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ndicates that this volume provides a reference is to the world's literature in the English lan- ents are arranged listing the journals, index of and subject headings. This represents a great assemble references from journals and books in guage. This volume covers a period of 30 years the library and departments of legal medicine.

Photographic Evidence and the Assassination of President John F. Kennedy *

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Introduction

The assassination of John F. Kennedy in 1963 and the publication of the Warren Commission Report in 1964 has understandably generated a sizeable literature which deals with the events of the assassination and the interpretation of evidence associated with the case. Despite the careful attempts on the part of those charged with the responsibility of providing an official documentation of the tragedy, a considerable number of citizens and scholars continue to raise questions. Admittedly, a certain portion of the published literature is of a highly speculative and emotional nature, while some is sufficiently well balanced and scholarly to merit serious attention. The fact, nevertheless, remains that the Warren Commission Report, supplemented by some official disclosures pertaining to an examination of the X-rays of President Kennedy's body, released in 1968, is the only official document accessible to scholars at this date.

The senior author has been concerned with the interpretation of some facets of the evidence in the assassination of President Kennedy as outlined in the Warren Commission Report for several years. The considerable study and collection of information in respect to this evidence has led to the following

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simple hypothesis, namely, that the first shot to strike the President was fired at a time earlier than that reported by the Warren Commission. This paper presents the information and evidence supporting the hypothesis.

The common photographic techniques of criminal investigation are generally called into use only after a crime has been committed. However, it occasionally happens that photographs of evidential value are taken by bystanders during the crime itself. One of the most striking examples of this is in connection with the assassination of President Kennedy. Strangely enough, perhaps the first recorded case of this type of "accidental" evidence was also in a presidental assassination—that of President McKinley in 1901. Kinematographs from the original Edison Laboratory recorded the events at the Buffalo Exhibition. Investigators who studied the films of the President's speech easily identified the assassin Czolgosz, as he made his way through the large crowd toward the President. Enlargements and drawings of the frames were studied in unsuccessful attempts to detect Czolgosz exchanging glances with some confederates (1). Another motion picture camera was operating inside the Temple of Music and was just a few feet from McKinley at the exact time that Czolgosz came through the receiving line and fired the two assassination shots (2).

The assassination of President Kennedy was a particularly well-photographed event. Over 25 photographers were present on November 22, 1963, in Dealey Plaza of Dallas, Texas. Witness Phil Willis, for example, was able to take six important color slides of the presidential limousine.

Unlike the McKinley case, however, the Kennedy assassination has raised wide controversies which show little signs of easy resolution. Some 70 books have been written, defending the Warren Commission findings, attacking them, or proposing various alternatives to the official lone-assassin theory. Only the conduct and findings of the President's autopsy at Bethesda, Maryland may have received more attention than the discussions and interpretations of the abundant photographic evidence—particularly the 8-mm color film of Abraham Zapruder, well known through the publication of selected frames in Life magazine (3).

This paper will show how the photographic evidence was used to analyze the timing of assassination shots and will examine some of the problems raised by the Warren Commission reconstruction of the event. Specific details will be developed regarding the first shot to strike President Kennedy.

Background Information

Some background information is necessary prior to the photographic analysis of the gunfire which killed President Kennedy and seriously wounded Governor Connally. The events of the assassination are generally placed in time sequence relative to the Zapruder film frames, which were sequentially numbered by the FBI (see 18H1–80) (4). For example, at a frame numbered 313 a head wounding of the President is clearly visible. During the frames 208–224 of this film, the President was blocked from the view of the Zapruder camera by a Stemmons Freeway road sign at the curb of Elm Street (R98) (5). This left a certain ambiguity, for many people believe that the President was first wounded during this interval.

Also, an FBI survey on May 24, 1964, determined that during the interval of Zapruder frames 166–209 the view of the President from the alleged assassin's window in the Texas School Book Depository was blocked by a tall live-oak tree along the north side of Elm Street. Only for about a tenth of a second at frame number 186 of this interval was the President visible through a gap in the foliage (R98 18H87, 17H883). Thus, the period of frames 210–224 represents the first interval during which an assassin in the southeast window of the 6th floor could have had a shot at the President clear of the tree foliage.

