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Technical Investigation Pertaining to the
First Shot Fired in the Kennedy Assassination

22 November 1963

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Introduction

In May of 2010, producers at the [National Geographic](#) cable channel, [NatGeoTV](#), requested Forensic Metallurgy Associates to participate in an inspection of a traffic signal assembly in Dealey Plaza at the intersection of Elm and Houston Streets in Dallas, Texas.

On 22 November 1963, this assembly consisted of a transformer base situated on the northwest corner of the intersection; a vertical steel pole, 18.5 feet in height, affixed to the base; a curved horizontal mast arm with an effective length of 15 feet, attached to the pole and supported by two brace rods; and a traffic signal that was attached onto the end of the mast arm.^[1]

President Kennedy's limousine passed underneath this signal assembly prior to his fatal shooting and just before Abraham Zapruder began filming the assassination, as seen in figure 1. (The ghost image in figure 1 approximates the position of the presidential limousine on November 22 at the moment Zapruder re-started his camera). The purpose of the inspection was to determine if the signal assembly displayed any bullet metal damage. If so, that would corroborate that Lee Harvey Oswald fired his first shot from a sixth floor window in the Texas School Book Depository just before the Zapruder film began, and that the bullet missed the presidential limousine and its occupants because it struck the signal assembly overhanging Elm Street.^[2]

Although the [Warren Commission](#) (1964) and [House Select Committee on Assassinations](#) (1979) considered various explanations for why the first shot missed, the signal assembly had never been subjected to any forensic examination. This oversight occurred because the obstruction presented by the signal assembly to the line of sight from the sixth floor window occurred before the Zapruder film started, and the film was always presumed to have captured the entire shooting sequence (see figure 1).^[3]

This report summarizes the results of inspections of various portions of the traffic signal assembly; corresponding forensic metallurgy observations; limited laboratory testing of exemplars; and the relationship of the technical findings to known factual information. All of the photos accompanying the report can be enlarged by clicking on them.

I. Observed Phenomena Associated with the First Shot

When a forensic metallurgical examination is done in a timely manner, as is usually the case, great care is taken not to let extraneous factors influence the observations and determinations of that inspection. In other words, what reportedly happened after the incident in question is not supposed to enter into the determination of what the evidence shows.

In this unusual, if not unprecedented situation, the first inspection and analysis of the traffic signal assembly occurred almost five decades after the event. There is no gauge for factoring in the effects of time, e.g., the deterioration of metal surfaces because of constant exposure to the elements, and any changes wrought by natural abrasion of surfaces. In addition, there have been man-made alterations in the interim, namely, work done on the signal assembly in the form of new signage, along with evidence that it has been repainted and possibly wire-brushed.

Accordingly, this technical investigation was conducted somewhat differently. What reportedly happened in conjunction with the first shot was indeed considered from the start, partly because some observed phenomena had never been adequately explained before and could provide valuable clues or insights as to what might have happened. To the degree that these observed phenomena could corroborate, or alternately, contradict the supposition that the first shot hit the signal assembly, they were always kept in mind.

These phenomena come down to three eyewitness observations, all exclusively associated with the first shot, that were documented in the immediate aftermath of the assassination.

1) A few witnesses reported seeing an object(s) strike the pavement near the president's limousine in conjunction with the first shot. Miss Virgie Mae Rackley, for example, who was standing at the northwest corner of Elm and Houston, told the FBI on 24 November 1963 that "after the first shot she saw something bounce from the roadway in front of the presidential automobile."[\[4\]](#)

2) Soon after the assassination, several witnesses associated the first shot with a disturbance in the turf adjacent to a concrete skirt around a manhole cover, located approximately 280 feet into Dealey Plaza, on the south side of Elm Street (figure 2). Still photos taken show law enforcement authorities crouching in search of ballistic evidence in the vicinity of the skirt. One of those men, Dallas police officer J. W. Foster, later testified under oath that a bullet had "ricocheted on out" of the turf.[\[5\]](#)

3) Shortly after the assassination, a Dallas deputy sheriff, "Buddy" Walthers, noticed that James T. Tague, an eyewitness to the motorcade, had a speck of blood on one of his cheeks. Tague took the officer to where he had been standing on the north side of Commerce Street, close to the triple underpass. Walthers searched the immediate area, and noticed that a nearby concrete curb on the south side of Main Street, later determined to be 23.3 feet from the triple underpass abutment, appeared to have been freshly struck by a projectile, accounting for Tague's slight wound.[\[6\]](#)

When the [FBI Laboratory](#) examined the removed curb in August 1964, it determined that the mark on the curb had metal smears that contained lead/antimony that could have originated from the core of a mutilated

metal-jacketed bullet such as the type loaded into Oswald's 6.5mm cartridges (figure 3). Because there was no copper present in the metal residue, the FBI Laboratory also concluded that the curb mark "could not have been made by the first impact of a high velocity rifle bullet," meaning the bullet had encountered an obstruction that stripped its jacket off before striking the curb. Further, the FBI Laboratory concluded that damage to the curb would have been much more extensive if the bullet had struck the curb without first having struck some intervening object.^[7]

Each one of these three unexplained phenomena associated with the first shot was kept in consideration as the technical investigation commenced.

