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AN EXPERIMENTAL STUDY OF THE BACKWARD MOVEMENT OF PRESIDENT KENNEDY'S HEAD

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ATTENTION has once again been drawn to the Warren Commission Report by its critics concurrent with the first publicly televised showing of the "Zapruder" motion picture of the shooting of President Kennedy before national audiences in 1975. Special attention has been focused on the backward movement of President Kennedy's head and body, which starts one frame (4) after his head was driven forward by a bullet coming from behind and a jet of brain tissue left his head, traveling up and toward the front of the car (3). The sudden subsequent backward and sideways lurch of his body was shown over and over (4), accompanied by insistent, repetitious statements that his backward lurch proved that the President's head was hit by a second bullet coming from the front or right-front of the Presidential automobile.

After this statement was repeated several times, an emotional plea was made by the announcer to reopen the investigation of President Kennedy's shooting on the basis of this so-called proof of an additional assassin's bullet, namely, the backward motion of his head after the initial forward motion.

It was the purpose of this study first to examine whether the backward motion of the head and body might have been due to reasons other than an additional bullet striking the President from the front or right-front and second to re-examine any evidence which might be relevant to the possibility of a bullet having struck the President's

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head from the front or right-front, based on our previous examinations of the President's autopsy photographs and roentgenograms of his body (11).

To study these problems, the experiments and theories of Alvarez and his associates (1) and Hanson (6) were reviewed, the Zapruder movie was again reviewed in detail and new experiments were conducted, using materials like those at Dallas.

POSSIBLE REASONS FOR THE BACKWARD AND SIDEWAYS LURCH OF THE PRESIDENT AFTER HE WAS SHOT IN THE BACK OF THE HEAD

Was it due to the abrupt acceleration of the automobile?

The answer to this question is clearly no!

The acceleration of the automobile was not a factor in the backward lurch, because the automobile did not accelerate abruptly until many frames after the ones in question (4).

Could it have been partly due to a jet engine effect from the heavy brain material leaving the front of the head with explosive force? The answer to this question is clearly yes!

Doctor Luis Alvarez, of the Department of Physics of the University of California at Berkeley, postulated that the explosive escape of heavy semiliquid brain material through a large wound of exit in the front of the head must have the propulsive effect of a jet engine, immediately driving the remainder of the head backward toward the rear of the automobile, toward the shooter. In cooperation with Sharon Buckingham, Paul Hoch

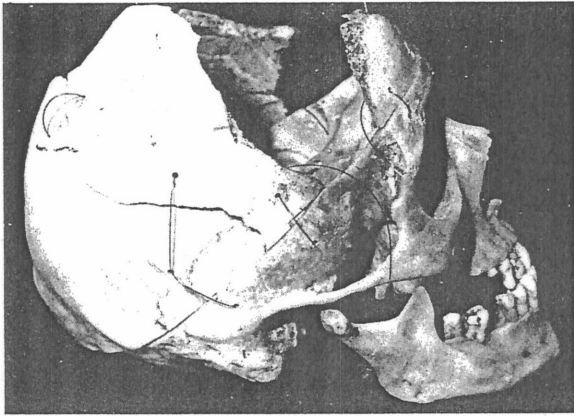


FIG. 1. Duplication of President Kennedy's skull wound, produced by a 6.5 millimeter Mannlicher-Carcano fully jacketed military bullet, striking at same point and at same angle as the one which struck the President. The wound of entry is cone-shaped, and the calvarium has burst into many fragments, with the front segments flying so far they were not recovered.

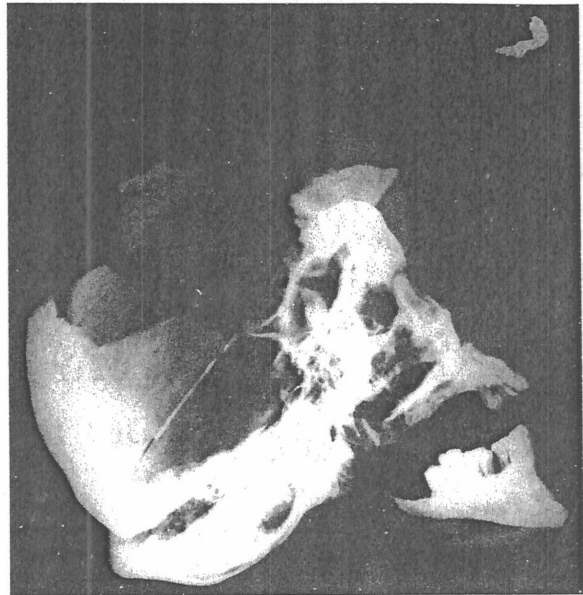


FIG. 2. Roentgenogram of the skull shown in Figure 1. Part of the bullet (Fig. 5), deformed by striking this skull, is shown in the upper right corner of the photograph.