FBI tests on the Mannlicher-Carcano assassination rifle established a minimum time of about 2.3 seconds for the firing of two successive shots (R97), although this time did not include allowance for aiming at a moving target. Since the FBI had determined that the Zapruder camera ran at 18.3 frames per second (R97), one can calculate that at least 42 frames of film time must elapse between any two shots, under the lone-assassin theory. Thus, if an assassin fired a

clear shot as early as frame 210, his second shot could not follow until frame 252 or later.

Warren Commission Hypothesis

This section will briefly summarize the Warren Commission hypothesis regarding the first shot to strike the President. An FBI report prepared for the commission included:

> Shot one was fired from a gun probably braced for a steady shot sighted-in on a predetermined point on the parkway just clear of tree foliage (6).

According to the analysis of the Warren Commission:

> President Kennedy was first struck by a bullet which entered at the back of his neck and exited through the lower front portion of his neck, causing a wound which would not necessarily have been lethal. (R–19)
>
> . . . the evidence indicated that the President was not hit until at least frame 210 and that he was probably hit by frame 225. The possibility of variations in reaction time in addition to the obstruction of Zapruder's view by the sign precluded a more specific determination. . . . (R105)

The above commission statements do not seem unreasonable, since the FBI photographic analysts noted nothing unusual in the frames prior to number 210, and since President Kennedy seems to be in strong reaction to a wound in frames 225–227, as he comes from behind the sign. These commission hypotheses are not without some difficulty, however. It was the firm belief of Governor Connally, as well as all the commenting witnesses, that Connally was struck with the second shot fired. Yet, the Zapruder film shows the governor reacting substantially before the frame 252 at which a second shot could have been fired, and significantly after the frame 225 in which the President is seen reacting. In fact, the governor seems to undergo no change until frame 234, at which point he slumps suddenly; he appears to be in strong reaction to a wound by frame 242. On these grounds, the commission was led to formulate the "single-bullet theory," in order to avoid the conclusion that a second rifleman was firing at the motorcade:

> . . . there is very persuasive evidence from the experts to indicate that the same bullet which pierced the President's throat also caused Governor Connally's wounds. (R19)

Thus one bullet, Commission Exhibit 399, was believed to have caused the wounds to the President's neck, and to the governor's chest, right wrist, and left thigh. The governor was theorized to have experienced a delayed reaction to his wounds in believing that he had been struck by a second shot, distinct from the one which wounded the President.

Although it was not possible to rule out completely that the assassin had taken an early wild shot through the tree, the commission strongly hinted that such was not the case, on the reasonable grounds that there was no motivation for such a blind shot:

> . . . it is unlikely that the assassin would deliberately have shot at him with a view obstructed by the oak tree when he was about to have a clear opportunity. It is also doubtful that even the most proficient marksman would have hit him through the oak tree. (R98)

The commission seems to be on solid ground in favoring that the first shot to strike the President was the first shot fired. Virtually all of the witnesses were of this opinion. Representative testimony is that of Secret Service Agent Clint Hill: (2H138)

> . . . I heard a noise from my right rear, which to me seemed to be a firecracker. I immediately looked to my right . . . and I saw President Kennedy grab at himself and lurch forward and to the left. . . . This is the first sound that I heard; yes, sir. I jumped from the car, realizing that something was wrong, ran to the presidential limousine.

Alternate Hypothesis

Besides the statements of Agent Hill, much related testimony and evidence will be presented in the following sections. In light of the previous discussions, the frames prior to number 210 may be referred to as the "early frames." The following

sections of this paper will present evidence to support the following hypothesis regarding this portion of the assassination: *Contrary to the theory of the Warren Commission, the evidence developed will show that President Kennedy was first wounded in the early frames of the Zapruder film, prior both to the time when he disappeared behind the Stemmons Freeway sign and to the time at which a clear shot was possible from the alleged position of the assassin. Specifically, during the interval of frames 186–190 in the Zapruder film, the first shot fired struck President Kennedy and threw him forward and to the left.*

Nine points relative to the photographic evidence will be developed.