II. Dealey Plaza Signal Assembly: First Inspection

The initial inspection occurred on Saturday, 10 July 2010, from approximately 7 a.m. to 10:45 a.m. local time. Dallas police blocked off the northern-most lane of Elm Street's three lanes to facilitate the inspection.

Prior to commencement of the inspection, the signal assembly was studied visually from the ground and compared with photographs taken at the time of the assassination or shortly afterwards. By every measure, the base/pole/mast arm portions appeared to be identical to the assembly as it existed in November 1963. Figure 4 juxtaposes a black and white picture of the signal assembly from 1963 with a color photo of same taken in 2007. In addition, prior research in The [Sixth Floor Museum](#) archives had located a color photograph exposed during the Warren Commission's May 1964 re-staging of the assassination. The photograph showed the pole painted yellow from its bottom to a height of approximately 10 feet; significantly, one of the underlying coats of paint on the extant pole appeared to be yellow.

Examination of the base anchoring bolts also revealed no indication that the pole was not the original one affixed to the base at that location. What appeared to be a manufacturer's nameplate was located near the bottom of the pole, but no identifying information was readable (figure 5).

The visual study also revealed a number of changes. The traffic signal light at the end of the mast arm was obviously different, and attached to the mast arm differently. Signage had been added to both the pole and mast arm portions. The oak tree adjacent to the signal assembly had grown significantly, to a point where large branches covered portions of the mast arm and some had abrasion contact with it.

The inspection utilized a scissor lift for close-up observations of metal surfaces. Because the lift was not sufficiently stable it could not be extended high enough to permit an inspection from above the mast arm; the mast arm was always just above eye-level. In

addition, the inspection was greatly hampered by the tree branches and signage, and some metal surfaces on the mast arm were not viewable for examination at all (figure 6).

Most important, the time allotted for the inspection was limited. Accordingly, the only portion of the mast arm that received close attention was the section that appeared most likely to present an obstruction (as viewed from the sixth floor of the former Texas School Book Depository), assuming the president's limousine was centered in Elm Street, as called for by Secret Service protocol.

As illustrated by figure 7, this same portion also coincided with a significant metal component—a steel coupler/clamp that fastened two brace rods from the pole to the mast arm. This coupler/clamp seemed suitably oriented to deflect a high-velocity bullet. In figure 1, a still photo taken by the Secret Service on 27 November 1963, the mast arm area that was inspected is enclosed in a box: chiefly the coupler/clamp and about six inches to either side of it.

The surfaces that were inspected most closely, using a low-power microscope, did not show obvious bullet damage. One area on the mast arm near the coupler/clamp displayed small physical disturbances from impingements to the surface, but these were later determined to be unrelated to possible damage from bullet fragmentation (figure 8).

The inspection further revealed the two brace rods that support and stabilize the mast arm are loose and that the protruding threaded portion of one of the rods is substantially shorter than the other one. Because of limited visibility from the scissor lift, it could not be determined if the rod end broke because of a bullet impact.

The limited inspection of the mast arm on July 10 yielded no discernable metal damage from a bullet. At this juncture it was believed that given the uncertainty over the exact bullet strike point, and equal uncertainty over the size of the possible strike area involved, that only an open-ended inspection under laboratory-like conditions would yield a conclusive result. Given the constant, steady traffic on Elm Street, that would require disconnecting the mast arm, if not replacement of the entire signal assembly.

After the inspection of the mast arm, it was observed that the base of the signal pole exhibited substantial damage from one or more vehicle collisions (figure 9). The curb immediately in front of the base has been removed and replaced with a wheelchair ramp and there is no longer any barrier to prevent oncoming vehicles from striking the signal pole. A measurement taken at this time showed the pole to be tilted approximately 10 degrees from the true vertical position.[\[8\]](#)

III. Dealey Plaza Signal Assembly: Second Inspection

In connection with a re-staging of the assassination incident and documentary filming by NatGeoTV, a second inspection of the signal assembly took place on the morning of 10 April 2011.

Before the actual inspection, steps were taken to see if more facts could be acquired to prove that the extant pole and mast arm portions of the signal assembly were also in place on November 22. In addition, points of interest in Dealey Plaza were surveyed using digitized instruments employing laser technology, and some areas of interest were scanned with a high sensitivity metal detector.

The dark paint layers on the signal pole were mechanically removed and revealed that the bottom paint color was yellow. This finding dovetailed with a photograph taken during the Warren Commission's re-staging of the assassination in 1964, which showed the pole painted yellow at that time (figure 10).