and Don Olson, he undertook an experiment using melons about the size of a human head, wrapped with two layers of tough adhesive tape, containing strong fibers, to simulate the scalp. These were set upon stands or suspended by straps of tape and fired into while being photographed from the side with a Super 8[®] motion picture camera using a remote control apparatus. Alvarez permitted us to see the results which dramatically confirmed his assumption. While a small jet of liquefied melon contents escaped from a small wound of entrance, a large mass of heavy, liquefied melon pulp jetted out the far side, through a large wound of exit. It immediately pushed the melons forcibly backward off the stand and caused the suspended melons to revolve so violently backward and upward around the point of suspension as to tear them completely loose from the restraints. Shots through melons not wrapped with tough layers of simulated scalp did not have this effect. The results of Alvarez's experiments have been published (1).

MELON EXPERIMENTS REPEATED AND EXTENDED

In reviewing these experiments, it became obvious that, because of the logistic problems in procuring and testing high-powered military ordnance which is not readily available, there were some aspects of these tests which needed to be repeated and extended, especially if, as seemed likely, they might be regarded as relevant to the backward motion of President Kennedy's head after he was shot. First of all, the rifle, used by Alvarez and his colleagues, used .30 caliber 30-06 cartridges with an extra load so as to have a muzzle

velocity of 3,000 feet per second, and the bullets used were the expanding-type, soft-nosed hunting variety. By contrast, we know that President Kennedy was hit by 6.5 millimeter bullets of only about 2,000 feet per second muzzle velocities and that two of the bullets which were recovered and presented by the Warren Commission had intact jackets and were indeed fully jacketed military bullets, rather than soft-nosed expanding bullets (2, 23). The theoretic possibility does exist that the shooter of President Kennedy might have slightly mutilated the noses of the other two bullets fired so that their jackets would open and these bullets might then have acted as soft-nosed expanding bullets after all, although there is actually no evidence to support this theory.

In any case, it seemed worth-while to repeat Alvarez's experiments, using fully jacketed Mannlicher-Carcano 6.5 millimeter cartridges made by the Western Cartridge Company, as at Dallas, and to use not only melons but skull components and combinations of melons and skull components to find out whether the reactions of the simulated heads would then be the same as those demonstrated by Alvarez and his group.

OSWALD-TYPE CARBINE USED

In April 1975, a series of experiments was conducted by the authors, using a Mannlicher-Carcano 6.5 carbine of the model 91-38, serial No.