(1) Phil Willis. Witness Phil Willis took his fifth color slide from a vantage point on the south curb of Elm Street. Willis can be seen in the early Zapruder frames; e. g., number 183, where he identified himself as, "the individual who stands almost directly behind the first motorcycle policeman in that picture. . . . With my camera raised. . . ." (7H493) Willis indicated that the first shot came *just before* this picture. He testified about the fifth slide:

> . . . in fact, the shot caused me to squeeze the camera shutter, and I got a picture of the President as he was hit with the first shot. So instantaneous, in fact, that the crowd hadn't had time to react. . . . (7H493)
>
> Mr. Liebeler: Do you remember hearing the shot?
>
> Mr. Willis: Absolutely. I, having been in World War II, and being a deer hunter hobbyist, I would recognize a high-powered rifle immediately. . . .
>
> Mr. Liebeler: And you heard it just about the time you took the picture that has been marked?
>
> Mr. Willis: That's right.
>
> Mr. Liebeler: Prior to the time you took the picture, which is marked Hudson Exhibit No. 1? [Willis slide 5]
>
> Mr. Willis: Absolutely. (7H495)

Fortunately, there is a simple and accurate method for the determination of the time of exposure of the Willis slide. Just as the Zapruder frames show Willis, the Willis slide in

turn shows Zapruder, standing with his movie camera on a pedestal of a concrete arcade. The view of the motorcade captured by the Willis slide must correspond to only one point of the Zapruder film.

As a first step in analysis, one may consider the direct line joining the two cameras of Willis and Zapruder. In the Willis slide, this line is seen to pass just north of the Stemmons Freeway sign (Figs. 1 and 2). Directly below this two-camera line is the edge of the left shoulder of Agent Clint Hill, who rides the left front running board of the presidential follow-up car. Thus, at the time of the Willis picture, Agent Hill was directly between Zapruder and Willis.

The timing of the Willis slide can now be found by watching the motion of the follow-up car in the Zapruder film. Study of the frames reveals that the corresponding view over Hill's shoulder is realized only at Zapruder frame 202. At this frame, and at no other, Agent Hill is seen to lie directly between Zapruder and Willis. Corroboration for this analysis

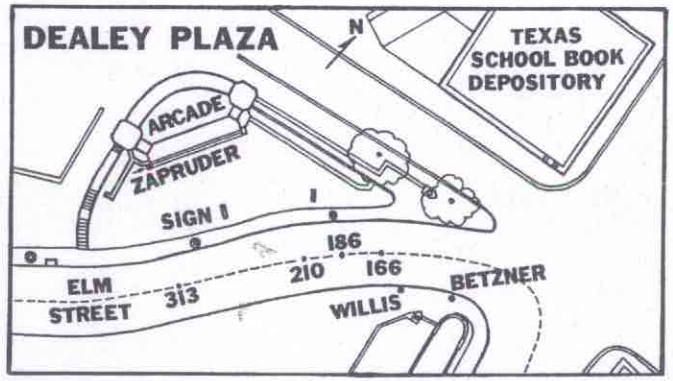

Fig. 1—This map of Dealey Plaza locates most of the relevant landmarks. The numbers in Elm Street show the position of the President at four important frames of the Zapruder film. Also, the three photographers mentioned in the text are located. Just two of the many trees have been marked; the tree mentioned in the text is the one to the east. The sign marked in the map is the "Stemmons Freeway Keep Right" sign which appears in the Zapruder film.

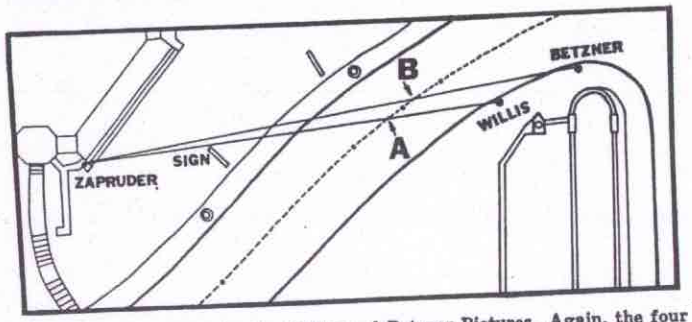

Fig. 2—Lines of View for the Willis and Betzner Pictures. Again, the four numbered dots in Elm Street mark the location of the President at Zapruder frames 166, 186, 210, and 313. Of more importance here, however, are the points marked "A" and "B". Point "A" marks the intersection of the Willis-Zapruder two-camera line with the path of the motorcade. The Willis slide shows Agent Hill at point "A", as does the Zapruder frame number 202. Point "B" marks the intersection of the Betzner-Zapruder two-camera line with the path of the motorcade. The Betzner photograph shows Agent Hill at point "B", as does Zapruder frame number 186.

is noted, as Willis seems to be lowering his camera from his eye in succeeding frames.