After securing permission from the city of Dallas, chemical processing of the previously-unreadable nameplate on the pole restored information that the signal pole was a product of the [Union Metal Manufacturing Company](#), Canton, Ohio (figure 11). Subsequently, Union Metal, which is still located in Canton, supplied information (including a complete schematic drawing) documenting that the signal assembly was custom-designed and manufactured in 1955.

That coincided with information about a re-routing of traffic patterns throughout downtown Dallas, including Dealey Plaza. On 9 September 1956, in conjunction with the designation of one-way streets through downtown, Elm Street was changed from a four-lane, east- and westbound street to a three-lane, westbound-only street in Dealey Plaza. Figure 12 depicts Elm Street circa 1954, before it became one-way. Consequently, the evidence is unequivocal that the main features (base, pole and mast arm) of the signal assembly have been unchanged since 22 November 1963.^[9]

[SAM, Inc.](#), a local surveying firm retained by [NatGeoTV](#), digitally recorded laser measurements of distances and angles from the sixth floor window to various points of interest in Dealey Plaza over a two-day period, 8—9 April 2011.

Many of these measurements pertained to the second and third shots fired by Oswald, and reasonably matched the distances and angles previously established during the Warren Commission's detailed survey and re-staging of the assassination in May 1964. In addition, however, SAM, Inc. surveyors also established for the first time the distances and angles between the sixth floor window, the signal assembly, and phenomena associated with the first shot.

The coupler/clamp on the mast arm was used as a reference point; the measurements are approximate, inasmuch as the current signal assembly is now tilted about 10 degree because of damage acquired subsequent to 1963. Nonetheless, the measurements are

presumed to be very close. The angles from the sixth floor window to the coupler/clamp are approximately 32 vertical degrees down, and 65 lateral degrees away from the face of the building formerly known as the Texas School Book Depository. The coupler/clamp was measured as being approximately 78 feet from the sniper's nest in the sixth floor window.

As described previously, immediately after the assassination several witnesses associated the first shot with a disturbance, likened to "[debris coming up from the ground](#)," that occurred near the concrete skirt around a manhole cover located on the south side of Elm Street.[\[10\]](#)

The SAM, Inc. survey established that the manhole cover is located approximately 327 feet from the coupler/clamp at a vertical angle of approximately minus 6 degrees.

At least one metal detector search of this area for bullet metal was reported to have been conducted by investigators after the assassination, but with negative results. It is also likely that the grass area in this location and elsewhere in the Plaza has been re-sod more than once. Removal of the original sod would have removed, in all likelihood, any unrecovered bullet fragments that may have been in the sod. Nevertheless, it was decided to conduct metal detector searches using a state-of-the-art detector in the event any bullet fragments might still be present beneath the sod level. Current metal detectors are considerably more sensitive than those available in the 1960s; they also may be "tuned" to detect particular metals, such as a copper-based alloy, or lead, both of which were present in the ammunition used by Oswald. The detector used in the search was a [Garrett GTI 2500](#) furnished by Mark Tollett, a metal detector dealer, in Spring, Texas (figure 13).

In consideration of the possibility that Oswald's first shot may have struck or ricocheted off the signal assembly, the metal detector searches focused on a wide area encompassing the concrete skirt on Elm Street to the concrete curb on Main Street near where James Tague was injured. After a thorough search lasting more than 20 hours, no bullet metal was recovered.

On the basis of the experience gained from the earlier inspection, a higher-capacity lift was used to inspect the mast arm while all of Elm Street was blocked off. Tree branches that previously impeded movement or visibility were trimmed or removed. All metal surface areas of the mast arm became accessible except for the last five feet of the mast arm, or slightly less than one-third its length. This portion remained largely unviewable as it was not possible to maneuver around or inspect surfaces obscured by bolted-on signage (figure 14).

Due to time constraints associated with the filming, the inspection of mast arm metal surfaces was again limited to the area immediately adjacent to the coupler/clamp; that was still deemed the area most likely to have interfered with a shot fired from the sixth floor. The hour-long visual inspection affirmed that there was no obvious bullet impact damage in the vicinity of the coupler/clamp, i.e., within an area of six inches to either

side. The traffic signal attached to the end of the mast arm was not inspected inasmuch as it was clearly not the signal in place at the time of the shooting.

IV. Review of Photographic Records

The failure to observe bullet metal damage on the mast arm raised a question about the assumed path of the presidential limousine. Secret Service protocol called for the limousine to be in the center of whatever street or intersection it was traveling on or through. Was there any way to gauge the actual path of the limousine on November 22 using the digitally enhanced films of the assassination commissioned by NatGeoTV?

Standing on the southeast corner of the intersection, 13-year-old Tina Towner filmed the motorcade in November 1963 as it turned onto Elm Street from Houston, a duration of slightly more than seven seconds. This portion of her film stopped less than a second before Abraham Zapruder re-started his camera.[\[11\]](#)

When Tina Towner Pender visited Dealey Plaza during the NatGeo re-staging, and stood again at the spot she occupied on November 22, she commented that she thought the limousine standing in for the president's car appeared to be too centered in the street, and that it should be further to the left, to mimic the genuine path of the president's limousine on 22 November 1963. Subsequently, the Tina Towner film was restudied for clues about the actual track. Frame number 141 from the Towner film reveals that the limousine was much closer to the traffic lane dividers on the driver's (or left) side of the center lane on Elm Street than was previously realized (figure 15).