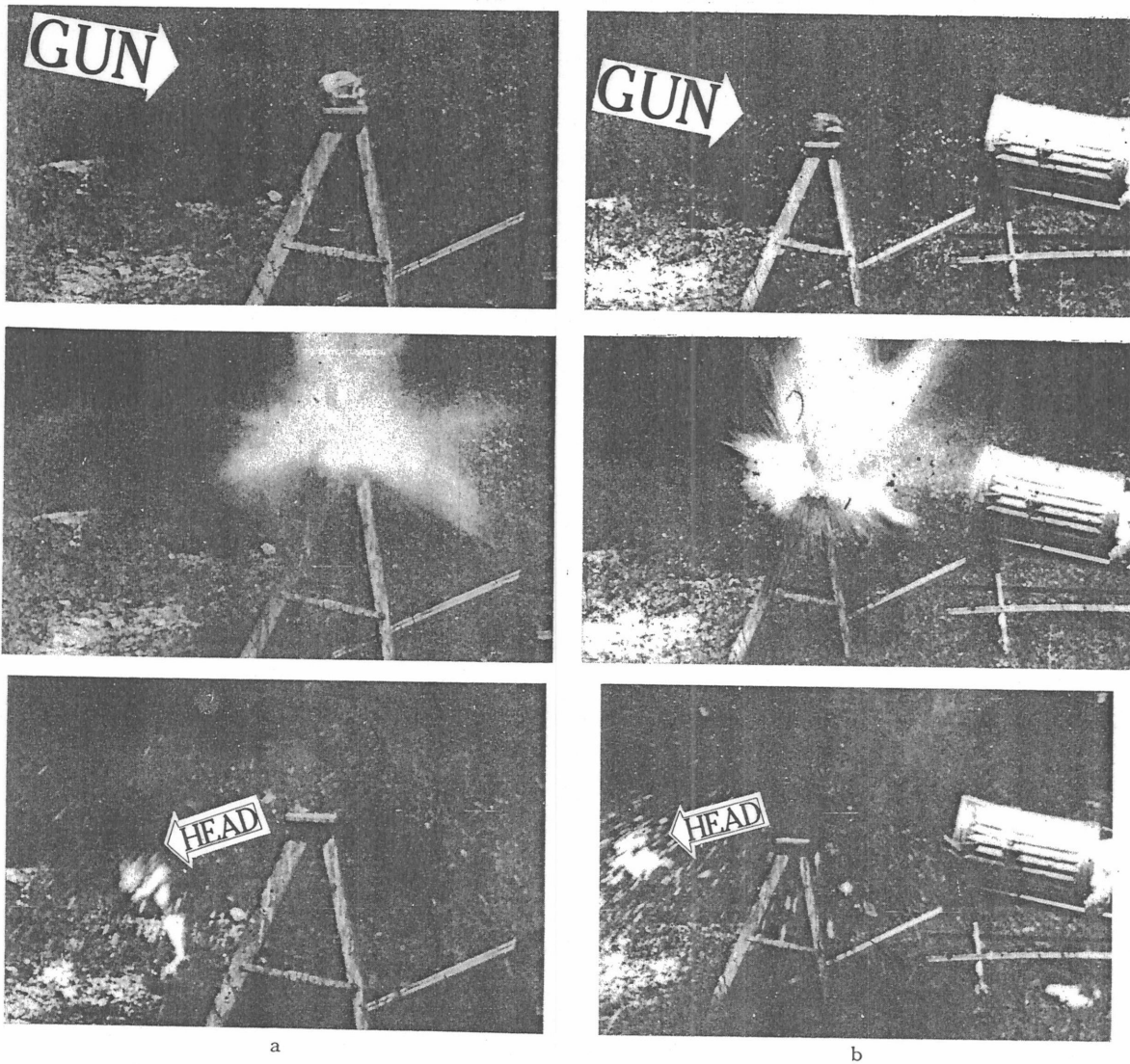


FIG. 3. a and b, Backward movement of heads. Remnants of heads jump off the stand toward the gun when struck by fully jacketed Carcano bullets exactly where President Kennedy was struck. Explosive jet of heavy semiliquid brain substance escapes in all directions but always somewhat more through large wound of exit on front of skull, producing a jet-engine effect. This drives what is left of the head toward the gun and toward the left, as with President Kennedy. This effect can be seen in both of these examples, from a series of 12, photographed with a movie camera similar to Zapruder's.

C2766, equipped with an Ordnance Optics Company four-power telescope, mounted exactly as on the rifle, Warren Commission Exhibit No. 139, which was demonstrated unequivocally by the Warren Commission to have been used to fire both bullets recovered from President Kennedy's car or at Parkland Hospital on the afternoon of 22 November 1963 in Dallas. The ammunition used was from lot 6,000 manufactured by the Western Cartridge Company of East Alton, Illinois, and verified as being one of the four lots manufactured at

the same time as the ammunition used in the killing of President Kennedy (15).

ALL TEST OBJECTS FELL BACKWARD, TOWARD THE GUN

When these bullets were fired into wrapped melons, the melons did indeed move backward off the stand, sometimes rocking preliminarily away from the gun. The size of the splash from our melons was not as large nor as violent as in the experiments of Alvarez and his group, possibly due

