis (NAA) research and applications for the past 20 years -- first, as Head of the Radiochemistry Section of the Shell Development Company, next (1962-1970) as Technical Director of the Activation Analysis Program at General Atomic, and (since early 1970) as Professor of Chemistry at the University of California at Irvine (UCI). The author's first studies of the application of the highly sensitive NAA method to problems in the field of scientific crime investigation commenced in early 1962, and continued steadily since that time, and his forensic activation analysis publications constitute 51 of his 181 publications, to date, in the field of radiochemistry/activation analysis. During the period, 1962-1970, his forensic NAA research was supported first by the U. S. Atomic Energy Commission and later jointly by the AEC and the Law Enforcement Assistance Administration (LEAA) of the U. S. Department of Justice. From this research came the NAA method for detection of gunshot residues that is now used by the FBI and many other law enforcement agencies around the

world, and extensive reports on the use of INAA for the trace-element characterization (as to probability of common origin) of such evidence-type materials as bullet lead, paint, paper, and oil.

NAA is a nuclear method of elemental analysis. It is a nuclear method of analyzing samples of all kinds of materials to determine the elements present in them. The samples to be analyzed are placed in small plastic vials, lowered into or near the core of a research-type nuclear reactor, and then bombarded with a very large number of slow neutrons (typically, about 10 trillion per second) for a selected period of time. When the samples are removed from the reactor, they are essentially unchanged in composition (and in most cases, in appearance), but they are now radioactive, since capture of a neutron by many of the atomic nuclei of many of the elements present in the samples has formed radioactive (unstable) nuclei of these elements. With or without (as needed) some chemical processing of the activated samples before counting, the samples are then counted on a gamma-ray spectrometer -- a sophisticated detector and electronic apparatus that measures the energies and numbers of the gamma rays emitted by each radioactive sample. The gamma-ray energies, observed as peaks in each spectrum, identify the various elements that have been made detectably radioactive, and the measured sizes of the peaks indicate the amounts of the elements present.

The principal advantages of the reactor neutron activation analysis method are (1) it can detect and accurately measure even very tiny amounts (typically, one billionth of a gram) and very low concentrations (e.g., one part per billion) of many elements in a sample, (2) it can utilize sample sizes ranging all the way from a tiny speck up to several grams, (3) it can simultaneously detect a number of elements in a sample, and (4) it can in many instances be carried out nondestructively. The main induced radioactivities are those that have rather short half lives (i.e., they decay away in a matter of seconds, minutes, or hours), and hence the analyzed samples soon become negligibly radioactive and hence can be handled with complete safety.

In previous extensive INAA studies of bullet-lead specimens (of many different calibers, manufacturers, and production lots), it was found that three key elements were almost always detectably present, but at widely different concentrations, depending upon the source of the bullet lead: antimony (Sb), silver (Ag), and copper (Cu). Antimony concentrations in the range of about 1 to 10 parts per million by weight (1 ppm = 0.0001%) are usually found in unhardened bullet lead, made with virgin lead, whereas levels in the range of about 0.4% to 4% Sb are found in commercial bullet leads that have been hardened by alloying Sb with the lead. Intermediate Sb levels (i.e., between about 10 ppm and perhaps

1500 ppm) are encountered in unhardened bullet lead in which some recycled lead is used, along with virgin lead, but in which no Sb has been deliberately added for hardening. Silver concentrations are usually found to lie in the range from about 0.5 ppm to 100 ppm, and the Ag appears to come in mainly as a natural impurity in the lead supply. Copper concentrations are usually found to lie in the range of about 5 ppm to 100 ppm, and the Cu also appears to come in mainly as a natural impurity in the lead supply. Of these three key elements, Cu is the one of least usefulness for comparisons, due to frequent occlusion of tiny bits of copper in the bullet lead coming from the copper jacket of jacketed bullets in the sampling, and from the brass cartridge or brass primer cap in the firing of the cartridge - producing occasional spuriously high Cu values.

Occasionally, the INAA of bullet-lead specimens also shows the presence of traces of certain other elements, such as aluminum, arsenic, manganese, tin, sodium, and chlorine. These elements, where detected, have generally not proved to be consistent enough to be useful for the characterization of bullet lead as to its origin. Sodium and chlorine, the constituents of common salt, appear to occur primarily as the result of external contamination.

In earlier INAA studies of bullet leads from many different manufacturers (See, references 4 and 5 in Appendix H), it was found that bullets from a given manufacturer and

production lot were generally quite uniform in their Sb and Ag concentrations, both within a given bullet and amongst bullets from the same box or production lot. Thus, for such typical ammunition it is generally not possible to distinguish amongst bullets, or bullet fragments, from the same box of cartridges.

However, when the author analyzed (See, Appendix C) quite a number of Western Cartridge Company Manlicher-Carcano 5.5 mm bullets, from their production lots 6000, 6001, 6002, and 6003 (the only four lots they produced of this type), this ammunition was found to differ sharply from typical bullet leads. Although individual bullets were found to be fairly homogeneous in their Sb and Ag concentrations, they differed greatly from bullet to bullet amongst samples taken from the same box. For example, the Ag levels in bullets from lot 6003 ranged from 7.9 ppm to 15.9 ppm, the Sb levels from 80 to 730 ppm (and the Cu levels from 17 to 62 ppm). This great variation from bullet to bullet from the same box thus indicated that, for this unusual kind of ammunition, it would be possible to distinguish one bullet (or bullet fragment) from another, even though they both came from the same box of Manlicher-Carcano cartridges.

II. PREPARATION OF THE SAMPLES FOR ANALYSIS

The analyses that are the subject of this report were conducted at the University of California at Irvine (UCI) during the period of September 12-14, 1977. In these measurements, eight elements were determined quantitatively, by the method of instrumental neutron activation analysis (INAA), using the thermal-neutron flux of the UCI research-type nuclear reactor for the activation of the samples, and the 38 cm³ Ge(Li)/4096-channel gamma-ray spectrometer at UCI for the counting of the activated samples. The eight elements measured in the samples were the following:

lead	aluminum
silver	manganese
antimony	sodium
copper	chlorine

The evidence specimens to be tested were removed from the U. S. National Archives, in Washington, D. C. by Mr. James L. Gear of the Archives staff. ^{1/} The evidence

1. The specimens were brought to California in secure containers by commercial airline. Except during the daytime periods of September 12, 13, and 14, 1977, when they were in the process of being sampled and analyzed, they were kept locked up at the Laguna Niguel, California, branch of the National Archives. During all of the operations on the evidence specimens carried out at UCI during the September 12-14, 1977 period, the specimens were accompanied by Mr. James Gear, of the National Archives, and by two Federal guards from Los Angeles. At the end of the day on September 14, 1977 all of the activated samples were returned to Mr. Gear.

specimens which are the subject of this report may be put in two groups. The first group are those reportedly found located in or near the occupants of the President's limousine, the limousine, or the area immediately surrounding it. The second group consists of a sample taken from the unfired cartridge reportedly found in the Texas School Book Depository Building on November 22, 1963, and a sample taken from the mashed bullet reportedly found in the home of General Edwin Walker, after he was reportedly fired upon in April of 1963. The evidence specimens consisted of the following:^{2/}

- GROUP I:
- (1) FBI no. Q609. Reportedly piece of curb from Dealey Plaza.
 - (2) FBI no. Q3 (CE-569). Reportedly a fragment recovered from the front seat of the Dallas limousine.
 - (3) FBI no. Q15 (CE-841). Reportedly particles scraped from the inside surface of the windshield of the Dallas limousine.
 - (4) FBI no. Q1 (CE-399). Whole bullet, still in its jacket, reportedly found on a stretcher at the Parkland Memorial Hospital in Dallas, on the afternoon of November 22, 1963.
 - (5) FBI no. Q2 (CE-567). Mashed large bullet

2. The CE-number is the number assigned by the Warren Commission as its exhibit numbers; the FBI Q number is the identification number assigned by the FBI Laboratory.

Fragment, still in its jacket, reportedly recovered from the front seat of the Dallas limousine.

- (6) FBI nos. Q4, 5 (CE-843). One larger fragment, and one smaller fragment, reportedly recovered from President Kennedy's brain at autopsy.
- (7) FBI no. Q9 (CE-842). One larger fragment, and two smaller ones, reportedly recovered from Governor Connally's wrist during surgery.
- (8) FBI no. Q14 (CE-840). Fragments reportedly recovered from the rear floor of the Dallas limousine.

Group II:

(9) FBI no. Q8 (CE-141). Complete unfired Western Cartridge Company 6.5 mm cartridge, reportedly found in the chamber of a Mannlicher-Carcano rifle found in the Texas School Book Depository Building (TSBD) on November 22, 1963.

(10) FBI no. 188 (CE-573). Mashed bullet, still in jacket, reportedly fired at General Walker in April, 1963.

The evidence specimens from the National Archives were inspected on September 12, 1977. Each specimen was examined to determine if it was suitable for INAA analysis. For a specimen to be suitable for analysis, it must contain in excess of one milligram of uncontaminated bullet lead. During the first inspection, it was determined that the

Dallas curbing sample (FBI no. Q609) was not suitable for INAA analysis. The slight gray smear on it had previously been scraped by the FBI Laboratory, and the scrapings analyzed by emission spectrography, in 1964. The amount of remaining metal (?) in the smear was too small for proper INAA measurements, and, further, any material scraped from the curbing would be too contaminated by cement material to yield any meaningful INAA results.

On September 13, 1977, the remaining evidence specimens were examined, one at a time, more closely, under magnification, to decide which ones were suitable for bullet-lead analysis by INAA. Two additional specimens were found to be unsuitable for analysis:

FBI no. Q3 (CE-569). Fragment reportedly recovered from the front seat of the Dallas limousine. This specimen consisted of only the copper bullet jacket, with no lead inside.

FBI no. Q15 (CE-841). Particles reportedly scraped from the inside surface of the windshield of the Dallas limousine. No particles were left in the specimen container received from the Archives. The particles probably were entirely consumed in the emission spectrographic analyses performed by the FBI Laboratory in 1963/1964.

The remaining evidence specimens were deemed suitable for INAA measurements, and were prepared for analysis on September 13, 1977, except for the CE-141, Q8 sample, which was prepared on September 14, 1977.