Study of the motion of the motorcade in the Zapruder frames will confirm the accuracy of the above analysis. FBI Agent Shaneyfelt, analyzing this same picture for the Warren Commission in Shaneyfelt Exhibit 25, used a triangulation of the positions on a map of Dealey Plaza. Regarding the position of Willis for the triangulation, Shaneyfelt testified:

> . . . I first determined from correspondence, that Mr. Willis was standing along the south curb of Elm Street, approximately opposite the Texas School Book Depository Building. (15H696)

After performing the triangulation, Shaneyfelt concluded that the Willis picture:

> . . . was taken in the vicinity of the time that frame 210 of the Zapruder picture was taken. This is not an accurate determination because the exact location of Mr. Willis is unknown. This would allow for some variation, but the

> time of the photograph A [the Willis slide], as related to the Zapruder picture, would be, generally, during the period that the President was behind the signboard in the Zapruder films, which covers a range from around frame 205 to frame 225. (15H697)

Although this testimony agrees perfectly with the Warren Commission hypotheses on the first shot, Shaneyfelt may have committed an error of some significance in placing Willis' position about seven or eight feet too far back from the curb (Figs. 1, 2, and 3). Thus his triangulation calculated too high a frame number and placed the car too far down Elm Street. In fact, the relevant Zapruder frames show Willis standing exactly *on* the curb of Elm Street. If Shaneyfelt's triangulation technique is carried out again, using the actual position of Willis, a value of frame 202 is obtained, in agreement with the previous analysis of this section.

Thus, the testimony of Phil Willis and accurate analysis of his photograph actually give strong evidence that the first shot may have been fired in the early frames prior to number 202.

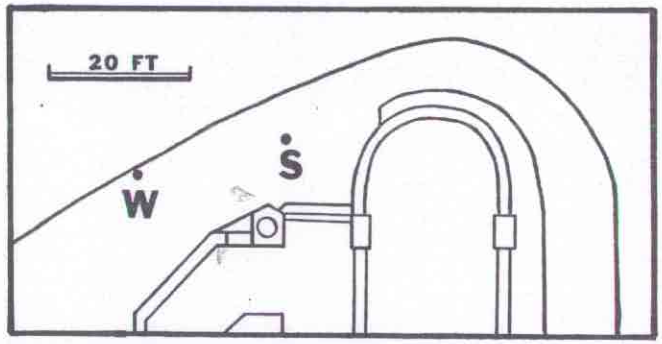

Fig. 3—"W" marks the actual position of Phil Willis as shown in the relevant Zapruder frames. "S" marks the position given Willis by Agent Shaneyfelt. Had Agent Shaneyfelt placed Willis forward nearer the curb, his triangulation would have been shifted upward and would have passed through the motorcade curve at the correct figure of frame 202.

(2) Mrs. Kennedy. Mrs. Kennedy was seated to the left of the president in the rear seat of the limousine. Regarding the first shot, she testified:

> . . . I was looking this way, to the left, and I heard these terrible noises. You know. And my husband never made any sound. So I turned to the right. And all I remember is seeing my husband, he had this sort of quizzical look on his face, and his hand was up. . . . I used to think if I only had been looking to the right I would have seen the first shot hit him. (5H180)

Three witnesses mention Mrs. Kennedy's actions at the time of the first shot. Phil Willis, very near the car, testified:

> Mrs. Kennedy was likewise smiling and facing more to my side of the street. When the first shot was fired, her head seemed to just snap in that direction, and he more or less faced the other side of the street and leaned forward, which caused me to wonder. . . . (7H496)

