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US Army Edgewood Arsenal
Chemical Research and Development Laboratories
Technical Report

CRDLR 3264

Wound Ballistics of
6.5-mm Mannlicher-Carcano Ammunition (U)

by

Alfred G. Olivier
Arthur J. Dziemian

March 1965

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By authority of: DD Lt. 9/3/73

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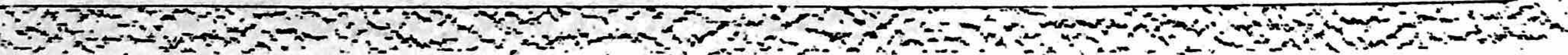


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CRDLR 3264

WOUND BALLISTICS OF 6.5-MM MANNLICHER-CARCANO AMMUNITION (U)

by

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Biophysics Division
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FOREWORD

The work described in this report was authorized under Project 1M012501A027, Wound Ballistics (U). The experimental data are contained in notebook MN-1811. This work was started in April 1964 and completed in October 1964.

In conducting the research described in this report, the investigators adhered to the "Principles of Laboratory Animal Care" as established by the National Society for Medical Research.

Acknowledgments

Mr. Donald Smith was the gunner in these tests. Many members of the Biophysics Division assisted with the experiments. In particular, Mr. Walter McDonald's efforts are greatly appreciated.

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DIGEST

Experiments were performed with the 6.5-mm Mannlicher-Carcano assassination rifle, serial no. C2766, and 6.5-mm Western Cartridge Company, lot WCC 6000, Mannlicher-Carcano ball ammunition to reproduce the conditions occurring at the time of the assassination of President John F. Kennedy on 22 November 1963.

The results indicated that the wounds sustained by the President and by Governor Connally, including the massive head wound of the President, could be produced by the above type of bullet and rifle.

Tissue-retardation studies showed that the bullet that wounded the President in the neck had enough remaining velocity to account for all of the Governor's wounds. If it had struck the car, the damage would have been very evident and much greater than the slight damage that was found on the windshield.

Shots at human skulls demonstrated that this stable, blunt-nosed, military bullet was capable of inflicting massive head wounds. Some of the recovered bullet fragments greatly resembled those that were found in the President's car. It was probably a fragment of this type that damaged the windshield.

It is more difficult to draw a firm conclusion from shots at the goat thorax. The wound received by Governor Connally could have been produced by either the shot that hit President Kennedy in the neck or by a separate shot. If it was a separate shot, then the bullet that hit the President in the neck must be accounted for.

The bullet that struck Governor Connally in the wrist was probably the same bullet that produced the chest wound and subsequently produced the small wound in the thigh. The comparative sizes of entrance and exit wounds, the amount of bone damage, and the lack of bullet deformation all indicate that the wrist was struck by a tumbling bullet traveling at a reduced velocity.

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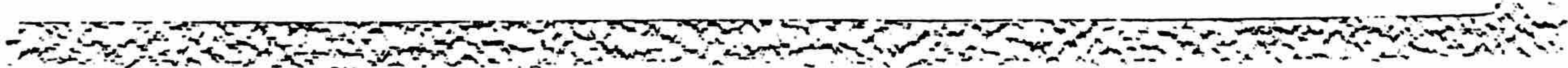
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(C) WOUND BALLISTICS OF 6.5-MM MANNLICHER-CARCANO AMMUNITION (U)

I. (U) INTRODUCTION.

Under the authority of Executive Order No. 11130, signed by President Lyndon B. Johnson, which states that "All Executive departments and agencies are directed to furnish the Commission with such facilities, services and cooperation as it may request from time to time," the President's Commission on the Assassination of President John F. Kennedy requested that these Laboratories conduct a series of experiments designed to simulate, if possible, the wounds received by President Kennedy and Governor Connally on 22 November 1963. It was hoped that information might be obtained that could relate the three shots that were reported to be fired to the wounds received by the President and the Governor.