Samples of the suitable evidence specimens were then taken and prepared for analysis. Each sample was placed in a cleaned, labeled, weighed half-dram polyethylene vial, then weighed again to obtain the sample weight. For security reasons, each vial was labeled "HC-1", "HC-9", etc. the HC standing for "House Committee" and the number being the FBI Q number (except for the Walker bullet sample, which was labeled according to its CE number). Each sample, taken in its entirety, or a portion of a larger specimen cut off or drilled out, when necessary to obtain only bullet lead, was washed three times, alternately, with distilled/deionized water and Reagent Grade acetone, then air-dried before analysis. Deionized water was used to remove water-soluble salts; acetone was used to remove oil. Once the sample was placed in its polyethylene vial, the hinged vial cap was snapped tightly shut. Cutting, where necessary, was performed with a cleaned surgical scalpel. Drilling, where necessary, was performed from the center of the bullet base with a tiny (approximately 0.5 mm diameter) cleaned carbon-steel drill in a pin vise holder. Care was taken to avoid contamination of the bullet-lead sample by jacket material, and each sample was examined under magnification, to be sure that no visible jacket material was ad-

hering to the lead sample. In some instances, when more than one suitable sample could be obtained from the same specimen, two samples were taken for analysis from a given specimen (HC-1, 5; HC-8; HC-9 and HC-14). The two separate samples of a given specimen were then given an additional number, to distinguish them from one another (e.g., HC-9-1 and HC-9-2).

The samples taken for analysis are summarized below:

CE No.	FBI NO.	UCI NO.	Sample Wt. (mg)	Remarks
399	Q1	HC-1	10.7	Drillings from bullet.
367	Q2	HC-2	50.5	Piece cut from large fragment.
843	Q4, 5	HC-4-1	41.9	Single larger specimen.
		HC-4-2	5.4	Single smaller specimen.
842	Q9	HC-9-1	16.4	Single larger specimen.
		HC-9-2	1.3	Two tiny specimens.
840	Q14	HC-14-1	33.4	One single specimen.
		HC-14-2	33.8	Second single specimen.
573	Q188	HC-573	16.3	Drillings from specimen.
1413/	Q8	HC-8-1	24.3	Drillings from bullet.
		HC-8-2	6.3	Drillings from bullet.

3. Regarding the CE-141 (FBI Q8) sampling, a special die for 6.5 mm cartridges was purchased and then used on September 14, 1977, along with the UCI reloading equipment, to disassemble and later reassemble the CE-141 cartridge. The cartridge was first examined visually, with the following observations made: (1) the cartridge base was stamped "WCC 6.5 mm", (2) the entire cartridge case, and the bullet

As well as preparing the evidence samples, four sample standards, each, of silver, antimony, and copper were prepared on September 8 and 9, 1977 to be used in this test. Standard samples of the elements to be measured are necessary in order to convert the measured gamma-ray peaks quantitatively to micrograms of element present in a sample -- this is the usual comparator method. Samples and standards are activated and counted exactly the same way. Each silver standard contained 3.25 micrograms (μg) of silver, each antimony standard contained 213 micrograms of antimony, and each copper standard contained 192 micrograms of copper. Each standard consisted of 0.100 cm^3 of a freshly prepared aqueous solution, gently dried in the bottom of a half-dram polyethylene vial, and cemented down with a few drops of a 10% paraffin solution in carbon disulfide (allowed to dry at room temperature).

Jackets, were rather dark in color -- indicating external oxidation/sulfiding; (3) there was no firing-pin impression on the base, where the primer cup is located, indicating that the cartridge had never undergone even an attempted (abortive) firing. Upon disassembly, the bullet (projectile) part was found to be the same in shape, dimensions, weight, and single cannular as other Western Cartridge Company 5.5 mm Hamlichner-Carcano bullets from their production lots 6000, 5001, 6002, and 6003. The pristine jacketed bullet, before sampling, was found to weigh 10.4082 grams (160.62 grains). This compares closely with the nominal bullet weight of 161 grains quoted by the Western Cartridge Company. The gunpowder from the cartridge was also weighed, and found to be 2.8294 grams (43.66 grains), which agrees closely with the manufacturer's nominal value of 44 grains. After the two drilling samples were taken from the bullet (24.3 mg and 5.3 mg), the bullet was weighed, and found to now weigh 10.3774 grams (160.15 grains). The cartridge was then reassembled, with the gunpowder and sampled bullet back in place.

III.

THE ANALYSES OF THE SAMPLES AT UCI

On September 13, 1977⁴ each sample (except for samples HC-8-1 and HC-8-2) was activated twice and counted twice, under conditions optimized for the generation and detection of short-lived induced radioactive species.^{5/} With the UCI TRIGA MARK I nuclear reactor running steadily at full power (250 kilowatts), each sample, in its closed 1.3 cm^3 polyethylene vial, was irradiated for 40 seconds in the pneumatic-tube reactor core position (where the thermal-neutron flux is 2.5×10^{12} n/ cm^2 - sec), allowed to decay for 40 seconds (during which the activated sample was transferred to a fresh, labeled vial), and then counted for 40 seconds clockwise on top of a one-centimeter thick plastic beta-particle absorber on top of a 38 cubic-centimeter high-resolution coaxial lithium-drifted germanium (Ge(Li)) semiconductor gamma-ray detector, coupled to a 4096-channel pulse-height analyzer. During the counting of a sample,

1. Present during these tests were Dr. Guinn Michael Purcell, a laboratory assistant; Archivist James Gear; and two Federal guards.
5. Optimized conditions vary for each element. For element radioisotopes with a short half-life, a short irradiation time, a short decay time, and a short counting time provide optimized IVA detection conditions. For element radioisotopes with a long half-life, optimal conditions are a long irradiation time, a long decay time, and a long counting time.

The analyzer percentage deadtime was read from the deadtime meter at the beginning and at the end of the counting period. 6/ As soon as the counting of the sample was completed, its complete pulse-height spectrum was transferred twice to a fresh magnetic tape, identified by its tagword. The samples, and the standards of antimony, silver, and copper, were processed identically in this fashion, in succession, one at a time. Each sample and standard was then activated and counted a second time, under the same conditions.

On the following day (September 14, 1977) the samples and the standards of antimony and copper, and sample HC-8-1, were activated in the reactor again -- this time for one hour and all at the same time, each sample, in its 1.3 cm³ polyethylene vial, in a separate tube of the 40-tube rotary specimen rack of the reactor. At full power (230 kilowatts),

5. While the pulse-height analyzer is measuring the size of one electrical pulse from the Ga(Li) detector, to determine in which of the 4096 channels it should be stored as a count, the analyzer cannot accept another input pulse. This period is called "deadtime". In the analyzer circuitry, the percentage of the total clock-time that is deadtime is continuously monitored and displayed on a percent deadtime meter. The counts obtained during a given clocktime period are then corrected for this deadtime loss of counts by dividing the observed counts by (1 minus the average fractional deadtime) during the counting period. In order to avoid spectrum distortion, it is not advisable to use the counting data for really quantitative calculations if the deadtime during the counting period is greater than about 10%.

each sample in the rotary specimen rack is exposed to an average thermal-neutron flux of 1.0×10^{12} n/cm² - sec. During the first part of this one-hour irradiation, sample HC-8-2 and one each of the antimony, silver, and copper standards were activated in the pneumatic-tube reactor position (at a thermal-neutron flux of 2.5×10^{12} n/cm² - sec) and counted as in the measurements on the previous day: at irradiation, decay and counting times of 40 seconds each. The HC-8-2 sample was activated and counted twice. After the end of the one-hour irradiation, each sample and standard was removed from the rotary specimen rack, each sample transferred to a fresh labeled polyethylene vial, and then each counted for 300 seconds livetime on the Ga(Li)/4096-channel gamma-ray spectrometer as before. As before, also, each pulse-height spectrum was recorded twice on the magnetic tape, along with its identifying tagword. The time of day at which each count was started was noted -- for use in subsequent decay corrections.

At the beginning of the counting on each day, the energy scale was calibrated by means of the 661.6 keV gamma ray of cesium - 137 and the 1332.4 keV gamma ray of cobalt - 60. The energy calibration pulse-height spectra were also stored on the magnetic tape. The energy range covered was from 15 keV (channel 2) to 3277 keV (channel 4096).

On subsequent days, each recorded pulse-height spectrum was read back off the magnetic tape. Each spectrum

was scanned carefully on the expanded oscilloscope display, and the energy of each significant photoppeak observed was calculated and printed out on the typewriter, using the built-in PDP-8 computer. Each selected photoppeak of quantitative interest^{7/} was printed out, channel by channel, including the regions on each side of the peak. In the spectra from the pneumatic-tube measurements, the principal photoppeaks observed were the following:

1. the 658 keV peak of 24.4-second silver - 110.
2. the 498, 603, and 646 keV peaks of 93-second antimony - $124m_1$.
3. the 1039 keV peak of 5.10-minute copper - 66.

Smaller peaks due to 2.31-minute aluminum - 28 (at 1779 keV) and due to 66.9-minute lead - 204m (at 375, 899, and 912 keV) were also observed and printed out. The 564 keV peak of 2.80-day antimony - 122 and the 511 keV peak of 12.80-hour copper - 64 were observed, but not printed out.

In the spectra from the rotary-track measurements,

7. An oscilloscope is employed to visually display the pulse-height spectrum. Generally, the spectrum has the shape of a descending curve, upon which peaks are superimposed. Each element radioscope shows characteristic peaks of certain energies and of different sizes. A peak size measurement is made by measuring its area. A peak of the tested sample is later compared with the area of the corresponding peak of one of the known standard samples. The relative area of the peak from the tested sample compared to the area of the peak from the known standard indicates the total weight of the element within the tested sample. In some cases, there are overlaps of peaks of similar energies. Accordingly, the photoppeak measured for any given element is chosen considering two factors -- a large peak, and one which does not overlap with a peak of another element. Such a peak is a selected photoppeak of quantitative interest.

the principal photoppeaks observed were the following:

1. the 511 keV peak of 12.80-hour copper - 64.
2. the 564 keV peak of 2.80-day antimony - 122.

Smaller peaks due to 2.576-hour manganese - 56 (primarily at 847 keV), to 60.4-day antimony - 124 (primarily at 603 keV), to 14.96-hour sodium - 24 (at 1368 keV and 2754 keV), to 37.29-minute chlorine - 38 (at 1643 keV and 2168 keV), and to 66.9-minute lead - 204m (at 375, 899, and 912 keV) were also observed and printed out.

For all spectra, the counts in each channel of each selected photoppeak, and the counts in several channels on each side of each peak, were printed out. From these readouts, and those of the antimony, silver, and copper standards and the sample weights, the concentration of each of these three elements of particular interest (and the standard deviation of each, calculated from the counting statistics) was calculated from the pneumatic-tube data for 24.4-second silver - 110, 93-second antimony - $124m_1$ (via its 498 keV peak), and 5.10-minute copper - 66. From previous activations of lead standards, the concentration of lead in each sample was calculated from the sum of the photoppeak areas of the 375, 899, and 912 keV peaks of 66.9-minute lead - 204m. Using standard table values, the concentration of aluminum in each sample was calculated from the 1779 keV peak of 2.31-

minute aluminum - 28. In the calculations, small corrections were made for the average analyzer fractional deadtime during each counting.