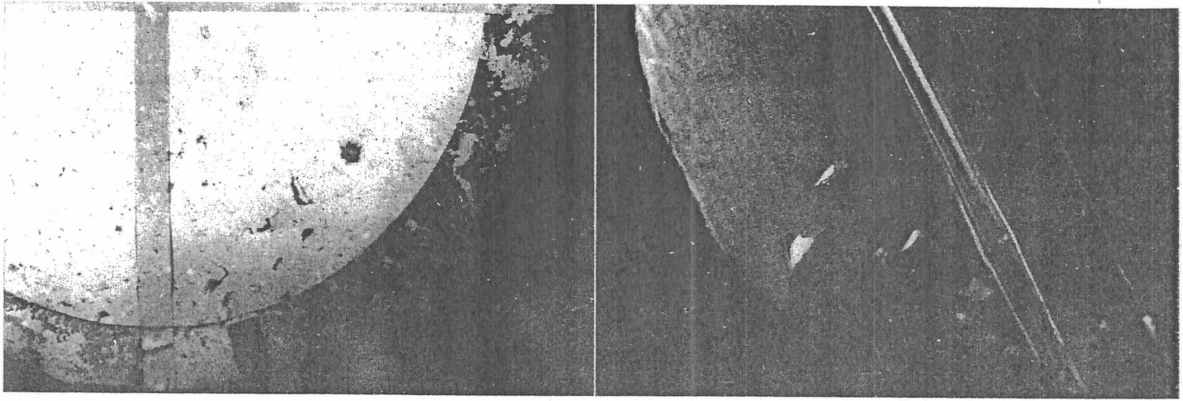


FIG. 4. Bullet fragments diverging. Cardboard screen which covered front of bullet trap seen in Figure 3b. Note the wide spread of the holes caused by the diverging bullet fragments as they struck the bottom of the screen and the splattering by simulated white brain substance, exactly as Governor Connally said he was splattered by brain tissue after the Kennedy head wound at Dallas.

to the fact that our melons may have been relatively greener than those of the Alvarez group and did not have as large a proportion of liquid contents due to the earliness of the melon growing season. However, it was also possible that the difference was due in part to the fact that Alvarez's group used soft-nosed bullets, which expanded, transferring a great deal more energy to the inside of the melon. This caused a larger wound of exit and a larger jet of melon contents leaving the melon through the wound of exit, which then drove the melon toward the shooter with more violence. Combinations of calvariums and melons were next tested, and again, all fell backward off the stand toward the shooter. No melon or skull or combination ever fell away from the shooter in these multiple experiments, in which President Kennedy's wound was duplicated accurately.

SKULL COMPONENTS TESTED

Human skulls were then packed with solid melon contents and taped tightly together with strong tape to simulate the scalp. These were fired into at the same point and at the same angle as the President was struck. The skull wounds produced were strikingly similar to those of President Kennedy (Figs. 1 and 2). Again, the skulls fell, jumped, off the stand toward the shooter, and large fragments of the top of the skull flew upward and forward for distances of 20 feet or more, just as fragments of President Kennedy's skull can be seen to fly upward and forward in frames 313 through 318 of the Zapruder movie. On this occasion also, the backward lurch of our skulls was not as violent as that in the Alvarez experiments, possibly due to the less liquid consistency of the melon contents used to simulate brain tissue and to the fact that

we used fully jacketed 6.5 millimeter, nonexpanding military ammunition. Alvarez noted that his melons recoiled backward faster than the President's head recoiled. When we repeated these experiments using more accurate simulations of fresh brain tissue inside the skulls mixed with white paint for visibility, our bullets struck the simulated heads at the same point on the right upper rear portion, as with President Kennedy. The bullets always broke up on striking the skull and then diverged, making a larger wound of exit. The brain tissue then exited explosively with the greater jets exiting through the larger wounds of exit on the front-right of the heads. This caused the jet-engine effect to drive what was left of the heads violently off the stand toward the shooter in every one of 12 experiments. What remained of each head was to the left of its original position, in addition to being back toward the gun (Fig. 3a and b). A cloud of brain tissue and fragments flew up in all directions.

NO SIMULATED HEAD EVER FELL AWAY FROM THE GUN

We wish to emphasize again that none of our test objects, melons or skulls, ever jumped or fell off the stand away from the shooter. In his book, Colonel Hanson had also mentioned that the retro-movement of the head could have been due to the jet-engine effect (6). However, he conjectured that the first of the three shots had hit President Kennedy a glancing blow on the right-anterior part of his skull, which was later shot away completely, thereby creating a weak spot out of which the jet of brain tissue flew more easily, creating the backward motion even more positively. Our experiments demonstrated that the jet-engine effect could be achieved even without a previous weakening of the anterior part of the head. It is of