Moreover, because Elm Street had been reduced from four to three lanes in 1956, the lanes were considerably wider than normal. Consequently, contrary to the presumption that had guided two inspections of the mast arm, it was deduced that the president had passed under the mast arm well to the left (south) of the coupler/clamp as seen from the perspective of the sixth floor window. In addition, it was determined that the traffic signal itself may have obscured the line of sight from the sixth floor even before the mast arm did.

That raised the question as to whether the bullet may have struck some portion of the traffic signal light instead of the mast arm, and altered the course of this investigation from an inspection of the mast arm into an examination of the traffic signal as an obstruction. Like the mast arm, it was clear that the traffic signal had never come up during the initial investigation by the FBI in 1963, or the subsequent investigations by the Warren Commission and House Select Committee on Assassinations.

Since the original signal light was no longer on the mast arm—and even if it still existed, its provenance could not likely be established satisfactorily—a search was made of investigative records, reports, archives, libraries, newspaper morgues, and privately-held collections to locate any photographs and/or films that included the traffic light both

before and after the assassination. The extant still photos that were located were inconclusive as to whether the signal had sustained any visible damage.[\[12\]](#)

However, a close study by John Joe Howlett of a US Secret Service (USSS) training film and still photos that he took on 27 November 1963 (Howlett was then an agent with the Dallas field office), resulted in the discovery of what appeared to be a possible bullet hole near the bottom right back plate (figure 16). Meanwhile, two signal experts had independently identified the traffic signal in place on November 22 as a “rodded flat back” signal of 1950s vintage, built by the [Eagle Signal Corporation](#), then located in Moline, Illinois.[\[13\]](#)

V. Examination of a Traffic Signal Exemplar

On 15 June 2011, an exemplar Eagle signal was located and subsequently borrowed from Willis Lamm, a Nevada-based consultant, for detailed examination. The preliminary inspection revealed that the configuration and shape of the cast aluminum housing comprising the bottom signal head had a suitably oriented base plate lip that, if struck by a bullet, could possibly cause deflection and a missed shot. The two rods in the signal (actually, long steel bolts), which fastened the three signal heads together, reinforced the housing at the very point that enhanced the possibility of deflection. Lastly, it was posited that if a bullet penetrated both thicknesses of the L-shaped aluminum back plate prior to hitting the signal housing, the likelihood of a deflection would be increased.

To explore this proposition further, a hole was drilled into the back plate of the borrowed exemplar, and toward the base plate lip at the sight angles as established by SAM, Inc. Figures 17 and 18 show views of the drilled hole.

After hanging the exemplar light and viewing it from roughly the same perspective as the USSS training film, the view through the drilled “bullet” hole showed that the intervening base lip, that was presumed to form a deflection surface, obscures the view (figure 18). The viewing also revealed that a gap opening exists in the corner between the right and bottom back plates and produces a visible unobstructed hole in the same location as the “possible bullet hole” that was observed in the USSS training film (figure 16). Consequently, the hole was eliminated as a possible bullet hole. Still, that finding did not provide closure regarding the Eagle signal as the possible obstruction and cause of deflection.

VI. Firearms Testing of Eagle Signal Exemplars

From available photographs, it could not be ascertained definitively whether the Eagle signal in place in November 1963 had sustained damage. One photograph, taken in 1964, suggested that it might have. Therefore, to determine if the unique configuration of the

Eagle signal might deflect a round fired from a 6.5mm Mannlicher-Carcano, the [H. P. White Laboratory](#), Inc. in Street, Maryland was contacted for assistance.

H. P. White is a nationally-renowned ballistics laboratory whose involvement with investigating the Kennedy assassination dates back to 1963, when the FBI performed some unspecified tests there. Subsequently, when CBS News re-investigated the assassination in 1966—67, the network retained H. P. White to build what remains, to this day, a replica with the [greatest fidelity to the physical characteristics and shooting parameters](#) in Dealey Plaza on November 22.

After discussions with Mike Parker, president of H. P. White, a preliminary meeting with laboratory personnel was held on August 30. A Mannlicher-Carcano rifle and an Eagle signal exemplar were brought to the meeting, and the specifications for a possible test explained. It was agreed that H. P. White would provide an enclosed shooting range; a fixture to secure signal exemplar(s); and an expert advisory team consisting of Lester W. Roane, chief engineer; Wesley Mason, manager; Tom Napper, manager; and Anthony Zipfel, technician. The testing was scheduled for 22 September 2011.