Similarly, from the rotary-rack data, the concentration of antimony in each sample was calculated from the size of the 564 keV peak of 2.80-day antimony - 122, and the concentration of copper in each sample was calculated from the size of the 511 keV positron annihilation peak of 12.80-hour copper - 64. From the previous activation of lead standards, the concentration of lead in each sample was again calculated from the sum of the photopeak areas of the 375, 899, and 912 keV peaks of 66.9-minute lead - 204m (note: lead - 204m is a fast-neutron product of lead, rather than a thermal-neutron (n, γ) product, formed by the lead - 204 (n, n') lead - 204m reaction). Using standard table values, the concentration of manganese in each sample was calculated from the 847 keV peak of 2.576-hour manganese - 56, of sodium from the 1368 keV peak of 14.96-hour sodium - 24, and of chlorine from the 2168 keV peak of 37.29-minute chlorine - 38. All observed peak areas were, of course, corrected to the same decay time, by means of the radioisotope half-life and the time between the end of the rotary-rack irradiation and the start of the counting period of the sample.

IV. THE RESULTS OBTAINED IN THIS STUDY (1977)

The results obtained on the tested specimens for Group I are presented in Table I, Appendix B, and those for Group II in Table III, Appendix G. The Tables list the concentration found in weight percent for lead, and in parts-per-million by weight (ppm) for the elements antimony, silver, copper, aluminum, manganese, sodium, and chlorine -- eight elements in all.

The values shown for silver and aluminum were calculated from peak areas of 24.4-second silver - 110 (at 658 keV) and of 2.31-minute aluminum - 28 (at 1779 keV), respectively, in the pulse-height spectra from the 40-second pneumatic-tube activations. As noted earlier, these spectra also showed peaks due to antimony - 124m, copper - 66, and lead - 204m, but these three elements were determinable more exactly from the spectra obtained in the one-hour rotary-rack irradiation, and, hence the Table values for antimony (via the 564 keV peak of 2.80-day antimony - 122), copper (via the 511 keV peak of 12.80-hour copper - 64), and lead (via the three peaks of 66.9-minute lead - 204m) are those obtained from the rotary-rack irradiation. The results shown in the Tables for manganese, sodium, and chlorine are also from the rotary-rack irradiation.

Two of the very small samples analyzed (the 5.4 milligram HC-4-2 sample, and the 1.3 milligram HC-9-2 sample) had results within expected standard deviations to those obtained from the respective larger samples (the 41.9 milligram HC-4-1 sample, and the 16.4 milligram HC-9-1 sample), but the much more exact values obtained from the larger samples, only, are shown in the Tables.

In most cases, the \pm value shown after each value in the Tables represents the uncertainty of the value expressed as one standard deviation) computed only from the counting statistics. In general, the overall uncertainty of a given value may be in some cases as much as two or three times the standard deviation calculated just from the counting statistics. For silver and aluminum, which were measured twice on each sample, the \pm values shown represent one standard deviation calculated from either the counting statistics or the spread of the two values -- whichever was larger.

The ppm values shown in the Tables for antimony, silver, and copper were obtained, as mentioned earlier, by comparison with standard samples of these elements activated and counted along with the various evidence samples, and hence these values should be quite accurate. Similarly, the results for lead should be very reliable since they were based on

previously tested lead standards. For the remaining elements (aluminum, manganese, sodium, and chlorine), whose presence was not known in advance, as mentioned earlier, standards of these elements were thus not prepared at the time of these experiments. Instead, standard table values were used in the calculations for these elements. As a result, the reported ppm values for these four elements present in the evidence sample could be in error by a factor of perhaps two on an absolute scale. However, the use of tabulated standard values does not affect the relative values -- only the absolute values of a given element in the various samples.^{3/}

3. For example, if the estimated values for aluminum, based on standard tables, in two samples were 5.0±0.5 ppm and 2.5±0.3 ppm, the ratio of their aluminum concentrations would be 2.0 (±0.3) to 1. If the standard table value for aluminum were 20% high, for example, the true sample aluminum values would be 6.2±0.6 ppm and 3.1±0.3 ppm, respectively, but their ratio would still be 2.0 (±0.3) to 1.

V. CONCLUSIONS

- A. It is highly probable that the evidence specimens from Group I are all fragments from Mannlicher-Carcano bullets.
- As discussed in Appendix C, Mannlicher-Carcano ammunition displays very distinct characteristics when analyzed by neutron activation analysis. The ammunition displays an unusual range of concentrations for the antimony in bullet lead. The concentrations for silver are unusual as well, although not as distinct as those of antimony. Based upon these characteristics, and the results obtained from an analysis of the evidence specimens, it is highly probable that all the evidence specimens are fragments from Mannlicher-Carcano bullets. The antimony content of the evidence fragments is such that it is significantly higher than that found in most unhardened bullet lead examined by the author, and significantly lower than that found in bullet lead of hardened lead bullets examined by the author. Such an intermediate range of antimony concentrations is particularly characteristic of Mannlicher-Carcano ammunition. The values of silver found in the fragments also support the conclusion that the fragments are from Mannlicher-Carcano ammunition, as these values also are within the range characteristic of Mannlicher-Carcano ammunition.
- B. It is highly probable that the Walker bullet is a Mannlicher-Carcano bullet.
- The bullet fragment recovered from the home of

General Walker is apparently also from Mannlicher-Carcano ammunition. This sample (CE-573, FBI Q188) of a bullet fragment recovered from the home of General Walker in April of 1963 was analyzed by the FBI in late 1963, but only by the rather qualitative method of emission spectrography. They did not analyze it by neutron activation analysis. This sample was analyzed by INAA during the UCI analysis. It was determined that the bullet lead consisted of almost 100% lead, with only 17 ppm antimony and 20.6 ppm silver. (See Appendix G.) Its composition, therefore, is considerably different from any of the Dallas specimens -- which are also almost 100% lead, but contain much more antimony (602 to 833 ppm) and much less silver (7.9 to 9.8 ppm). However, the antimony content of the Walker bullet is close to the range of Sb values found earlier at UCI for Mannlicher-Carcano bullets from the four Western Cartridge Company production lots (24 to 1218 ppm), and also close to the range of Ag values found in such ammunition (6.0 to 15.9 ppm). Furthermore, the composition of the Walker bullet is very close to that of the unfired Mannlicher-Carcano cartridge reportedly recovered from the rifle found in the TSBD.

The unfired MC cartridge (CE-141, FBI Q8) was never before taken apart or analyzed. At UCI it was examined, taken apart, its several components weighed, the bullet lead sampled, the cartridge reassembled, and the two small bullet-lead samples taken from it analyzed by INAA. (See Appendix G.)

its composition (almost 100% lead, 15 ppm antimony, and 22.4 ppm silver) is extremely close to that of the Walker bullet and, consequently, supports the conclusion that the Walker fragment is from WC ammunition.

C. The results indicate the presence of only two bullets in Group I.

When the recent UCI results were analyzed statistically, taking into account both the overall reproducibility of the measurements on a single sample and the variability due to counting statistics of the individual measurements, evidence for the presence of only two bullets is found. Whereas, for most brands of ammunition it is not possible to distinguish between two bullets from cartridges from the same box/production lot, earlier studies by the author on Western Cartridge Company Mannlicher-Carcano 5.5 mm bullets have shown that this brand (lots 6000, 6001, 6002, 6003) exhibits widely different antimony values, even amongst bullets from a given lot, so that individual bullets of this brand can usually be distinguished from one another. (See Appendix C.)

The presence of only two bullets is indicated as follows:

- Q1 (Secretary bullet) and Q9 (fragments from Connally's wrist) match one another within one standard deviation in both antimony and silver.
- Q4, 5 (fragments from President Kennedy's brain), Q2 (large fragment found in car), and Q14

(smaller fragments found in car) match one another within one standard deviation in both antimony and silver.

- Q1, although similar in silver content, is markedly different in antimony content from Q2, Q4, 5, and Q14.
- Q9 differs considerably from Q2, Q4, 5, and Q14 in both antimony and silver.

These results therefore indicate the presence of only two bullets: (Q1 and Q9 one bullet) and (Q2, Q4, 5, and Q14 a second bullet). There is no evidence of a third bullet.^{9/}

The analyses not only resulted in values for silver and antimony in the various samples, but also in values for six additional elements: lead, copper, aluminum, manganese, sodium and chlorine. The values for these additional six elements do not appear to contribute much useful information -- except to confirm, quantitatively, that all the samples are approximately 100% lead. With the exception of Q9, all the

9. Independent research conducted by the author (See Reference Number 10 in Appendix H.) indicates that a careful analysis of the data obtained by the FBI during the INRA tests conducted by the FBI in 1964 (using a scintillation detector rather than the higher-resolution modern Ge(Li) detector) would reach this same conclusion. The FBI reported the results of its tests as inconclusive due to the wide variety of absolute values obtained each time a sample was tested. These results, however, were under differing test conditions. It is necessary to compare the results obtained under a given set of conditions, rather than a comparison of all the values under all conditions, to reach the conclusion that only two bullets were present.

copper values were approximately the same -- in the range of 40 to 58 ppm. The very high copper value of the Q9 sample (994 ppm) is most likely due to contamination from the copper jacket of the bullet. The copper values for samples Q4, 5, Q2, and Q14 average 42 ± 2 ppm -- appreciably different from the Q1 (stretcher bullet) copper value of 58 ± 3 ppm. The aluminum values range from 1.1 to 3.1 ppm and show no systematic trends between the two groups of samples. Similarly, the manganese values range from 0.01 to 0.10 ppm and show no systematic behavior. The sodium values show a wide range, from 5 to 134 ppm, and the chlorine values also show a wide range, from 19 to 257 ppm -- in both cases with no evidence of any trends. Even though all the samples were washed three times with pure water and pure acetone, to free them of any salt (sodium chloride) possibly accumulated on the exteriors of the samples from previous exposures to the air and/or possible handling by fingers (perspiration), it cannot be ruled out that some slight and variable amounts of salt contamination were still present in some of the samples. It might be significant that the two samples that show the highest levels of sodium and chlorine are samples Q4, 5 (President Kennedy's brain) and Q9 (Governor Connally's wrist) -- the only two samples that were recovered from biological tissue. It is barely possible that these samples, in spite of the washing, still contained a small but significant amount of dried body fluid (e.g., blood), which would

increase the levels of sodium and chlorine in the samples. The other samples exhibited much lower levels of sodium (only 5 to 19 ppm) and of chlorine (only 19 to 40 ppm).

Accordingly, neutron activation analysis of the evidence specimens tested indicates the presence of only two bullets in Group I. It is highly probable that the specimen tested from Q1 (the stretcher bullet) and the specimen tested from Q9 (the fragments from Governor Connally's wrist) are from the same bullet. It is highly probable that Q2 (large fragment found in the limousine), Q4 and 5 (fragments from President Kennedy's brain) and Q14 (smaller fragments found in limousine) are all from a second bullet. There is no evidence of a third bullet from any of the evidence specimens tested.