S. M. Holland viewed the motorcade from the Triple Underpass directly ahead of the car on Elm Street. He testified that prior to the shots Mrs. Kennedy had been looking off:

> . . . in the southern direction . . . about that time he went over like that and put his hand up, and she was still looking off, as well as I could tell . . . that was the first report that I heard . . . she turned around facing the President and Governor Connally. In other words, she realized what was happening. . . . (6H243)

Kenneth O'Donnell, riding in the follow-up car, commented similarly:

> She appeared to be immediately aware that something had happened. She turned toward him. (7H449)

The Zapruder film lends evidential value to the above observations. In the beginning frames of the film Mrs. Kennedy is indeed looking off into the crowd on the left side of the street. The point at which she suddenly snaps her head around to the right is extremely striking in the film. Study of the individual frames show that this turn occurs at frames 195–197.

After that point Mrs. Kennedy seems to be looking directly into the President's face.

Mrs. Kennedy's actions, corroborated by several witnesses and the film, are a strong indication that the President may have been struck by an early shot.

(3) Agent George Hickey. Secret Service Agent Hickey was seated in the left rear seat of the follow-up car. He is easily located in the still photographs of Phil Willis and Hugh Betzner, as well as the Zapruder frame, where his head and shoulders are visible above the windshield of the follow-up car. Agent Hickey is the man who handled the AR–15 rifle just after the assassination shots were fired.

Discussing his reaction to the first shot, Hickey stated:

> . . . I heard a loud report which sounded like a firecracker. It appeared to come from the right and rear and seemed to me to be at ground level. I stood up and looked to my right in an attempt to identify it. . . . (18H762)

The beginning Zapruder frames show Agent Hickey watching the crowd on the left side of the street, up until frame 194. At frame 195, however, he can be seen to begin turning about to the right. Half-standing in the rear seat, Hickey continues turning to the right for as long as he can be seen in the frames; i. e., up to frame 207, at which point he is looking off to the right of the motorcade. A still photograph, taken by James Altgens and identified by the commission as having been taken at frame 255 (R112), shows Hickey and several other agents twisted around and looking back in the direction of the depository building.

Agent Hickey seems to be a good witness and his actions are another indication that an early shot was fired.

(4) President Kennedy. It is clear that the actions of President Kennedy in the early Zapruder frames are of interest. FBI Agent Shaneyfelt testified before the Warren Commission about these frames:

> . . . in some frames it is obvious that he is smiling. . . . His arm is up on the side of the car and his hand is in a wave. . . . I see nothing in the frames to arouse my suspicion about his movements . . . as he disappears behind the signboard. . . . (5H151)

Frame 183 shows the essential features described by Shaneyfelt. The President is sitting on the extreme right side of the car and is leaning back against the rear seat. His head is turned almost directly to the right as he waves to the crowd. His right arm extends out over the side of the car, and his right elbow can be seen well below a chrome strip visible on the outside of the car.

A very marked change is apparent by frames 225–230, as the President emerges from behind the signboard. As has been mentioned previously, the President seems to be in strong reaction to a wound at this point. For example, in frame 230 the President is leaning forward, away from the seat, back and away from the right edge of the car. His head has turned back from the crowd, and he faces almost directly forward. More importantly, these frames show that the President's hands have been raised to the area of his chin and neck. Also, his arms are in an extremely unusual position, with both elbows raised very high, almost to the level of his chin.

The Warren Commission believed that frames 225–230 represented the President's reactions to a shot fired somewhere in the interval of Zapruder frames 210–224, while the President was behind the road sign. However, certain observations in the Zapruder film will be noted here to indicate that the first wounding of the President may not have been blocked from the record by the road sign. The transition in the President's appearance between frames 183 and 230 (described above) in fact seems to begin with certain reactions in the interval of frames 194–206.