The test rifle (figure 19) was borrowed from John Cahill, a Virginia firearms collector. The 6.5 mm Mannlicher-Carcano model 91/38 short rifle, serial number AN 7689, was manufactured in Terni, Italy (the Italian “Manchester”) in 1940. This meant it was produced in the same factory and in the same year as the identical model Mannlicher-Carcano owned by Lee Harvey Oswald.

The ammunition obtained for the test consisted of three 6.5 x 52mm World War II-vintage Italian military-surplus cartridges (one shown in figure 20). Ammunition manufactured by the Western Cartridge Company (WCC) identical to the 6.5mm cartridges actually used by Oswald could not be found. The rounds of Italian manufacture were fully jacketed with a copper alloy, and were similar in nose shape to the ammunition used by Oswald; WCC rounds are depicted in figure 21. From among all the 6.5mm ammunition available, the Italian factory-loaded rounds were judged to most resemble the WCC ammunition, and any differences in velocity, load, or jacket composition were believed to be of negligible importance.

Initially, the rifle was secured in a bench rest about 10 feet from the exemplar, although in real life the distance would have been seven or eight times that. However, because of uncertainty over whether the rifle could be aimed with precision, it was decided to forego this distance and fire the rifle at point-blank range using laser-assisted aiming. That meant the bullet would be penetrating the exemplar at near-maximum velocity, but it was deemed better to have greater control over the impact point than achieve the very slight reduction in velocity that would occur by shooting from a further distance.

The most difficult aspect of the firearms test was constructing the fixture that would secure the Eagle signal exemplar at the appropriate sight line angles relative to the rifle. The fixture required that the signal exemplar be positioned horizontally rather than

vertically. Bullet deflections and metal fragmentation directions were captured by cardboard witness panels. Figures 22 and 23 show views of the test arrangement: Exemplar No. 1 is clamped to the customized fixture and the rifle is secured to a test bench.

In the first firing test on Exemplar No. 1, the bullet struck the base lip very close to the intended point. The impact badly shattered the aluminum housing adjacent to the steel assembly bolt and generated a number of fragments, both large and small. There were two large holes produced in the witness panel, but it could not be determined if one or both were produced by the bullet core. Based on the penetration locations, there were significant deflections of the bullet/fragments from the rifle sight path, but the deflection angles were not determined because of the substantial visible metal damage to the back plate and the signal housing, including breakage of the light bulb reflector adjacent to the impact area. Figure 24 shows one view of the test damage.

In the test firing at Exemplar No. 2, the bullet completely missed the lip of the base and struck the 2-inch steel pipe that was part of that signal's hanger support. It did not penetrate the pipe but produced a ricochet indentation on the pipe surface as shown in figure 25. This damage would also be representative of bullet impact damage to the 2-inch steel pipe that forms the mast arm.

After replacing the bullet-damaged back plate component on the second exemplar, and cutting off vestiges of the steel pipe hanger support, a third test firing was performed. In this test, the bullet struck the lower portion of the lip on the base plate and the deflection imparted to the bullet was less than in the first firing test. Again, there was substantial visible metal damage to the back plate (figure 26).

All three test firings revealed that an exemplar Eagle signal could deflect a bullet from its flight path, but could not do so without sustaining very visible damage. It appears that if Oswald's first shot had been deflected by the Eagle signal, the damage to the traffic light would have been easily observable from a street level position. It surely would have been noticed in the wake of the assassination.[\[14\]](#)

VII. Re-evaluation of the Mast Arm as the Deflecting Object

In view of the laboratory finding that an Eagle signal sustained observable metal damage from a bullet deflection, bullet damage determinations were refocused on the mast arm, particularly since the last five feet were not examined during the two previous inspections.

Initially, efforts to locate bullet damage concentrated on the mast arm surfaces that were 1) deemed most likely to have been struck if the limousine had been centered in Elm Street and 2) had an obvious suitable orientation for possible bullet deflection, i.e.,

the steel coupler/clamp. The effects of bullet dynamics on metal surfaces were not considered.

If a bullet struck the surface of the 2-inch round steel pipe that comprises the mast arm, it would be deflected and the direction and degree of deflection would depend on where on the circumference of the pipe the bullet strikes. Survey measurements indicate that a bullet deflection from the mast arm of minus 6 vertical degrees is required to reach the manhole cover/concrete skirt approximately 325 feet away. This vertical deflection could be achieved if the bullet from the window struck the mast arm at an impact point that is approximately 1/8-inch past the top surface centerline of the mast arm. Such an impact would be expected to create only a light indentation in the steel pipe surface because of the small bullet contact angle and the relative hardness of the steel metal. Figure 27 is a close-up photo of the damage inflicted on the 2-inch hanger pipe attached to Exemplar No. 2 by a bullet fired at point-blank range.

The lateral deflection of the bullet striking the mast arm would be dependent on a number of factors, including bullet rotation, impact velocity, bullet shape, bullet hardness, and the ductility of the impact surface. A bullet with a right hand spin rotation, as would be the case with any bullet fired from a 91/38 Mannlicher-Carcano, will change its direction of travel to the right upon striking the mast arm surface. This lateral deflection to the right would place the bullet on a path in a general direction toward the manhole cover/concrete skirt. It is not possible to determine with greater specificity the angle of deflection because of numerous unknown factors.