10. More recent very detailed IMAA studies made at UCI (See reference 11 in Appendix H) on 10 samples from each of 16 Mannlicher-Carcano bullets -- 4 from each of the 4 production lots -- give a more complete picture of the generally high degree of homogeneity of individual bullets and the wide variation from bullet to bullet, regardless of lot number, of the antimony concentration in particular, the appreciable variation of the silver concentration, and the lesser variation of the copper concentration. However, the earlier data and these more recent data do show some Mannlicher-Carcano bullets that cannot be distinguished from one another via only their antimony and silver concentrations. From these data, it appears that if 2 cartridges are removed at random from a box of Mannlicher-Carcano cartridges, although it is highly probable that they would differ significantly in their antimony and silver concentrations, it is at least possible that they might not.

APPENDIX A
LIST OF ABBREVIATIONS AND SYMBOLS

UCI	University of California at Irvine, or U.C. Irvine.
FBI	(U.S.) Federal Bureau of Investigation.
MC	Mannlicher-Carcano.
Sb	Chemical symbol for the element, antimony.
Ag	Chemical symbol for the element, silver.
Cu	Chemical symbol for the element, copper.
Pb	Chemical symbol for the element, lead.
Al	Chemical symbol for the element, aluminum.
Mn	Chemical symbol for the element, manganese.
Na	Chemical symbol for the element, sodium.
Cl	Chemical symbol for the element, chlorine.
122 _{Sb}	Symbol for the antimony radioisotope of mass number 122. (half life of 2.80 days), antimony - 122.
124 _{m1Sb}	Symbol for the metastable antimony radioisotope of mass number 124 (half life of 93 seconds), antimony - 124 _{m1} .
124 _{Sb}	Symbol for the antimony radioisotope of mass number 124 (half life of 60.4 days), antimony - 124.
110 _{Ag}	Symbol for the silver radioisotope of mass number 110 (half life of 24.4 seconds), silver - 110.
64 _{Cu}	Symbol for the copper radioisotope of mass number 64 (half life of 12.80 hours), copper - 64.
66 _{Cu}	Symbol for the copper radioisotope of mass number 66 (half life of 5.10 minutes), copper - 66.
204 _{mPb}	Symbol for the metastable lead radioisotope of mass number 204 (half life of 66.9 minutes), lead - 204 _m .
28 _{Al}	Symbol for the aluminum radioisotope of mass number 28 (half life of 2.31 minutes), aluminum - 28.
56 _{Mn}	Symbol for the manganese radioisotope of mass number 56 (half life of 2.576 hours), manganese - 56.
24 _{Na}	Symbol for the sodium radioisotope of mass number 24 (half life of 14.96 hours), sodium - 24.
38 _{Cl}	Symbol for the chlorine radioisotope of mass number 38 (half life of 37.29 minutes), chlorine - 38.
NAA	Neutron activation analysis.
INAA	Instrumental neutron activation analysis.
CE	Abbreviation for (Warren) "Commission Exhibit".

HC	Sample designation abbreviation used at UCI, referring to "House Committee".	Std. dev.	Abbreviation for standard deviation, a statistical measure of precision (also abbreviated as σ or s).
cm ³	Abbreviation for cubic centimeter, a metric unit of volume (one cubic inch equals 16.4 cm ³).	cm	Abbreviation for centimeter, a metric unit of length (one inch equals 2.54 cm; one cm equals 10 mm).
Ge(Li)	Abbreviation for a lithium-drifted germanium semiconductor gamma-ray detector.		
mm	Abbreviation for millimeter, a metric unit of length (one inch equals 25.4 mm).		
mg	Abbreviation for milligram, a metric unit of mass or weight (one gram equals 1000 mg.).		
g	Abbreviation for gram, a metric unit of mass or weight (one ounce equals 28.3 g).		
μ g	Abbreviation for microgram, a metric unit of mass or weight (one gram equals one million μ g).		
n	Abbreviation for neutron, a fundamental particle that is a constituent of atomic nuclei.		
cm ²	Abbreviation for square centimeter, a metric unit of area (one square inch equals 6.45 cm ²).		
keV	Abbreviation for one thousand electron volts of energy.		
γ	Abbreviation for gamma, as in gamma ray (γ -ray).		
ppm	Abbreviation for parts-per-million by weight (one ppm equals one μ g of constituent per gram of material).		

APPENDIX B

TABLE I

RESULTS FROM SEPTEMBER 1977 INAA OF EVIDENCE SPECIMENS AT U.C. IRVINE

Sample Number			% Lead	ppm Antimony	ppm Silver	ppm Copper	ppm Aluminum ^a	ppm Manganese ^a	ppm Sodium ^a	ppm Chlorine ^a
CE-	FBI Q-	HC-	101±4 ^b	833±9	7.9±1.4	58±3	ND ^c	0.09±0.02	5±1	19±12
399	1	1	95±2	602±4	8.1±0.6	40±1	1.1±0.4	0.01±0.01	9±1	22±6
567	2	2	95±2	621±4	7.9±0.3	40±2	5.5±0.7	0.10±0.01	134±3	59±10
843	4,5	4-1	104±2	797±7	9.8±0.5	994±7	8.1±1.4	0.07±0.02	120±4	257±14
842	9	9-1	94±2	638±4	8.6±0.3	44±2	2.7±0.6	0.06±0.01	13±1	38±7
840	14	14-1	103±2	647±4	7.9±0.5	42±2	2.4±0.5	0.05±0.01	19±1	40±8

^a The absolute values shown for Al, Mn, Na and Cl are approximate values, since standards of these elements were not run, but table values used instead. However, this does not affect their relative values.

^b The ± values shown for Pb, Sb, Cu, Mn, Na, and Cl represent one standard deviation, based only on the counting statistics. They were calculated in the usual way, taking into account the gross photopeak counts and the counts in the underlying Compton continuum. For a normal distribution, about 68% of the values observed in repetitive measurements should fall within the limits of the mean value ± 1σ. For Ag and Al, which were measured twice on each sample, the ± value shown is 1σ calculated either from the counting statistics or from the spread of the two values, whichever resulted in the larger values.

^c ND means none detected.

538

539

APPENDIX C
BACKGROUND DATA ON MANNLICHER-CARCANO
AMMUNITION

During 1964, Dr. John Nichols obtained boxes of Western Cartridge Company Mannlicher-Carcano 6.5 mm cartridges from the four different production lots of this ammunition that they produced: lots 6000, 6001, 6002, and 6003. According to the Western Cartridge Company, these production lots of this ammunition were of one million rounds each, all produced in 1954 for the U. S. Army. Each cartridge contained an average of 44 grains (2.85 grams) of a special blend of Western Ball Powder. The lead cores of the bullets weighed 110 grains (7.13 grams), had a diameter of 5.31 mm and a length of 26.2 mm, and consisted of #0 soft lead (99.85% pure). The bullet jacket weighed 51 grains (3.3 grams), had a side wall thickness of 0.56 mm, and consisted of CDA No. 220 Commercial bronze (90% copper, 10% zinc). The primer cup was made of CDA alloy no. 260 cartridge brass (70% copper, 30% zinc), and its main components were 37% lead stannate, 32% barium nitrate, 15% antimony sulfide, 7% aluminum powder, 5% PETN, and 4% tetracene. Dr. Nichols used some of this ammunition in various test firings

that he conducted with a Mannlicher-Carcano rifle of the same make as that reportedly used by Lee Harvey Oswald. Late in 1972, Dr. Nichols contacted the author, offering to supply bullet-lead samples from the four production lots, for NAA examination by the author. The author accepted the offer, and Dr. Nichols shortly sent him two bullets from lot 6000 and four each from lots 6001, 6002, and 6003. The author commenced analysis of these in late 1973 with most of the work carried out during 1974 and a few final measurements early in 1975.

Samples ranging in weight from 44 to 58 milligrams (each weighed to within ± 0.1 milligram) were drilled out from the open base end of each bullet with a cleaned small steel drill, after first scraping the surface of the bullet face free of oxidized layer with a clean stainless-steel scalpel. Each drilled sample was washed with high-purity toluene, to remove any oil or grease possibly present.

In the first analyses, all 14 samples, along with a standard of antimony, were activated for 2 hours in the rotary-specimen rack of the UCI TRIGA Mark I reactor, at a thermal-neutron flux of 1.0×10^{12} n/cm²-sec. After

a decay period of approximately 24 hours, each activated sample was counted for 200 seconds livetime on top of a 38 cm³ Ge(Li) detector (with a 1 cm beta-particle absorber), coupled to a 4096-channel pulse-height analyzer.

The only photopeaks observed were those of 12.80-hour ⁶⁴Cu, 2.80-day ¹²²Sb, 60.4-day ¹²⁴Sb, and 14.96-hour ²⁴Na. The counts in the 511 keV peak of ⁶⁴Cu, in the 564 keV peak of ¹²²Sb, and in the 1368 keV peak of ²⁴Na were printed out. After correcting all of the data to the same decay time, the number of micrograms of copper (Cu), antimony (Sb), and sodium (Na) in each sample was calculated, along with its standard deviation -- calculated from the counting statistics. Dividing each μ g value by the sample weight, in grams, then gave the ppm concentrations. The Cu and Na values were calculated from tabulated standard values. These are tabulated in Table II-A.

Later, after the previously-induced activities had decayed down to negligible levels, the 14 samples were activated and counted again, under different conditions. This time, the samples were activated and counted in sequence, one at a time. Each sample was activated for 40 seconds in the pneumatic-tube position of the reactor, at a thermal-neutron flux of 2.5×10^{12} n/cm²-sec. After a

decay period of 40 seconds (during which the activated sample was transferred to a fresh vial), each sample was counted for 40 seconds clocktime under the same counting conditions used in the previous measurements. In the subsequent calculations, a small correction was made for the average analyzer deadtime during each counting. The principal induced activities observed in the pulse-height spectra were those of 24.4-second ^{110}Ag (658 keV γ), 5.10-minute ^{66}Cu (1039 keV γ), and 93-second ^{124}mSb (498, 603, and 646 keV γ 's), although the 12.80 hour ^{64}Cu (511 keV γ) and 2.30-day ^{122}Sb (564 keV γ) activities were also observed, as well as very small peaks due to 66.9-minute ^{204}mpb (375, 899, and 912 keV's). Standards of silver, antimony, and copper were then activated and counted under the same conditions, but at a thermal-neutron flux only 1/100 as large. Microgram and ppm values for Ag, Sb, and Cu were then calculated for each sample (along with its standard deviation, based upon the counting statistics) from the sizes of the 658 keV peak of 24.4-second ^{110}Ag , the 498 keV peak of 93-second ^{124}mSb , and the 1039 keV peak of 5.10-minute ^{66}Cu . The silver results are also included in Table II-A.