First, a general trend in the frames 194–206 may be noted. Beginning as early as frame 194, the President's body seems to undergo a motion forward and to the left. This motion, which can be visually approximated to be on the order of six or seven inches, seems to begin in frame 194 and continues through about frame 200. The President seems to move away from the seat back and to tilt to the left, away from the window ledge. The witness statement of Kenneth O'Donnell may be noted:

> He was leaning out waving. He may have just been withdrawing his hand. And the shot hit him, and threw him to the left . . . looking at the manner of the President's movement, I would think you would have to feel the thrust of the shot was from the right rear. (7H449)

Study of the frames reveals further information. Recalling the descriptions above, it is clear that between frames 183 and 230, two specific changes occurred in the President's position. First, the President turned his head and shoulders back from the crowd until he was facing forward. Also, the President's right arm moved from a position with the elbow below a chrome strip on the outside of the car, into a position with the arm and elbow well inside the car and raised almost to chin level. These frames and motions have been described in such great detail because both of these specific changes in Kennedy can be observed to occur in the "early Zapruder frames," i. e., those *before* the President disappears from view behind the road sign. In this context, it happens that frame 204 is very important.

On the interval 194–200 the President's body is seen to narrow somewhat to the view, indicating that he not only leans to the left front, but also is rotated to the left. The rotation of the shoulders begins as early as frame 195. His head comes around at 200–202. By frame 204 the President is facing almost directly forward.

As the President moves and rotates to the left, his right arm is pulled back into the car. While his elbow has been resting outside the car, it comes up noticeably at frame 195. The President's elbow can be seen to cross the chrome strip on the side of the car at frames 198–199. As President Kennedy disappears from view behind the sign, his right arm seems to be in a particularly unusual position—the clearly visible gray of his suit coat indicating that his right arm and elbow have been raised at least to the level of his chin.

At this point, three of the most detailed witness descriptions may be quoted:

> David Powers: President Kennedy was sitting on the extreme right-hand side of his automobile, with his arm extending as much as two feet beyond the right edge of the car . . . the first shot went off and it sounded to me as if it were a firecracker. I noticed then that the President

moved quite far to his left after the shot from the extreme right-hand side where he had been sitting. (7H473)

Mr. Holland: And the motorcade was coming down in this fashion, and the President was waving to the people on this side (indicating). . . .

Mr. Holland: And about that time he went over like that (indicating), and put his hand up, and she was still looking off, as well as I could tell.

Mr. Stern: Now, when you say, "he went like that," you leaned forward and raised your right hand?

Mr. Holland: Pulled forward and hand just stood like that momentarily.

Mr. Stern: With his right hand?

Mr. Holland: His right hand; and that was the first report that I heard. (6H243)

William Newman: We were looking back up the street to see if the motorcade was coming and the first two shots were fired, and of course the first shot, boom, the President threw his arms up like that, spun around sort of . . . (7).

These witness statements compare favorably with the actions of President Kennedy noted in the frames 194–206. The following seems clear: the actions of President Kennedy in the early Zapruder frames are not at all inconsistent with the hypothesis that the President was first struck in these early frames, prior to frame number 195.

(5) Linda Willis. Witness Linda Willis, a daughter of the witness whose photographs were mentioned above, can be located in Zapruder frame 183, in which she is dressed in a red dress and white scarf and is at the extreme right of the frame. She described for the Warren Commission:

. . . well, I followed along the street with the car . . . I was directly across when the first shot hit him . . . I was right in line with the sign and the car, and I wasn't very far away from him . . . When the first one hit, well, the President turned from waving to the people, and he grabbed his throat, and he kind of slumped forward . . . I stayed there . . . where the Stemmons sign is. . . . (7H498)

In all the Zapruder frames up to 199 Linda Willis can be observed as she runs along the grass on the south side of Elm Street, following the presidential limousine. At frame 200, however, she abruptly stops running. In succeeding frames (200–204) she turns sharply and looks back to the right and rear of the motorcade. At this point the car is indeed directly between her and the Stemmons Freeway sign. Linda Willis then remains fixed in the same spot for as long as she is visible; i. e., up to frame 222.

It is reasonable to suggest that these frames are showing Linda Willis reacting to the sound of an early first shot.

(6) Governor Connally. It is well known that the governor and his wife believe that the President was struck with the first shot and that the governor was hit by the second shot. The governor has stated:

My recollection of that time gap, the distinct separation between the shot that hit the President and the impact of the one that hit me, is as clear today as it was then. They talk about the "one-bullet" or "two-bullet theory," but as far as I'm concerned, there is no "theory." There is my absolute knowledge, and Nellie's too, that one bullet caused the President's first wound, and that an entirely separate shot struck me (8).