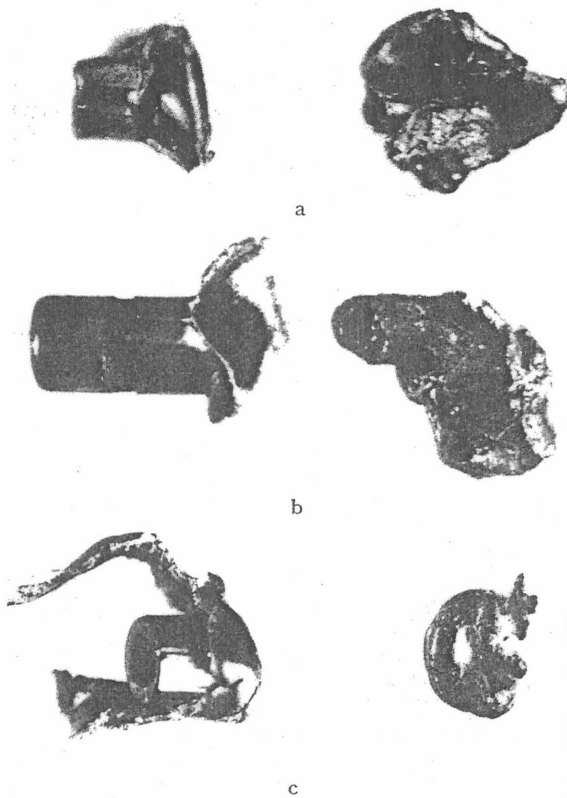


FIG. 5. a, The two largest fragments of the bullet which struck President Kennedy in the head and separated into an empty copper jacket, right, and a lead core, left. Both fragments bore markings from the rifling of Oswald's rifle, showing that they were fired from this rifle, to the exclusion of all other rifles. Both fragments were found in the front seat area of the Presidential automobile, apparently having struck the inside of the windshield and its frame at greatly reduced velocities before dropping into the front seat area. Other tiny fragments were found in the President's brain case and on the floor under the jump seats of the automobile. Still other fragments are assumed to have flown over the windshield and struck the ground or pavement ahead of the car. Courtesy of the National Archives. b, Pair of fragments showing complete separation of the jacket and lead core of one of the bullets by Olivier of the Aberdeen Proving Grounds into human skulls in an effort to reproduce President Kennedy's wounds. Courtesy of the National Archives. c, Pair of fragments from one of ours, after passing through one of our skulls. All three bullets were 6.5 millimeter Western Mannlicher-Carcano rounds.

interest that, if a vessel filled with water is used for such experiments, a weak spot is needed to achieve such a jet-engine effect, as pointed out by Hanson. The larger wound of exit, caused by the diverging courses of the multiple fragments of disrupted bullet (Fig. 4), probably provided this relatively weaker area, and all the bullets were either broken up or deformed enough by striking the skulls to make a larger wound of exit than of entrance.

BULLET FRAGMENTS DEFLECTED UPWARD

We arranged bullet traps made of barrels filled with packed mechanics waste and layers of tough canvas and covered with cardboard screens to show the imprint of each bullet. When we mounted these traps 6 feet behind the target, we discovered that the bullet fragments would sometimes be deflected upward after striking some of the skulls or combinations of skulls and melons and would miss the bullet traps. This was similar to the change of course of the fragments of the disrupted bullet which struck the President in the back of the right side of his skull and were apparently deflected upward so as to strike the upper part of the frame and glass of the windshield of the Presidential automobile. Indeed, some 95 grains of these fragments of the last bullet, which struck the President in the head, apparently went completely over the windshield to strike the street further along (21). The total weight of all the recovered fragments attributed to the bullet that struck the President's skull was only about 65 grains, out of an expected total of 160 grains. A few tiny fragments were recovered from the President's brain case, a few from the floor of the car under the jump seats (22) and two large fragments from the driver's seat area (Warren Commission Exhibits 567 and 569) (5) (Fig. 5).

When we moved our bullet traps close to the skulls, 3 feet, we were able to recover fragments of the disrupted bullets after they had penetrated varying depths of canvas and cotton waste. The penetrating ability of these fragments was poor after disruption. A photograph of such fragments is shown in Figure 5. The jacket of the bullet had separated from the core, and several smaller fragments were also recovered, as in the case of the Presidential bullet. Our trap lost 12 grains of the original 160 grains in the form of fragments which were not recovered, as shown in Figure 3b.

Figure 5 is a composite photograph showing the mutilated and fragmented Kennedy head bullet, one of Doctor Olivier's skull bullets and one of our skull bullets.

SKULLS SHATTERED

In each instance in which a bullet struck one of our skulls in a slightly tangential manner, as with the skull wound of President Kennedy, the bullet apparently deformed enough to cause a larger wound of exit and a large soft-tissue cavity inside the confined brain case with tremendous pressure, which then expanded after the bullet had left and blew the calvarium into several fragments, many of which went upward and forward for distances as great as 20 to 30 feet, as in frame 313 of the Zap-



FIG. 6. Roentgenograms of several calvariums show the degree of fragmentation caused in each instance by the bursting effect of the high pressure cavitation within the simulated brain when struck by a 6.5 millimeter Carcano, fully jacketed military bullet, as in the case of President Kennedy.

ruder movie (4). In Figure 6, roentgenograms of several such fragmented calvariums are shown. Commander Humes stated that when he "peeled the President's scalp back, the skull fell apart in his hands" (7), as can be seen in Figure 6.