The new antimony results (from ^{124}mSb) and the new copper results (from ^{66}Cu) in all cases compared well with the results for these two elements obtained in the previous longer irradiation (with measurement, instead, of ^{122}Sb and ^{64}Cu). However, the counting statistics (precisions) of the ^{122}Sb and ^{64}Cu results from the longer irradiation were much better than those of the ^{124}mSb and ^{64}Cu results from the 40-second irradiations, so only the ^{122}Sb and ^{64}Cu results are given in Table II-A.

The antimony results obtained, shown in Table II-A, were surprising. In all earlier studies of commercial bullet leads, individual bullets were found to be quite homogeneous in their antimony concentrations, and bullets from the same box of cartridges were found to be closely similar to one another in their antimony concentrations. In sharp contrast, the bullet-to-bullet variation in antimony content amongst bullets from the same box of Mannlicher-Carcano cartridges is seen to be tremendous: the four samples of lot 6001 bullet lead ranged all the way from 158 ppm to 1218 ppm Sb; those of lot 6002 bullet lead all the way from 24 to 949 ppm Sb; and those of lot 6003 all the way from 80 to 730 ppm Sb. In general, such antimony values indicate that (1) the bullets were indeed a soft

lead, since bullet lead deliberately hardened by alloying the lead with antimony requires the addition of anywhere from about 0.4% (4000 ppm) Sb up to several percent. (2) no effort was made by the manufacturer to control the antimony content of the bullet lead, so long as it was much less than 4000 ppm, and (3) the high degree of Sb variability during a production run indicates that the lead supply was of mixed sources, apparently containing an appreciable amount of scrap lead (some of which is antimony-hardened lead), since virgin lead seldom contains more than 10-20 ppm Sb.

From a great deal of earlier work on the INAA of bullet-lead samples for Ag, Sb, and Cu, it had been established that the method itself was highly reproducible, approximately to within the limits imposed by the counting statistics, for any individual sample. To prove this point, however, two individual specimens (6001 B and 6002 B) were each analyzed four times, for Ag, Sb, and Cu, under the pneumatic-tube conditions. As can be seen from the results, shown in Table II-B, the reproducibility for a given sample is indeed quite satisfactory. After each ppm value is shown its standard deviation, based upon its counting statistics. The t value shown after each

mean value, however, is the standard deviation of the set of four values, calculated from the deviations of the values from the mean value. It can be seen that the standard deviation shown with the mean value is generally fairly close to the counting-statistics standard deviation of an individual measurement.

To study the degree of homogeneity of individual Mannlicher-Carcano bullets, four samples of bullet lead were analyzed from each of three individual bullets (bullets 6001 C, 6002 A, and 6003 A). The larger drillings obtained from each of these three bullets (which were made approximately down the longitudinal axis of each bullet) were cut into four pieces -- one of which was the specimen analyzed earlier. These samples were then analyzed for Ag, Sb, and Cu under the same pneumatic-tube conditions used before. The results are shown in Table II-C. As can be seen, of the three bullets sampled, one (6001 C) is fairly homogeneous in all three elements; one (6002 A) is fairly homogeneous in Ag and Cu, but not so homogeneous in Sb; and one (6003 A) is fairly homogeneous in Cu, but not homogeneous in Sb or Ag. However, comparison of Table II-C with Table II-A indicates that, in general, the

heterogeneity within an individual Mannlicher-Carcano bullet is much less than the heterogeneity from one bullet to another. One of the primary conclusions, therefore, of the results of the UCI background study of WC bullet lead indicates a wide range of Sb values, from bullet to bullet, but reasonable homogeneity within an individual bullet.

APPENDIX D
TABLE II-A

THE TRACE-ELEMENT COMPOSITION OF MANNLICHER-CARCANO 6.5 mm BULLET
LEADS FROM LOTS 6000, 6001, 6002, AND 6003
(INAA results obtained by V.P. Guinn during 1973-1975)

Lot No.	Bullet Sample No.	Bullet Sample We. (mg)	Ppm Element Found, and Standard Deviation in Ppm*			
			Silver	Antimony	Copper	Sodium
6000	A	51.2	11.8±0.4	173±3	372±6	13±1
	B	45.6	13.5±0.5	261±3	167±4	15±1
	A	47.8	12.2±0.6	158±3	(2766±16)**	13±1
	B	57.9	15.3±0.5	732±5	23±2	13±1
6001	C	58.5	8.5±0.4	1218±7	48±2	15±1
	D	47.2	11.6±0.4	161±3	147±4	17±1
	A	51.8	9.1±0.4	385±4	30±2	12±1
	B	52.8	9.7±0.4	949±6	25±2	12±1
6002	C	55.3	6.0±0.3	24±1	120±3	15±1
	D	51.3	8.3±0.6	121±2	(4516±21)**	13±1
	A	54.3	15.9±0.5	730±5	21±2	12±1
	B	44.6	7.9±0.4	80±2	62±2	20±2
6003	C	44.7	8.8±0.4	464±5	36±2	17±1
	D	44.0	8.7±0.4	240±3	17±2	15±1

* One standard deviation, based only upon the counting-statistics standard deviation of a single measurement.

** These two copper values are extremely high. It may be that these two samples were contaminated with jacket material during the drilling out of the sample.

APPENDIX E
TABLE II-B

REPRODUCIBILITY MEASUREMENTS ON TWO INDIVIDUAL SPECIMENS OF
MANNLICHER-CARCANO BULLET LEAD (MADE BY V.P. GUINN, PNEUMATIC-
TUBE CONDITIONS).

Specimen	Measurement No.	Ppm Element Found + One Standard Deviation*		
		Antimony	Silver	Copper
6001B (57.3mg)	1	621±56	15.3±0.5	19±10
	2	646±55	16.6±0.4	19±4
	3	646±55	13.9±0.4	18±5
	4	791±55	15.0±0.4	20±5
mean:		676±78	15.2±1.1	18.5±1.3
6002B (52.8mg)	1	990±60	9.7±0.4	16±10
	2	1007±56	10.1±0.4	10±5
	3	942±56	9.8±0.4	24±5
	4	946±56	10.7±0.4	24±5
mean:		971±32	10.1±0.5	18.5±6.8

* Standard deviation of individual measurements based upon counting statistics only. Standard deviation shown with mean values based upon the spread of the four individual measurements.

APPENDIX F
TABLE II-C

HOMOGENEITY MEASUREMENTS ON FOUR SPECIMENS FROM EACH OF THREE
INDIVIDUAL MANNLICHER-CARCANO BULLETS (MADE BY V.P. GUINN,
PNEUMATIC-TUBE CONDITIONS)

Production Lot	Specimen	Ppm Element Found + One Standard Deviation*		
		Antimony	Silver	Copper
6001	6001C	1139±60	8.5±0.4	67±11
	6001C1	1062±60	9.5±0.4 (391±17)**	
	6001C2	1235±93	10.1±0.6	20±7
	6001C3	1156±90	9.2±0.5	23±10
mean:		1148±71	9.3±0.7	37±26
6002	6002A	358±47	9.1±0.4	45±11
	6002A1	983±51	10.3±0.3	34±5
	6002A2	869±47	9.9±0.3	58±6
	6002A3	882±81	10.2±0.5	30±8
mean:		773±281	9.9±0.5	42±13
6003	6003A	667±58	13.9±0.5	27±10
	6003A1	395±54	9.6±0.4	28±6
	6003A2	363±39	8.3±0.3 (257±12)**	
	6003A3	441±51	9.8±0.4	16±5
mean:		466±137	10.9±3.4	24±7

* Standard deviation of individual measurements based upon counting statistics only. Standard deviation shown with mean values based upon the spread of the four (or three) individual measurements.

** These two copper values excluded from the means as probably due to contamination from the bullet jackets.

APPENDIX G

TABLE III

RESULTS FROM SEPTEMBER 1977 INAA OF ANALYSIS OF WALKER BULLET FRAGMENT AND UNFIRED
MC CARTRIDGE AT U. C. IRVINE

	Sample Number		MC-	%Lead	ppm Antimony	ppm Silver	ppm Copper	ppm Aluminum	ppm Manganese	ppm Sodium	ppm Chlorine
	CE-	FBI Q-									
Walker Bullet Fragment	573	188	573	100+2	17+2	20.6+0.6	100+3	32+3	0.24+0.02	39+3	102+11
Unfired MC Cartridge	141	8	8-1	107+2	15+1	--	22+1	--	0.01+0.01	3+1	15+6
			8-2	--	--	22.4+1.0	--	ND	--	--	--

550

(The + values shown represent one standard deviation, based only on the counting statistics.)

551

APPENDIX H

REFERENCES ON THE INAA OF BULLET LEAD

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5. H. R. Lukens and V. P. Guinn, "Comparison of Bullet-Lead Specimens by Nondestructive Neutron Activation Analysis", J. Forensic Sciences, 16 (1971) 301-308.
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7. V. P. Guinn and M. A. Purcell, "A Very Rapid Instrumental Neutron Activation Analysis Method for the Forensic Comparison of Bullet-Lead Specimens", J. Radioanal.

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10. V. P. Guinn and J. Nichols, "Neutron Activation Analysis of Bullet-Lead Specimens: The President Kennedy Assassination", Trans. Amer. Nucl. Soc., 28 (1978) 92-93.
11. V. P. Guinn, T. Izak-Siran, and M. A. Purcell, "Detailed Measurements of Homogeneity of Mannlicher-Carcano Bullets," to be submitted for publication.

Mr. Wolf. Mr. Chairman, I have no further questions of Dr. Guinn.

Chairman Stokes. The Chair now recognizes the gentleman from Indiana, Mr. Ftynian, for such time as he may consume.

Mr. Ftynian. Thank you, Mr. Chairman.

Dr. Guinn, we are happy to have your expertise assisting the panel. I am holding in my hand a lead pencil, and I have now broken the point from this lead pencil. Would you tell me is this enough for you to analyze by your process?

Dr. Guinn. Well, that is a different kind of material.

Mr. Ftynian. I know.

Dr. Guinn. It is called pencil lead, but it is actually graphite—not lead.

Mr. Ftynian. Sizewise?

Dr. Guinn. Sizewise, that is plenty. For materials such a bullet lead, to be specific, any sample that weighs anywhere between 1 and 50 milligrams is sufficient or plenty. Such an amount represents a rather tiny sample of lead, but it is all we need.

Mr. Ftynian. Now, if this were not graphite, and if it were bullet lead, and it contained a variety of these elements that you have described here today, antimony, silver, and so forth, would your neutron activation analysis sort out the count sufficiently accurately to tell us which elements are in that particle?