As noted earlier, witnesses described the strike in the area of the concrete skirt as “[debris com\[ing\] up from the ground.](#)” This description, along with the fact that no bullet metal residue was found on the manhole itself or concrete skirt, indicates that the bullet strike was most likely to the turf at the concrete’s edge. A deflected bullet from the mast arm would strike the concrete skirt area at a small angle of incidence and that would favor a ricochet from the soil toward the concrete curb further downstream from the manhole cover, i.e., approximately 153 feet away, near where James Tague was standing. The [FBI Laboratory’s](#) finding of bullet metal smears on the curb surface supports a ricochet strike that came from the general direction of the manhole cover/concrete skirt area.

From these observations and the position of the sight line from the mast arm coupler/clamp, it appears that the only reasonable explanation for all three observed phenomena is to associate them with a first shot that was deflected from its target flight path after striking the mast arm, as illustrated in figure 28. In addition to explaining the phenomena downstream, a deflection of the first shot by the mast arm would also cause 1) deformation of the bullet and an immediate separation of the jacket from the bullet core; 2) a ricochet of the bullet core and a miss of the presidential vehicle area; and 3) a deflection of the separated bullet jacket and a strike near the target area. That would explain witness observations that something struck the pavement adjacent to the presidential limousine shortly after it began traveling down Elm Street.[\[15\]](#)

In figure 28, the path of Lee Harvey Oswald's first shot is illustrated by a composite of stills from Secret Service photographs taken 27 November 1963 (Warren Commission Exhibit 875). The white arrow represents separation of the copper jacket after the pristine bullet struck the mast arm. The red arrows trace the path of the shot's bullet core. Oswald fired the second shot about 6.3 seconds later, after the presidential limousine cleared the oak tree. That bullet struck President Kennedy and then Governor Connally. Approximately 4.9 seconds after that (or 11 seconds after the first shot), Oswald fired the third and final shot that hit the president in the head.

VIII. Conclusions

The above examination results and observations are consistent with the idea that Oswald's first shot missed the presidential limousine and all its occupants because the bullet struck the mast arm. Although a bullet damage signature has not yet been found on the examined portions of the mast arm to confirm bullet contact, there is a possibility, even at this late date, that observable damage can be located on the mast arm portion that has not yet been made accessible for examination.

IX. Recommendation

It is imperative that an inspection, preferably under laboratory conditions, be conducted of the remaining five feet of the mast arm after all signage has been carefully removed.

Endnotes

[1] Schematic of "Special" for Dallas, Texas, 25 August 1955, courtesy of [Union Metal Corporation](#), Canton, Ohio. The actual length of the mast arm is greater than 15 feet because of its curvature. The figure of 15 feet represents the distance from the pole to the end of the mast arm via a straight line.

[2] The first frame of the Zapruder film to include the presidential limousine is frame 133, figure 29. Technically, Zapruder re-started his camera because he had already exposed 132 frames filming images of the motorcycle lead escort. Richard B. Trask, *National Nightmare on Six Feet of Film: Mr. Zapruder's Home Movie and the Murder of President Kennedy* (Danvers, MA: Yeoman Press, 2005), 39. By frame 133, the

limousine had already completed its turn onto Elm Street from Houston Street and was in the second set of lane dividers on Elm. According to estimates derived from measurements taken during the Warren Commission's 1964 survey, the limousine was already approximately 71 feet into Dealey Plaza, as measured from "station C," a line drawn along the west curb line of Houston Street.

[3] "Zapruder filmed the presidential limousine as it came around the corner and proceeded down Elm." Warren Commission, *Report*, [98](#); "The Zapruder film [is] the only continuous chronological visual record of the assassination." House Select Committee on Assassinations, *Report*, [45](#).

It should be noted, however, that the Warren Commission realized in May 1964, during its re-staging of the assassination, that the president's silhouette from the rear readily presented itself to Oswald *before* Zapruder started filming. The Commission labeled this "position A," and it was defined as the "first point at which a person in the sixth floor window . . . could have gotten a shot at the president's back after the car had rounded the corner." Warren Commission, Shaneyfelt Testimony, V *Hearings* [144](#)—[145](#).

[4] Warren Commission, [Virgie Rackley FBI Interview](#), 25 November 1963, [Commission Document 5](#).

During her subsequent testimony before the Warren Commission in July 1964, Miss Rackley, now known as Mrs. Virgie Mae Baker, was less sure about whether the object hit the pavement in front, in back, or to the side of the presidential limousine. But she maintained that the object struck the pavement before the second shot. Warren Commission, Baker Testimony, VII *Hearings* 509—510. Another eyewitness to the motorcade, Royce G. Skelton, who was standing about 400 feet away on the railroad overpass, told the sheriff's department on 22 November 1963 that after the first shot sounded he "saw something hit the pavement at the left rear of the [president's] car." Warren Commission, Commission Exhibit 2003, XXIV *Hearings* [227](#).