After hours of study of the clear Life magazine enlargements, Connally chose frame 234 as the point where he was hit by the second shot. No record is found indicating that he was asked when he thought the first shot had come, even though he claimed a clear recollection of the time gap. Fortunately, he had volunteered his opinion on this point during an earlier session with the Zapruder pictures, on April 21, 1964. At this commission screening of 35-mm slides prepared from the frames, Governor Connally's opinion was recorded in a memorandum for the record:

. . . He felt the President might have been hit by frame 190. He heard only two shots and felt sure that the shots he heard were the first and third shots. He is positive that he was hit after he heard the first shot; i. e., by the second shot, and by that shot only (9).

Governor Connally's estimate for the time of the President's reaction to the first shot is striking corroboration for the previous analysis of this report. The above memorandum was not introduced into evidence and thus did not become a part of the commission's published record.

(7) Blurred frames. Study of the Zapruder frames immediately reveals that some of the frames are much more blurred than others. For example, highlights in the windshield and chrome of the presidential limousine appear as dots in frame 193, while they become horizontal streaks in frame 197. The phenomenon of blurred frames has been studied in some detail by Dr. Luis Alvarez of the University of California, Berkeley. It is his hypothesis that the blurred frames do not just appear randomly in the Zapruder film, but rather they seem to occur in distinct chains of blurs. His analysis indicates that the chains of blurs are attributable to horizontal oscillations of Zapruder's camera, possibly as a neuromuscular response to the sounds of shots fired.

Without going into the details we can see how this can be related to the analysis of the first shot (10). A very pronounced chain of blurs occurs over the entire interval of frames 190–207. This can be interpreted as a possible reaction of Zapruder to the sound of an early first shot.

(8) Hugh Betzner, Jr. Witness Hugh Betzner, Jr., took the last of a series of three black and white still photographs from a vantage point on the south curb of Elm Street. His location can be established from his photograph and the Zapruder frames; frame 183 shows Betzner at the curb, with his camera raised to his eye. He is dressed in white and is located almost directly above the red searchlight on the left front of the Secret Service follow-up car.

In an affidavit of November 22, 1963, Betzner reported that the first shot came just after he took his last picture:

> I took another picture as the President's car was going down the hill on Elm Street. I started to wind my film again and I heard a loud noise. I thought that this noise was either a firecracker or a car had backfired. (19H467)

To calculate the time of exposure of the Betzner picture, one can use the same method that was described in detail for

the Willis slide in part *1*. In Betzner's case the two-camera line passes over the fifth lady standing east of the Stemmons Freeway sign and by a curious coincidence with the Willis picture also passes over the left shoulder of Agent Clint Hill (Figs. 1 and 2). Comparison shows that the corresponding Zapruder frame can only be number 186.

This result is of some interest, for it is in perfect agreement with the previous analysis that the first shot came in the early frames, prior to frame 195 (and possibly prior to frame 190), and just after the time of the Betzner picture. This result further serves as a strong indication that the first shot did not come before the presidential car went under the tree at frame 166; no witness places a shot that early, moreover.

The exposure times of both the Betzner and Willis pictures are now known to be frames 186 and 202, respectively. Given the average speeds of the presidential limousine as 11.2 miles per hour (R49) and of the Zapruder camera as 18.3 frames per second (R97), it is possible to estimate the distance travelled by the car between the two pictures. Two alternate methods of this calculation are based on the FBI survey measurements of Dealey Plaza (17H902) and the known dimensions of the car (17H867). The three figures derived are 14, 15, and 14 feet, respectively, according to the analysis of this report.

While the Betzner photograph was not used by the Warren Commission, it was printed in Life magazine. Part of the text there mentioned an analysis by Itek Corporation, a company which is a recognized expert in photoanalysis:

> Itek, using a technique called resectioning to determine the time of exposures, computed the President's car to be five feet farther along Elm Street in Willis' picture than in Betzner's. Similar analysis places the time of the Willis picture as just before the first shot (11).