Dr. Guinn. It won't tell you all the elements that may be in them, but it will usually give you numerical results for a number of elements that will become detectably radioactive and readily identified; yes.

Mr. Ftynian. As I understand it, this is from one pass through the equipment, simultaneously you read out several different elements?

Dr. Guinn. That is true. Usually when you activate a sample for a certain length of time in the reactor, wait a while, and then count the sample, you see peaks from a number of radioactive elements. Then if you take the same sample, if you wish, and do it over again, but this time irradiate longer and wait longer, then all of the isotopes you saw before you won't see this time because you have waited long enough that they are all gone, and now you will see some long-lived isotopes that were not there detectably before but now they are.

So you don't usually just do an activation and a count once, but you usually do it two or three times, if you are trying to look for a large number of elements.

Mr. Ftynian. You used the term counting equipment. Could you explain that for those of us who are laymen in this?

Dr. Guinn. There are many kinds of radioactive detection devices which are usually loosely called counters. The most common one most people know about is a Geiger counter. If these same samples, after activating them, had been held near a Geiger counter, you would hear the Geiger counter ticking away. Unfortunately, the Geiger counter is, No. 1, not very sensitive for gamma radiation, and, No. 2, it can't tell one gamma ray from another. You have to go to a more elaborate detector. The kind, for example, that was used by the FBI in 1964, which was the only useful kind that was available then, was a scintillation detector. That is a

solid detector. It absorbs gamma rays better, so it is more efficient, and also the size of the output pulse from the detector is proportional to the gamma ray energy it has absorbed.

So with such a detector one has the possibility of using what we call a multichannel analyzer to look at the output pulses, sort them into their sizes, and get a spectrum with peaks.

Mr. FITZMAN. The current equipment is generations removed from the 1964 equipment?

Dr. GUINN. Yes, sir. The old scintillation detectors are still useful for some purposes, but the difficulty is that in a spectrum obtained from it, each of the peaks is typically about 20 times wider than the peaks from a modern germanium detector. We say that means that the older scintillation detector has very poor energy resolution.

In the chart example that shows the silver-110 peak, with a little antimony-124m, peak next to it, for example, with a scintillation detector all you would see would be one broad peak that included both of them, and you wouldn't know that you really were looking at two gamma rays, of two different energies.

The germanium detector, the more modern type, which wasn't available generally in 1964, is a high-resolution detector. It is of a new generation of detectors, and that was really one of the primary reasons for wanting to reanalyze these samples, but now with much more modern equipment.

Mr. FITZMAN. Just for the record, before I ask the additional questions, in your answer to counsel Wolf's question you used the phrase that the WCC Mannheim-Carcano bullets were made of unhardened lead. You were referring only to the lead core and not to the hardened copper jacket?

Dr. GUINN. That is correct. The specifications for those bullets were that they were to be made of No. 0 soft lead, unhardened, that was at least 99.85 percent lead.

Mr. FITZMAN. One of the most serious questions facing the panel is the identification of the "pristine" bullet with the fragment taken from Governor Connally, in the wrist wound area. I realize the importance of your conclusion that the fragments removed during the surgery from Governor Connally's wrist were from the "pristine" bullet, and I realize the difficulty of saying you are absolutely certain to the exclusion of all other possibilities, but I am wondering if you could go any further than you have, in terms of certainty of the comparison of those two specimens?

Dr. GUINN. I don't think that I can in the sense of putting a percent probability or something like that. All I can say is that those two specimens, CE-399 and 842, agree so closely in their antimony concentration and their silver concentrations that I could not distinguish one from the other. However, I can clearly distinguish those two from the other three specimens. They are different. They are still WCC Mannheim-Carcano; but they represent a different WCC Mannheim-Carcano bullet.

Mr. FITZMAN. And so it is your testimony that it is very unlikely that these were fragments from two different bullets?

Dr. GUINN. It would be extremely unlikely. You can imagine that certainly there are some WCC Mannheim-Carcano bullets that are of essentially the same composition, and hence that the pristine

bullet might be one bullet that just happened to have the same composition as a different bullet that fractured the wrist, for example, but it is very, very unlikely.

Mr. FITZMAN. But the scientific term that you used, is it extremely unlikely?

Dr. GUINN. Extremely unlikely, or very improbable, however you prefer.

Mr. FITZMAN. To your knowledge, has any other scientist to date linked the so-called pristine bullet to the injuries?

Dr. GUINN. Not that I am aware of, no.

Mr. FITZMAN. Equally important, as your conclusions concerning Governor Connally's wrist injuries and the "pristine" bullet, is the second conclusion you make, and that is that there is no evidence of a third, fourth, or fifth bullet represented in any of the fragments that you tested?

Dr. GUINN. That is correct.

Mr. FITZMAN. And therefore, it is highly likely—is that the term you used to Mr. Wolf—that all fragments tested match up with two bullets and two bullets only?

Dr. GUINN. Yes, sir. The other three samples that we have been referring to—one being the fragments recovered from President Kennedy's brain, and then two different groups of particles found on the floor of the limousine—those three specimens are indistinguishable from one another, but markedly different from CE-399 and 842. So there is only evidence for the presence of two different bullets.

Mr. FITZMAN. I understand that the Warren Commission did emission spectrography tests on many of the same items you have tested with neutron activation analysis. How does the neutron activation analysis process, just in brief layman's terms, differ, and what are the advantages or disadvantages of the two methods of testing?

Dr. GUINN. Well, they have some similarities and they have some differences. They are both methods of elemental analysis. They will both detect down into what we call the trace element range, approaching parts per million, let's say, and they will both detect a number of elements more or less simultaneously in the specimens.

Now, where they differ is that for most elements, at least, we can detect much lower concentrations by activation analysis. In other words, activation analysis is more sensitive for most elements.

What is perhaps even more important, though, is that activation analysis, when it measures something, measures it very quantitatively. Emission spectrography does not.

I have a copy of all of the FBI raw data from those measurements, and they list things like magnesium, a trace; chromium, a very slight trace; and things like that. No numbers. So you can't make any kind of quantitative comparisons by looking at information of that sort. And the remaining difference is that the emission spectrographic method is destructive. You normally would like to have about 10 milligrams of samples, which isn't a great deal, but that 10 milligrams is totally consumed, it is vaporized and it is gone, whereas the way we analyze bullet-lead samples, at least, and

many other kinds, by activation analysis, the method is non-destructive.

These same samples I analyzed, if somebody didn't agree with the numbers, they could come back and do them all over again on the same specimens.

Mr. FITZMAN. Your results then could be verified by others?

Dr. GUNN. Yes, sir, all the samples I activated and analyzed were turned right back over to the Archives, and they are right back there, and they could be reanalyzed.

Mr. FITZMAN. Dr. Gunn, this is not meant to be an embarrassing question, but I think I must ask it. Mr. Chairman, a recent article in the New Times magazine stated that you had worked for the Warren Commission and, therefore, your conclusions for this committee would be implicitly biased.

Did you even work for the Warren Commission or work for the FBI in connection with the analysis of these evidence samples?

Dr. GUNN. Neither one, I think Mr. Wolf called my attention to the existence of this article, which I haven't seen, and I don't know where they got their misinformation, but I never did anything for the Warren Commission, and although I know people in the FBI, I have never done any work for them.

Mr. FITZMAN. But it is correct, isn't it, that the Warren Commission had the FBI perform neutron activation analysis measurements on the bullet-lead specimens in 1964?

Dr. GUNN. Yes, sir.

Mr. FITZMAN. How did you find this out?

Dr. GUNN. Well, it was rather interesting because both Dr. John Nichols and I felt that activation analysis of the bullet-lead specimens in the President Kennedy case should be done, and he in particular was trying to persuade J. Edgar Hoover, first, and later Clarence Kelley, that these things should be done. He made no progress with them, and then quite accidentally there turned up in the Archives a letter from J. Edgar Hoover to J. Lee Rankin, in July 1964, stating that indeed the FBI had made activation analysis measurements on these samples. Until then, this fact was totally unknown to us, so, therefore, after that we requested the results, because the letter didn't give any numerical results; it just said that the analyses had been done and the results were generally inconclusive. This again took quite some time, and it was only finally, under the amended Freedom of Information Act, that Dr. Nichols was able to obtain the some 70 pages of raw data copied out of the FBI records, from the FBI. I then took all of those data and recalculated them from scratch.

Mr. FITZMAN. I want to come back to that data in just a moment, because I think it is very, very, important for us to explore that with you, but let me ask, prior to doing that, do you know why the existence of these tests was never divulged until recently?

Dr. GUNN. No, I certainly don't know why. I can just speculate. The letter states that—if I may just read this one last little short sentence in it—this is from J. Edgar Hoover to the Warren Commission. It states:

While minor variations in composition were found by this method, these were not considered sufficient to permit positively differentiating among the larger bullet

fragments and thus positively determining from which of the larger bullet fragments any given small lead fragment may have come.

I believe probably that the FBI and the Warren Commission both felt that this didn't prove anything, in their opinion, and, therefore, didn't need to be noted.

Since we had been asking them for quite sometime to perform such analyses, we rather thought it would have been nice if they had told us, instead of our eventually finding out accidentally.

Mr. FITZMAN. Mr. Chairman, I would like the record to show that the witness, Dr. Gunn, was reading the last paragraph of a letter from J. Edgar Hoover to J. Lee Rankin, the General Counsel to the President's Commission, the so-called Warren Commission, dated July 8, 1964, and delivered by courier service. I would ask that the entire letter be made a part of this exhibit as JFK exhibit No. F-332.

Chairman Stokes. Without objection, it may be entered into the record.

[The above referred to JFK exhibit No. F-332 follows.]

UNITED STATES DEPARTMENT OF JUSTICE
FEDERAL BUREAU OF INVESTIGATION

WASHINGTON 25, D.C.

July 9, 1964

By Courier Service

FORWARDED
JUL 11 11 32 AM '64
UNIVERSITY MICROFILMS
PATROL OFFICE AND CLERK
UNIVERSITY MICROFILMS

Honorable J. Lee Rankin
General Counsel
The President's Commission
200 Maryland Avenue, Northeast
Washington, D. C.

Dear Mr. Rankin:

As previously reported to the Commission, certain small lead metal fragments uncovered in connection with this matter were analyzed spectrographically to determine whether they could be associated with one or more of the lead bullet fragments and no significant differences were found within the sensitivity of the spectrographic method.

Because of the higher sensitivity of the neutron activation analysis, certain of the small lead fragments were then subjected to neutron activation analysis and comparisons with the larger bullet fragments. The items analyzed included the following: C1 - bullet from stretcher; C2 - fragment from front seat cushion; C4 and C5 - metal fragments from President Kennedy's head; C9 - metal fragment from the arm of Governor Connally; C16 - metal fragments from rear floor board carpet of the car.

What part of your file covers the gun fragments and fragments from the car?