We were surprised to discover that the use of the more fragile dried skulls, as reported by the Warren Commission experimenters (14), was still followed by the same marked deformation and fragmentation of the bullets, as with tough fresh bone (Fig. 5). Possibly this was due to the fact that these bullets were fired into the bases of the dried skulls, where the bone was thickest, because the true location of the wound of entrance into the President's skull was not known to them at that time. The roentgenograms and photographs of the body, which the autopsists had taken so carefully, had been taken away from them and had not been returned at the time the Warren Commission experiments had to be designed. Our use of fresh bony components has made for greater verisimilitude in our experiments, at least concerning this point.

In any case, our experiments verified that the backwards movement of the President's head was compatible with his being struck from the rear and that our simulated heads never fell away from the shooter under these conditions.

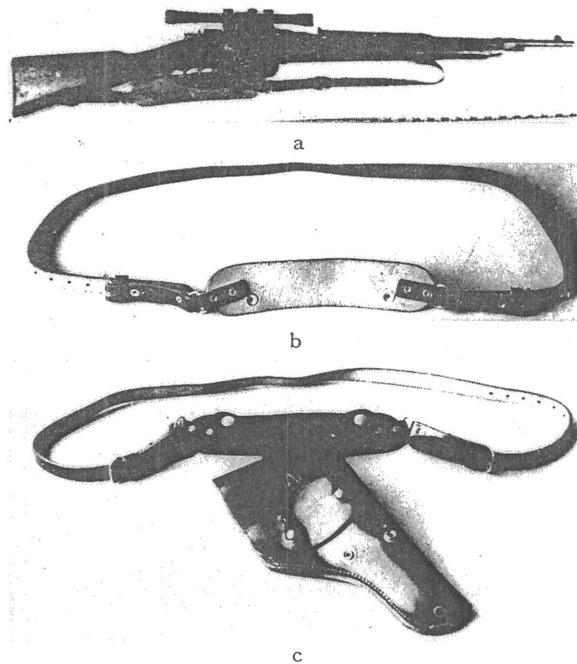


FIG. 7. Mystery solved. a, Oswald's peculiar sling on his rifle. Courtesy of National Archives. b, This is the shoulder harness strap of an obsolete type of United States Air Force pistol holster, c, which was discovered by Leon Day.

NEUROLOGIC SPASM AS AN ELEMENT IN THE BACKWARD LURCH OF THE BODY

When a brain in an intact, living, large animal, goat, is struck by a high speed military bullet, as in the case of President Kennedy, in whom most of the right side of the brain was destroyed by such a bullet and the resulting cavitation, there is a massive downward discharge of neurologic impulses to every muscle in the body. The body then stiffens, with the strongest muscles predominating. These strongest muscles are the back muscles and the muscles of the back of the neck (12). The upper limbs react next. The President's head was bowed slightly forward at the moment of impact of the bullet which destroyed the right side of his brain. While his head was seen to move slightly forward for one frame of the Zapruder motion picture (4), the dominance of the stronger back and neck muscles would be expected to pull his head and thorax abruptly backward, toward an upright or even hyperextended position, only one frame later, 50 milliseconds (12). He was already leaning slightly to his left, so that combination of the backward movement of his head from the jet engine effect described previously plus the stiffening and pulling upward and backward from the predominant contractions of his neck and back muscles