Both of these statements are contradicted by the analysis of the present report. In fact, Howard Sprague, Jr., Vice President of Itek, has acknowledged by letter the error in the first statement, for reasons similar to Agent Shaneyfelt's erroneous triangulation:

> We have analyzed the distance question since November of 1967 . . . and have found the distance to be 13.5 feet

> with one method using single frame resections, and 15.5 feet with a second method in which the two photographs were positioned by synchronization with a Zapruder frame. . . . Our discrepancy occurred because we lacked reliable information concerning the exact locations of Betzner and Willis (12).

Regarding the second Itek statement above, Mr. Sprague said that the Itek report contained "no insinuated relationship with the sequence of gunshots" (13). Thus, the second sentence quoted above is exclusively a Life conclusion and has no scientific support from Itek.

In summary, the Betzner and Willis pictures, while similar in view, provide an interesting contrast of the beginning and the end of a period of particular interest in the Zapruder film.

(9) Secret Service reconstruction. This final point consists more in corroboration of the above points than in further evidence. Surprisingly, a document in the National Archives shows that an agent of the Secret Service made observations of President Kennedy in the Zapruder film very similar to those of section 4 above. An FBI document, filed on November 29, 1963, includes:

> SA John Joe Howlett, United States Secret Service, Dallas, advised that with the aid of a surveyor and through the use of 8-mm movie films depicting President John F. Kennedy being struck by assassin's bullets on November 22, 1963, Howlett was able to ascertain that the distance from the window ledge of the farthest window to the east in the sixth floor of the Texas School Book Depository Building, 411 Elm Street, to where the President was struck the first time in the neck was approximately 170 feet. He stated this distance would be accurate within two or three feet. . . . SA Howlett advised that it had been ascertained from the movies that President Kennedy was struck with the first and third shots fired by the assassin, while Governor Connally was struck with the second shot (14).

A map was included, which showed a point "A" at 170 feet from the window, with the notation: "President struck with first bullet."

The reference to distance of firing clearly indicates that Agent Howlett meant neither the "blind" period behind the sign (indeterminate to about 12 feet) nor the frames of obvious reaction after 225 (all further than 191 feet from the window). (18H90) Indeed, Howlett's figure of 170 feet corresponds to about frame 199 or 200. It can be recalled from section 4 above, that at this point of the film the reaction of President Kennedy first becomes particularly noticeable.

The above document, filed within a week after the assassination (on the same day that the Warren Commission was formed), clearly represents the original Secret Service analysis of the assassination, before the permutations of rifle speed and the single-bullet theory had been added. One other relevant archives document concerns a screening of the 35-mm slides for which Howlett was present in Washington on April 14, 1964. A memorandum for the record contains remarks which may be attributable to Agent Howlett:

> (b) The reaction shown in frames 224–225 may have started at an earlier point—possibly as early as frame 199 (when there appears to be some jerkiness in his movement) or, with a higher degree of possibility, at frames 204–06 (where his right elbow appears to be raised to an artificially high position) (15).

Again, this agrees with the analysis in section 4 of the present report.

After the detailed FBI reconstruction of May 24, 1964, which established the obstruction by the oak tree prior to frame 210, there is no indication that the commission investigators gave further consideration to the clues given by Howlett's report and later comments.

Neither of the two documents mentioned was introduced into evidence or the published record.

Conclusions

The Warren Commission conclusion of a first wounding of both President Kennedy and Governor Connally (the "single-

bullet theory") occurring during the frames 210–224 used to some extent the process of elimination, based on the blocking by the road sign, the conviction that the first shot was fired clear of the tree foliage, and the ignorance of evidence in the early Zapruder frames. The evidence developed in this report supports the conclusion that President Kennedy was first wounded during the interval of frames 186–190 in the Zapruder film.

Such topics as the medical evidence or the detailed ballistic evidence clearly go beyond the photographic analysis of this report. For the present, however, one thing can be concluded with some certainty: the exact events of President Kennedy's assassination did not happen as described in the Warren Report.

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To anyone familiar with the writings on the assassination, it is unnecessary to add that the conclusions of this report are not to be taken as necessarily representing the views of the persons mentioned here or those mentioned in the text of the report.

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