While minor variations in composition were found by this method, these were not considered sufficient to permit positively differentiating among the larger bullet fragments and thus positively determining from which of the larger bullet fragments any given small lead fragment may have come.

Sincerely yours,

J. Edgar Hoover

JFK Exhibit F-332

Dr. GUINN. May I comment—I will give you this copy of the letter—but it does have stamped on it, which of course wasn't there originally, John Nichols stamp when he received it, in November 1973, and he also wrote in himself one little handwritten line. Those were not in original, but otherwise it is a copy of the original letter.

Mr. FITZMAN. So, for the record, then, the handwritten notation between paragraphs two and three, which read "He did not examine the copper, zinc jackets and fragments," was written by Prof. John Nichols and were not a part of the original letter when we received it?

Dr. GUINN. I guess that was John Nichols little note from him to me that he put in there.

Mr. FITZMAN. With regard to that important paragraph that says, "These are inconclusive," I would like now to ask you, Dr. Guinn, if you could tell us what your findings were when you looked at the same 70 pages of raw data, and prior to that, are you aware or do you know who and how this neutron activation analysis work was done and whether this was a common practice of the FBI or just how this came about?

Dr. GUINN. Yes, I have subsequently found out most of the details of it. The FBI work was done in May 1964, at which time the FBI laboratory had not done any prior activation analysis work, so far as I am aware. But in the same elemental analysis group, where such work would normally fall, they asked Mr. Jack Gallagher (John F. Gallagher) of their staff, whom I know, to take these bullet lead specimens down to the Oak Ridge National Laboratory.

Mr. FITZMAN. To where?

Dr. GUINN. To the Oak Ridge National Laboratory, in Oak Ridge, Tenn., where they have all the nuclear facilities, and so on, they are quite good, and they do a lot of activation analysis work, although not usually connected with crime investigation, but for other purposes. He took the samples down there.

Two of the people down there, who were highly conversant in activation analysis, but not in forensic work, and Mr. Gallagher, who was highly conversant in forensic work but not in activation analysis work, worked together. He actually did all of the measurements, but with the two Oak Ridge people showing him how to do it and how to calculate the results, et cetera, since this really was his first experience in this field.

Mr. FITZMAN. Are you saying this was the first neutron activation analysis work done by the FBI?

Dr. GUINN. So far as I am aware, it was, yes.

Mr. FITZMAN. This is the first that they had ever done? Dr. GUINN. Two years later, in 1966, they set up a regular activation analysis group in the FBI laboratory, which it still operates. But at that time, it was their first, direct contact with the method, I believe.

At any rate, Jack Gallagher, in a period of some days there, did go ahead and analyze the samples, and he calculated the results, and he obtained a lot of numerical results.

When I obtained all of these data and went through the calculations, my initial reaction was pretty much the same as theirs, or his.

Mr. FITZMAN: That is, it was inconclusive?

Dr. GUINN: The numbers appeared to bounce everywhere. Any one sample just didn't seem to be consistent. To just pick an example here, for one particular specimen, one time he measured it and found it to be 977 parts per million antimony. Another time he measured it, but the result was only 676. The numbers just bounced around.

He measured each sample a number of times under somewhat different conditions, but this shouldn't make any difference, you should get essentially the same number every time, merely somewhat different with uncertainties. My initial reaction was thus, exactly the same as his. At that time I just went through all of the data quickly and initially could not make any sense of it. I concluded they had done careful work, in general, but it somehow didn't make sense.

Then I did my own analyses here and found very definitely that the samples fell into the two groups, two bullets, so then I asked myself, as far as I know, even though they had more antiquated equipment at that time, these analyses were done well, why can't you get the same results out of their data, and I went back through a second time, and in a very detailed way, and I tried a little bit different approach, and I think I figured out finally what was wrong with their original work, which they were not aware of and I wasn't initially either.

If you take the numbers that they obtained on the whole group of samples and you only look at them under one set of measurement conditions, that is, you don't look at all the conditions for the moment, but just look at one set of conditions, lo and behold, it is exactly the same result.

Mr. FITZMAN: The same result as what?

Dr. GUINN: As what I found in my own measurements.

Mr. FITZMAN: How do you mean?

Dr. GUINN: CE-399 matches CE-842 in each of the four sets of conditions that he used, and the other three specimens match one another and are different from the other two every time. But if you look at all the numbers at once, everything is varying so much you don't get the picture at all. But once you sort them out this way then the same result comes out as what I obtained—a little fuzzier picture of course, because his detector didn't have the sharp resolution of the modern germanium detector. But, of course, hindsight is much better than foresight. I didn't get this out of his data either until after I had my own data. In a sense it is confirming.

Mr. FITZMAN: Are you testifying then, Dr. Guinn, that a more in-depth reading of the 1964 neutron activation analysis data would have led equally trained scientists to the conclusion that there were in fact fragments from only two bullets that were tested?

Dr. GUINN: Yes; the data were there but they were not interpreted as far as they could have been taken.

Mr. FITZMAN: Using the charts that you provided the committee, and they have been previously admitted into evidence, would you

just briefly summarize for me how the readings of your equipment might be more accurate, more specific, than those of the FBI?

Let me see if I can understand this as a layman. As I understand the process, what you do is you take a particle of something and you put it in some kind of little—

Dr. GUINN: Container.

Mr. FITZMAN [continuing]: Container. And you put that inside the nuclear reactor and you bombard it with trillions of neutrons per second?

Dr. GUINN: Yes, sir.

Mr. FITZMAN: And then you remove it from the reactor, and in some time frame thereafter, the unstable atomic nuclei that have been created, each by the absorption of a neutron, from the extra neutrons that you have bombarded the sample with, undergo radioactive decay, with the emission of gamma rays of characteristic, or identifying energies. Am I roughly correct?

Dr. GUINN: Yes, each radioactive nucleus that undergoes disintegration, which it decides on its own to do, spontaneously, in the typical case emits a beta particle of some energy (which turns out not to be very useful to measure, for detailed reasons), but it also usually emits one or sometimes two or three different gamma rays, gamma rays of different energies. Those we can measure much more easily and exactly, and so those are the ones we look for.

The decay of one nucleus may just give one gamma-ray photon. At best it would give one count on that counter. So what we are looking at, of course, are thousands or millions of these disintegrating nuclei, and we accumulate the results. The detector is capable of distinguishing between gamma rays of different energies, and they show up in our spectra as peaks.

Whether you are looking for it or not, for example, if somebody gave me a sample and I didn't know it had any antimony in it, if I activated it and looked at it under either of those conditions and saw that peak, at 564 keV, I would know that the sample contained antimony.

Mr. FITZMAN: The antimony peak will always come at the same part of the spectrum?

Dr. GUINN: That is right, that is the characteristic; yes.

Mr. FITZMAN: And, therefore, without any knowledge of what is in it, if you see a peak in that frame of numbers, it has to be antimony?

Dr. GUINN: That is right.

Mr. FITZMAN: And then the height of the peak indicates the quantity?

Dr. GUINN: It is proportional to it. We usually measure the area of the peak instead of its height, because the peaks aren't quite symmetrical, but otherwise you are right.

Mr. FITZMAN: You have said this whole process that you go through does not destroy the material, is that correct?

Dr. GUINN: That is correct.

Mr. FITZMAN: Now, then, did you test exactly the same particles that the FBI tested in 1964?

Dr. GUINN: Well, it turns out I did not, for reasons I don't know, because as they did the analysis, they did not destroy the samples either.

Mr. FITZMAN. So?

Dr. GUNN. The particular little pieces that they analyzed, I could just as well have analyzed over again, but the pieces that were brought out from the Archives—which reportedly, according to Mr. Gear, were the only bullet-lead fragments from this case still present in the Archives—did not include any of the specific little pieces that the FBI had analyzed.

Presumably those are in existence somewhere, I am sure nobody threw them out, but where they are, I have no idea.

Mr. FITZMAN. And the 1964 equipment wouldn't have consumed them either?

Dr. GUNN. No.

Mr. FITZMAN. What was the state of the knowledge at that time in terms of storing radioactive materials? Would there have been any prospect that someone not adequately informed, such as perhaps the FBI at that time or law enforcement people, would have been a little leery about keeping radioactive materials in their files?

Dr. GUNN. I wouldn't think so. I am sure by that time they knew enough about the safety aspects that, considering the very small size of samples we are dealing with here, and the very small amount of radioactivity in them, they would have rightly considered them to be perfectly harmless. Also, the little activity in them soon decayed out.

Mr. FITZMAN. So, finally, it is your conclusion that despite what Mr. Hoover said to Mr. Rankin, the FBI data are not really inconclusive, though it appeared to be so to you initially?

Dr. GUNN. That is right, the data really were fundamentally better than they thought, or than I initially thought.

Mr. FITZMAN. The reason I raise that issue, Dr. Gunn, is this. As I understand the critical literature, it falls into two categories with regard to this question. Earlier on, the critics said that the Warren Commission was afraid to do the neutron activation analysis measurements because if they did it, it would show something other than the single bullet theory and thereby would undermine the entire Warren Commission findings. This charge was made in several places in the literature, and I have several examples here to that effect, namely, that the reason for their not doing the neutron activation analysis work at that time was the fear on the part of the Bureau that it would show something other than a single bullet theory, that is, the fragments from Connally's wrist and the "pristine" bullet sample would turn out to be two different bullets.

Dr. GUNN. Yes.

Mr. FITZMAN. In post-1973 literature, after the Freedom of Information Act episode to which you refer, the critics have said that it was done, but with inconclusive results, and since the results were inconclusive, it did not prove that they were from the same bullet, and, therefore, the publication or the publishing of the results were suppressed because it did not support the single bullet theory.

That is the reason I raised the question specifically about the FBI data and about your analysis or interpretation of their data.

Dr. GUNN. I don't know anything about any of the peoples involved motives but what I do know is that indeed in 1964 the FBI did do the analyses and according to this letter that we just intro-

duced into evidence, they did not appear to be able to draw any conclusions from the numbers.

Looking at them many years later, I can see why that would be possibly the case, but as I say, with the advantage of these new results to guide me in the right direction of how to statistically treat the data they had gotten earlier, I do and behold, they very definitely did agree, with my more recent findings from my own measurements, using more powerful equipment.

Mr. FITZMAN. Now, is there any evidence, in either the FBI interpretation of the test results of 1964 or in your own interpretation of the tests for this committee, that would support the speculation that the "pristine" bullet and the one that hit Connally's wrist are two separate bullets? Is there any evidence in either report?

Dr. GUNN. No, there is no evidence either in my work or the previous FBI work of that. You cannot distinguish one specimen from the other, from the analytical results. Both my findings and the earlier FBI findings give this same result.