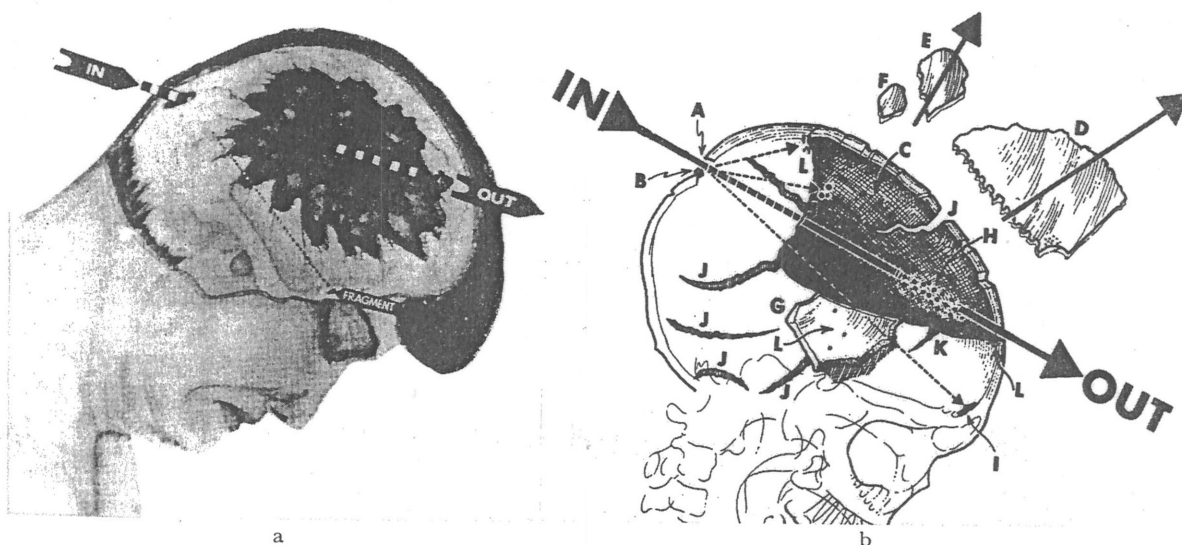


FIG. 8. a, Diagrammatic drawing of President Kennedy's skull wound as presented in the Warren Commission Report. This wound is not severe enough and made us suspicious of the Warren Commission at first, until we learned that the drawing was done from indirect instructions. b, A more accurate representation of the President's skull wounds, as seen in his autopsy photographs and roentgenograms, which were carefully studied by one of us, showed the true and much more severe extent of the skull wounds plus the fact that the wound of entry was some 4 inches higher on the back of the President's head than the depiction in the Warren Commission Report. Note the similarity to our experimental skull wounds (Figs. 1 and 2). Courtesy of Resident & Staff Physician (11).

could understandably result in a backward lurch of his head and body, starting a frame after the bullet struck him. The torque vectors created by the forces applied to the right side of his head would tend to turn him slightly to his left, as he lurched backward. This is exactly what can be seen to happen in the Zapruder movie in frames 314 through 317 (4).

When combined with the overpowering evidence that the roentgenograms of his head show metallic bullet fragments arranged only from back to front in the right side of his brain case (12) and with the skull damage all centering on the right side of his skull (12), we are left with absolutely no indication that he was struck from the front or right-front by an additional bullet, as claimed by recent critics.

In fact, if his body had not lurched backward from the wound received in the back of his head, we would have been suspicious, as would Hanson (6).

TIME INTERVAL BEFORE NEUROLOGIC REFLEX SPASM

Tests done on goats, both awake and anesthetized, with ultrahigh-speed motion pictures at the Aberdeen Proving Grounds (17) have demonstrated that the reactions of the goat's limbs and body began 40 milliseconds after the brain was struck by a high speed military bullet in an anesthetized goat and 50 milliseconds after an an-

esthetized goat was struck in a similar manner. If we assume that neurologic conduction times would be approximately the same in humans, this would cause the reaction to start about one frame after President Kennedy's brain was struck. That is exactly what appears to happen in the Zapruder movie.

OSWALD'S RIFLE SLING IDENTIFIED AT LAST

During the course of these investigations, a communication from Leon Day of Hoboken, New Jersey, solved the mystery of the strange-looking strap with a wider, ovoid, curved segment in its midportion, which has been the subject of many futile questions to many people by the Warren Commission investigators (19). Oswald's sling was variously described as possibly a strap from a photographic case or from a guitar-carrying device (19) (Fig. 7).

Day correctly points out that it is none of these but that it is actually the shoulder harness strap from a United States Air Force revolver holster of a now obsolete pattern. A photograph of such a shoulder harness strap is shown (Fig. 7). The distinctive way in which the end straps are riveted to the body of the ovoid patch at a slight angle plus the strange built-in curve of the patch and the additional rivets leaves no doubt as to the true identity of this strap. One of us has examined the

strap on the rifle used to shoot President Kennedy and can verify this point. The question arose as to whether the pistol holster of Oswald originally had such a strap, but the photograph of his holster (18), while having some slight similarities, is certainly not identical with the Air Force holster for which this strap was designed. Where Oswald obtained it is still a point to be researched. Perhaps he acquired it during his Marine Corps service in Japan, although he had used an improvised rope-like sling on his rifle shortly after he acquired it. On his mail order form for his pistol, he had at first indicated that he wanted a holster with the pistol but had scratched out the holster request before sending in the order (20).

SUMMARY

Sudden acceleration of the automobile was not a factor in the backward and sideways lurch of President Kennedy after he was shot, because this acceleration did not occur until many frames later in the Zapruder movie.