[5] Warren Commission, Foster Testimony, VI *Hearings* [252](#). The distance to the manhole cover to station C is from a measurement taken in July 2011.

When the Secret Service subsequently examined the manhole cover, concrete skirt, and adjacent turf in February 1964, it found no evidence of a bullet impact. Warren Commission, [Commission Exhibit 2111](#), XXIV *Hearings* 540. But in a later oral history, Officer Foster not only affirmed that a shot had "knocked [a] clump of grass up," he specifically linked the turf impact with the strike on the curb near Tague. "[The bullet] struck the skirt near the manhole cover and then hit this person who had stood by the column over on Commerce Street," Foster recalled. Larry A. Sneed, [No More Silence: An Oral History of the Assassination of President Kennedy](#) (Dallas, TX: Three Forks Press, 1998), 212—213.

Two other police officers who noted the impact around the skirt, Sergeant Stavis "Steve" Ellis and W. G. "Bill" Lumpkin, were in the escort group of lead motorcycles. They had

stopped before going under the triple underpass and were both looking back up Elm Street, waiting for the motorcade to catch up to them. See Sneed, *No More Silence*, 144—145, 155; Richard B. Trask, *Pictures of the Pain: Photography and the Assassination of President Kennedy* (Danvers, MA: Yeoman Press, 1994), 234—235; Gary Savage, *JFK: First Day Evidence* (Monroe, LA: The Shoppe Press, 1993), 360—361; House Select Committee on Assassinations, *XII Appendix to Hearings* [23](#).

[6] Warren Commission, Walthers Testimony, Tague Testimony, VII *Hearings* [546](#)—[547](#), [553](#)—[554](#).

Tague was unsure about associating his minor injury with a particular shot (the first, second, or third). However, in his Warren Commission testimony under oath in July 1964, he recalled that he heard a shot or shots after his cheek was stung. This means that he did not sustain his injury from the third shot, which hit President Kennedy in the head, because that was the last shot; and because the second bullet was retrieved from Governor John Connally's thigh, Tague could not have been harmed by it. Therefore, his injury could only have been caused by the first shot fired, according to his testimony. Warren Commission, Tague Testimony, VII *Hearings* [555](#).

The laser measurements established during the NatGeo re-staging in July 2011 confirmed that when shot three was fired, the sight line from the sixth floor window to the limousine was in a relatively straight alignment with the curb. Some experts have thus associated the third shot with the curb impact. See the section on “Resolving the Logical Incompatibility” in Kenneth A. Rahn, *Neutron Activation Analysis and the John F. Kennedy Assassination*, March 2001, 10—15, and Larry M. Sturdivan, *The JFK Myths: A Scientific Investigation of the Kennedy Assassination* (St. Paul, MN: Paragon House, 2005), 124—125.

However, for a large lead core fragment from the third shot to strike the curb, initially it would have had to exit the president's head in an upward direction to avoid hitting the custom chromed-steel parade rail, front windshield, chromed trim molding, and the sun visors, both of which were flipped upward (adding another 3—4 inches of height to the top of the limousine). Zapruder frame 262, figure 30, depicts the effect from the raised sun visors. Then, over a distance of approximately 270 feet, this same lead fragment would have had to drop a vertical distance of nearly 16 feet, while at the same time retaining sufficient mass and kinetic energy to leave a visible mark and metal smear on the curb. This scenario is highly improbable, given the large mutilated fragments, Warren Commission Exhibits [567](#) and [569](#), recovered from the limousine.

[7] Warren Commission, Shaneyfelt Exhibit No. 27, XXI *Hearings* [475](#), [476](#), [477](#).

[8] Subsequently, Terry D. Garcia, an executive vice president at National Geographic, wrote [David S. Ferriero](#), archivist of the United States, asking the [National Archives](#) to take possession of the mast arm and pole on the grounds that they constituted an important assassination artifact that should be preserved and not unwittingly removed and destroyed. Writing in support of the petition were [US District Court Judge John R.](#)

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[Tunheim](#) and William L. Joyce, members of the [Assassination Records Review Board](#); [Professor Melvin A. Eisenberg](#), an assistant counsel with the Warren Commission, and Larry M. Sturdivan, a wound-ballistics expert formerly employed by the US Army's [Aberdeen Proving Ground](#).

[9] Harvey Bogen, "1—Way Street Plan Proposed for City," [Dallas Morning News](#), 25 March 1956; "Streets Due for Change on Sept. 9," [Dallas Morning News](#), 11 August 1956.

[10] House Select Committee on Assassinations, XII *Appendix to Hearings* [23](#).

[11] Dale K. Myers, [Epipolar Geometric Analysis of Amateur Films Related to Acoustics Evidence in the John F. Kennedy Assassination](#) (Milford, MI: Oak Cliff Press, 2007), 111.