Mr. FITZMAN. Going from this conclusion, could the FBI have been able to draw the conclusion of only two bullets being present if someone, anyone there, did not have the kind of expertise in WCC Mannlicher-Carcano ammunition that you have testified or that we understand you possess? Would someone not familiar with that kind of ammunition—could they have drawn the right conclusion?

Dr. GUNN. It would have been certainly much more difficult because, as I say, most kinds of ammunition, other kinds that we have looked at over years, have been so uniform that you can't tell—you literally cannot tell one bullet from another out of the same box.

WCC Mannlicher-Carcano bullet lead, however, is different. The concentration range from bullet-to-bullet is tremendous. For example, out of the same box, one bullet may only have 20 parts per million antimony, the next one you take out of the box might be 1,200 parts per million antimony, and each of these values can be measured quite precisely.

Actually, when Jack Gallagher did these measurements, he also analyzed a couple of known WCC Mannlicher-Carcano bullets, just as background samples: One from lot 6,000, one from lot 6,003, but that is all. That is not much of a background to look at; but sure enough, those two, just the two that he looked at were quite different from one another—one was about 90—I have the numbers somewhere here but not handy—one was like 90 parts per million antimony and the other one was something like 700 parts per million.

So even the two samples he happened to pick as background samples immediately showed the same thing regarding which we have much more data.

Mr. FITZMAN. So is it your testimony, then, or is it your estimate that the FBI's failure to correctly interpret the 1964 data, which is so disturbing to so many people—would the FBI have had the knowledge and experience in 1964 to correctly interpret the results?

Dr. GUNN. Well, it is a little hard to say. I think they might have been able to, but I think it might have been more difficult for

them to at that time since they didn't have an extensive background in activation analysis or interpretation of such results, and they didn't have any experience with WCC Mannlicher-Carcano ammunition, either. For that matter, in 1964 I didn't have any experience with this kind of bullet lead either.

Mr. FITZMAN. We must, I think, Mr. Chairman, clarify one thing for the record.

Dr. Guinn, is your interpretation of the FBI data based on the information you obtained through the FBI, as opposed to any secret or otherwise restricted data you obtained through this committee?

Dr. GUINN. No. You are only referring to the FBI data?

Mr. FITZMAN. Yes.

Dr. GUINN. No; the FBI data that I have, copies of all the raw data that Jack Gallagher got, were obtained actually not even by me; they were obtained by Dr. John Nichols from the FBI under the Freedom of Information Act, and then turned over to me, since Dr. Nichols is not an activation analyst. He didn't know what to do with such specialized data—his expertise is in the field of forensic pathology.

Mr. FITZMAN. Therefore any information that has been published either by him or by you no way falls under any restrictions, is that correct?

Dr. GUINN. No, none of this is restricted information.

Mr. FITZMAN. One final line of questioning, Dr. Guinn, and I will subsidize. Have we done, have you done—as far as your expert knowledge is concerned, have we done all the tests that are possible to ascertain the number of bullets that the fragments came from? Is there anything else that we should do?

Dr. GUINN. One can always think of other analytical methods, et cetera, that might show up some elements that were not detectable by activation analysis, or you can even—using activation analysis go to the destructive form of the method, but then you destroy the samples. I am sure that is not desirable.

I would not recommend any further analytical studies at the present time. I think that the findings that we have are pretty definitive and most other things that one can think of that you could try on the samples might or might not add some additional information. It is questionable. And most of those methods that are really sensitive would destroy or alter the samples or alter their compositions.

Mr. FITZMAN. And I close with this question, then: Since there are no fragments from President Kennedy other than the skull shot, in actual fact, using your scientific methods, you cannot shed any light on whether or not the bullet that passed through Governor Connally also passed through the President; is that a correct statement?

Dr. GUINN. That is correct. These results only show that the CE 399 "pristine" bullet, or so-called stretcher bullet, matches the fragments in his wrist. They give you no information whatsoever about whether that bullet first went through President Kennedy's body, since it left no track of fragment's and, for that matter, it doesn't even say that it went through Governor Connally—through his back, that is—because it left no track of fragments there. At

least I have never see or heard of any recovered lead fragments from either of those wounds.

The results, merely say that the stretcher bullet matches the fragments in the wrist, and that indicates indeed that that particular bullet did fracture the wrist. It unfortunately can't tell you anything else because there were no other bits and pieces along the other wounds.

Mr. FITZMAN. Then your conclusions are what you just stated as far as the back entrance and throat exit wound of President Kennedy, and as far as the close match of the fragments from Connally's wrist with the "pristine" bullet, and the other conclusion you referred to today is that the particles taken from President Kennedy's skull matches other fragments that were in the car?

Dr. GUINN. That is right, they match one another, but they do not match the Connally samples.

Mr. FITZMAN. And that means there were two bullets?

Dr. GUINN. There were definitely two bullets. There is no evidence for the presence of three, or more.

Mr. FITZMAN. Repeating then, there is no evidence for three bullets. Thank you, Dr. Guinn.

I have no further questions, Mr. Chairman.

Chairman STOKES. The time of the gentleman has expired. Dr. Guinn, I think I just have perhaps maybe one, maybe two questions. Obviously from your testimony here it is evident, as an expert in neutron activation analysis, that we are talking about a field in which there are relatively few experts; aren't we?

Dr. GUINN. I wouldn't say so any more. It might have been true many years back, but every time we have an international conference we have something like 500 people there, all supposedly and most of them really experts in some phase or another of activation analysis. It has grown to be a field where there are probably altogether a few thousand people who are knowledgeable in the field.

Chairman STOKES. And if we go back to the period of time we are talking about, 1963-64, that period of time, what type of field would there have been then of experts?

Dr. GUINN. Smaller numbers, although even in 1964 we had already had one international conference in the field. We had another one the year after that. So it was obviously already getting to be of some size, but obviously not as many people as there are now. It was still considered to be a relatively new method by some people, at least in 1964, although the method itself was first originated in 1937, way back then.

But it couldn't become a really very useful method until the nuclear reactor came along, and that was during World War II, and then it was some years before reactors became very widely available to people, and so it was not until about 1950, you might say, that at least a few places had nuclear reactors and the scintillation detector kind of counting equipment, and then the field began to grow at a pretty good clip.

Chairman STOKES. I have no further questions. At this time, under the rules of our committee, any witness appearing before the committee, at the conclusion of his testimony, is entitled to 5 minutes. During that 5-minute period he may explain, amplify, or

in any way expand upon the testimony he has given to our committee. I would like to extend to you such time at this time if you so desire.

Dr. GUINN. Thank you, Mr. Chairman. I will just make one comment that I thought we might have brought out before, but we didn't quite get around to it. If any of you start looking at these detailed numbers, there needs to be a little further interpretation. First of all, some of the elements listed in my report, in our experience with all kinds of bullet leads often show up and often don't show up, and they don't seem to be characteristic of anything. Some of them are probably the result of external contamination. For the sake of completeness, I have included all of the elements detected, but I don't think that some of them contribute one way or the other to the characterization of source of the specimens.

Also, when you look at the antimony and the silver values to see if these samples match these and these match these, it should be noted that the plus or minus that is shown after each of those numbers is merely the uncertainty of each value calculated from what we call the counting statistics. We can calculate that.

The overall measurement uncertainty of that number on that specific sample is somewhat bigger than that, meaning that if we took that identical little piece and did the same experiment over and over again we would get about the same value, but the variation would be somewhat more than that calculated from the counting statistics—perhaps as much as twice larger. It depends on the value.

And then, if you are trying to match this piece and this piece—which really both came from the same bullet but you don't know it and you are trying to prove it—you have to take into account another factor—how homogeneous is that bullet? Is every piece that you take from a bullet the same? And the answer is: No; they are not. The individual bullets are fairly homogeneous, but there are significant variations within them.

We have a great deal of background data, specifically on WCC Mannlicher-Carcano bullet lead, that isn't in the report, but we use that as the backup which shows that the variation within a bullet is significant.

So when you start to compare numbers, it turns out, for example, on the antimony numbers, roughly speaking, if you take the plus or minus that is shown and multiply it by about 6, that will take care of all of those variabilities within the sample, as well as the small measurement uncertainties.

The variation within that individual bullet is then taken into account, and then you find out that two samples indeed match one another as closely as could be expected. For example, the CE-399 sample gave a measured value of 833 parts per million antimony, whereas the CE-842 sample showed 797. Well, any grammar school boy will tell you 797 is not the same as 833. But when you consider that the 833 is plus or minus about 50 and the 797 is plus or minus about 50, then you see that you can't distinguish one from the other. They are indistinguishable, but, by the same token, the other samples which are only about roughly 620 plus or minus a smaller amount, in that case about 20 or 30—they very clearly not

only match one another, but they also widely differ from this 800 figure.

But some of that is explained in the text of the report. You can't just take the numbers from the table and blindly go ahead; you have to read the fine print as well to see that everything is properly taken into account.

In any event, though, I think the results have come out in a fairly clean-cut fashion. We didn't predict any particular way they would come out; they just fell out this way. And, as I say it led me to reexamine the FBI data more carefully than I had done earlier. I frankly was very surprised to see that even their data, somewhat fuzzier, et cetera, still fell right into the same picture.

So I think the conclusions are well established. Also, as I have stated earlier, fortunately by using this method one does not destroy the samples. The identical samples are still there. They weigh the same; they can be analyzed all over again. All of the radioactivity that we induced in them a year ago has long decayed out, so they could readily be analyzed over again, if desired.

Other than that, I just want to say it has been a real pleasure working with the committee and with the staff of the committee, and I thank you very much for inviting me here.

Chairman STOKES. I guess you raised one additional question in my mind. Assuming that your data were presented to another expert in your field, can we assume with a reasonable degree of certainty that the expert will come to the same conclusions that you have?

Dr. GUINN. I believe so, yes. As I say, if you just handed him the table of measured values, he initially might interpret the plus and minuses as meaning the total uncertainty; and, of course, then he would say: Well, 797 is not the same as 833. However, in the text of the report, it is pointed out that the table plus-minus values do not represent the total uncertainty of a sample; it is larger than that. If he took that into account, he would reach the same conclusions; yes.

Chairman STOKES. The Chair recognizes counsel Jim Wolf.

Mr. WOLF. Mr. Chairman, for the record, I would like to note that Dr. Guinn's report has been submitted to an independent consultant for review and evaluation and he completely agreed with the results achieved and reported by Dr. Guinn.

Chairman STOKES. Dr. Guinn, on behalf of our committee, we thank you very much. You have made a very valuable contribution here today and we certainly appreciate all the time you have expended on our behalf. Thank you.

Dr. GUINN. Thank you.

Chairman STOKES. There being no further business to come before the committee today, this committee meeting is adjourned until 9 a.m. Monday morning.

[Whereupon, at 5:10 p.m. the committee adjourned, to reconvene at 9 a.m. Monday, September 11, 1973.]