Mannlicher-Carcano fully jacketed 6.5 millimeter cartridges, made by the Western Cartridge Co. exactly like those used to shoot President Kennedy, were fired from a Mannlicher-Carcano carbine, model no. 91-38, exactly like the one used to fire the two bullets which struck President Kennedy from above and the rear into various melons and human skulls and skull components, using melon contents to simulate brain tissue. The wounds were as closely similar to those of President Kennedy's head wound as was possible for us to arrange. When the bullets struck the skulls in the same manner as with President Kennedy, the skulls always jumped backward off the stand toward the shooter, propelled by a large jet of simulated brain tissue, which left through a larger wound of exit on the front of the skull, caused by the deformed bullet. The calvarium was then separated by cavitation of the brain into several fragments, which flew 20 to 30 feet upward out of the skull, as with President Kennedy. The largest remnant of what was left of the head always jumped to the left and backward toward the gun (Fig. 3a and b).

The deformed bullet fragments fanned out and were often deflected slightly upward from their straightaway course, and there was always a tendency of the bullet jacket to separate from the lead core of the bullet. The fact that the bullet broke up into multiple fragments which took divergent courses upon striking the skull is shown by the imprint of the many fragments on the cardboard cover over the bullet trap before it began its pas-

sage through the cotton waste, as seen in Figure 4. All of the bullet fragments which passed through our screens, after traversing skulls, made multiple jagged holes and had greatly reduced velocities.

A stiffening, with an upward and backward lurch from contractions of the President's bowed neck and back muscles, would be expected to occur from a massive downward rush of neurologic stimuli from such a major brain wound of the type sustained by President Kennedy. The reaction time before such a movement might be expected to begin was of the order of 50 milliseconds, as determined by experiments of Olivier at the Aberdeen Proving Grounds, using ultrahigh-speed motion picture cameras on wounded goats. This was approximately the same time interval as shown to occur in the case of President Kennedy by the Zapruder motion picture, in which the backward and sideways lurch of the President's body began about 50 milliseconds, one frame, after he was struck in the head.

The severely fragmented skull wounds demonstrated on our models (Figs. 1, 2 and 6) were strikingly similar to the skull wound of President Kennedy (Fig. 8). Humes, who did the autopsy, stated that, when he peeled the scalp back (7), the skull fell apart in his hands. (Fig. 6).

There was a discrepancy between the drawings in the Warren Commission Report, which indicated relatively minor skull wounds (Fig. 8a), and our knowledge from our wartime and research experience that much more severe wounds were to be expected from this type of military rifle bullet. It was this discrepancy which had led to our initial skepticism about the accuracy of the Warren Commission Report, as reflected by the illustrations of the President's wounds. We have since discovered that the Warren Commission drawings were made only as an aid in attempting to explain the course of the bullets and that the artist who made them had been asked to do so without the benefit of having seen the body or even being permitted to see the photographs or roentgenograms of the body (7). We have satisfied ourselves by our own experiments and by our two detailed studies of the autopsy photographs and roentgenograms of the President's head and body that no inconsistencies are visible, when the evidence is examined closely. Everyone who has examined and described the autopsy materials agrees that there is no evidence of shots striking the President either from the front or side-front. When one combines this with the fact that both bullets which struck the Presidential car undeniably, to the exclusion of all other rifles, came out of the Mannlicher-Carcano 6.5 millimeter

carbine (Fig. 4) which was found on the sixth floor of the Texas Book Depository Building with the handprint of Oswald on it and fibers from his sweater clinging to the stock, it is difficult to disagree with the basic conclusions of the Warren Commission. Some details were overlooked by the Commission or drawn incorrectly (7), but the fact remains that the only firm evidence is that the President was hit by two bullets coming from above and behind about five seconds apart. We could find no evidence that he was hit by a third bullet.

Our experiments, done with more anatomically similar materials, bore out the results of the experiments of Alvarez and his group and the conjectures of Hanson with regard to the fact that the backward and sideways lurch of President Kennedy's head, one frame after the bullet struck him in the back of the head, causing a large jet of heavy brain substance to fly forward out of the front of his head (Fig. 3), is certainly no indication that the President was struck by an additional bullet from either the front or right-front.

Moreover, our experiments confirmed that it was not necessary to have a previous wound to weaken the right-front of President Kennedy's head for this jet-engine effect to be achieved, driving his head toward the back of the car. It seems probable that the neuromuscular spastic stiffening, to be expected after a brain shot, would greatly augment this backward lurch with an even more powerful force and at just the time interval seen in the Zapruder film.

In short, the backward and sideways lurch of President Kennedy's head toward the shooter, starting one frame after the bullet struck, was to be expected from a bullet striking his head from the rear, as it did, and does not mean he was hit by an additional bullet from the front or right-front. There is absolutely no roentgenographic or other evidence that President Kennedy was struck from any direction except from the rear.

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