[12] Among the sources checked were the [Sixth Floor Museum](#); [Special Collections, Dallas Public Library](#); [Dallas Municipal Archives](#); photo morgue at [The Dallas Morning News](#); the [President John F. Kennedy Assassination Records Collection](#) at the National Archives; and the [Special Collections Library](#) at University of Texas, Arlington, as well as private collections.

[13] As best could be determined the Eagle signal with 8-inch lenses was replaced well before the early 1990s, when Oliver Stone filmed [JFK](#) in Dealey Plaza. A signal manufactured by the [Econolite](#) corporation apparently replaced the Eagle signal, probably in the early 1980s. In turn, the Econolite signal was replaced circa 2004 by the current signal, which features 12-inch lenses.

[14] In 1964, the Warren Commission first put forward the idea that the first shot "might have struck a portion of the tree [outside the sixth floor window] and been completely deflected." Since then, several well-regarded analyses have supported this proposition, including ones put forth by CBS News (1967); the House Select Committee on Assassinations (1979); Gerald Posner (1993); and ABC News/Dale K. Myers (2003). Although the various explanations proffered differ over the exact moment shot one was fired, in each instance the Zapruder film was already running; indeed, the instant of the shot is always correlated to a specific Zapruder frame. See, for example, Warren Commission, *Report*, 111 (Z frame 183/184); CBS News, *The Warren Report—Part 1*, 25 June 1967 (Z frame 186); House Select Committee on Assassinations, *Report*, 47 (Z frames 157—161); Gerald Posner, *Case Closed: Lee Harvey Oswald and the Assassination of JFK* (New York: Random House, 1993), 323 (Z frame 160); and ABC News/Dale K. Myers, *The Kennedy Assassination—Beyond Conspiracy*, 20 November 2003 (Z frame 160).

The obvious damage inflicted to the signal head from a bullet fired by the Mannlicher-Carcano, however, undermines this notion. Any object in the path of a pristine bullet will have *some* effect on its subsequent direction. Yet the oak tree's insubstantial branches (as seen in figure 31 which approximates the November 1963 view from the sixth floor

window at Z frame 160) surely did not pose an obstruction sufficient to deflect the first shot by such a margin that it missed not only the presidential party, but the entire limousine and immediate area.

[15] Some experts have suggested that rather than hit a branch of the oak tree, an intact bullet from the first shot struck the pavement adjacent to the presidential limousine and thus was responsible for the eyewitness reports of object(s) striking the roadway; see Sturdivan, *JFK Myths*, 239 (cites Z frames 152/153), and Vincent Bugliosi, *Reclaiming History: The Assassination of President John F. Kennedy* (New York: W. W. Norton, 2007), 471, 311n, 315n—317n (cites Z frame 160).

In this scenario, a pristine bullet, traveling at a near-muzzle velocity of more than 2,100 feet per second and impacting the pavement at a steep angle, would imbed in the pavement or fragment rather than ricochet. Yet no bullet mark was observed or found in the roadway by anyone in the aftermath of the assassination; nor did fragments from the disintegration of the bullet core strike any spectators in the immediate vicinity (figure 32 shows spectators lining Elm Street at Z frame 152).

If eyewitness reports of a strike on the pavement in conjunction with the first shot are to be assigned any weight, then the phenomenon must have been caused by a hit of a bullet jacket fragment after its separation from the lead core during a low-angle bullet ricochet from the mast.

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Figure 1: Warren Commission Exhibit 875, design by Sarah Clayton
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Figure 2: Warren Commission Exhibit 2111.

Figure 3: John F. Kennedy Assassination Records Collection, National Archives.

Figure 4: Johann W. Rush.

Figure 5: Max Holland.

Figure 6: Max Holland.

Figure 7: Frank DeRonja.

Figure 8: Frank DeRonja.

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Figure 9: Max Holland.

Figure 10: Malcolm E. Barker Collection, The Sixth Floor Museum at Dealey Plaza.

Figure 11: National Geographic Television.

Figure 12: Dallas Municipal Archives.

Figure 13: National Geographic Television.

Figure 14: Wheeler Sparks.

Figure 15: Tina Towner Pender.

Figure 16: Warren Commission Exhibit 875.

Figure 17: Frank DeRonja.

Figure 18: Frank DeRonja.

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Figure 21: Warren Commission Exhibit 574.

Figure 22: Frank DeRonja.

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Figure 24: Max Holland.

Figure 25: Frank DeRonja.

Figure 26: Frank DeRonja.

Figure 27: Frank DeRonja.

Figure 28: Warren Commission Exhibit 875, design by Sarah Clayton.

Figure 29: Abraham Zapruder Film, The Sixth Floor Museum at Dealey Plaza.

Figure 30: Warren Commission Exhibit 885.

Figure 31: Warren Commission Exhibit 875.

Figure 32: Abraham Zapruder Film, The Sixth Floor Museum at Dealey Plaza.

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