For these experiments the rifle used by the assassin (Commission exhibit 139, serial no. C2766*) was used [figure A1, appendix A (all figures, A1 through A24, are in appendix A)]. The ammunition used for these experiments was the 160-gr, 6.5-mm, Mannlicher-Carcano-type ball, manufactured by Western Cartridge Company, East Alton, Illinois (figure A2, part A). The lot number was WCC 6000 (figure A2, part B). This is believed to be the same type of ammunition used by the assassin. These bullets have a gilding metal jacket, whereas the Italian-made military ammunition uses steel-jacketed bullets.

The experiments that were performed for the Commission were similar to the work that is normally conducted at the Biophysics Division; no innovations were used. All shots were fired from the shoulder because the rifle could not be altered in any way to enable it to be held in a gun mount (figure A3).

Copies of the admission notes and operative records from Parkland Memorial Hospital were made available to these Laboratories, as were the autopsy records from the Naval Medical School. Personal discussions with Drs. Hume, Boswell, Fink, Shaw, and Gregory were also conducted. The movies and slides of the assassination were viewed on two occasions.

* The President's Commission on the Assassination of President John F. Kennedy, Report. U. S. Government Printing Office, Washington, D. C. 1964.

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II. (C) PROCEDURES.

(U) Experimental procedures were divided into six general categories as follows: tissue-retardation studies, shots at gelatin-filled and coated human skulls, shots at human-cadaver arms, shots at the ribs of anesthetized goats, energy studies in 20% gelatin tissue models, and effects of ammunition temperature upon velocity.

A. (U) Tissue-Retardation Study.

The tissue-retardation studies were conducted to determine the amount of velocity lost when the 6.5-gr Mannlicher-Carcano bullet passed through an amount of tissue or tissue model equivalent to the distance traversed in the lower neck of the President.

The autopsy measurements gave the precise location of the entrance wound. The exit wound, while not located from autopsy measurement because of surgical intervention, could still be accurately estimated from the description of the tracheal injury. This was further substantiated by the bullet path through the knot of the President's necktie. Using a caliper on several people of various heights and body builds, it was found that the length of the "wound tract" varied very little from person to person, always falling between 13.5 and 14.5 cm.

The distance from the rifle to the targets was 60 yd for the tissue-retardation studies. This was the approximate distance (in round figures) from which the bullet that hit the President in the neck was fired.

Three substances were used to simulate the tissues of the neck: blocks of 20% gelatin, large blocks of horse meat, and an aggregate of leg and back muscles from freshly killed goats. All three substances have been shown in previous work to differ little in their retarding effects on projectiles of this type.

Figure A4, part A, shows the setup for the tests with the gelatin blocks. These blocks of gelatin were 13.5 cm in length and were covered with swatches of cloth cut from a suit, shirt, and undershirt. Also placed over the block and under the clothing was a piece of clipped skin from a recently killed goat. Velocity-recording screens were placed behind each block to measure the velocity of the bullet after it had passed through the block.

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The velocities were recorded by electronic counter chronographs. Striking velocities were recorded by firing three shots through the screens before the blocks were put in place. Table B1, appendix B (all tables, B1 through B4, are in appendix B) gives the temperature data for the day of this experiment and for subsequent experiments. Marked changes in the ambient temperature can have an observable effect upon the bullet velocities.

The goat meat and horse meat were each placed in a box (figure A4, part B) that was adjusted to give the proper thickness (13.5 to 14.5 cm), and the bullets were fired through precut openings in the box. Both entrance and exit sides of the meat were covered with clipped goat skin, and clothing swatches were placed over the entrance side as was done with the gelatin. Exit velocities were recorded for each shot.

Several large gelatin blocks were placed behind the velocity screens in order to check on total penetration as well as to recover the spent bullets if possible.

B. (U) Human-Skull Study.

The human-skull studies were conducted to see if the 6.5-mm Mannlicher-Carcano bullet would inflict massive skull wounds, such as the President received. A full-jacketed blunt-nosed bullet of this type tends to be very stable and should not cause such massive wounds unless the nose of the bullet were to flatten or deform severely, causing rapid slowdown with a resultant increase in kinetic-energy expenditure within the cranium. Before conducting these tests, the experimenters were of the opinion that only an unstable bullet or a soft-nosed hunting bullet could produce such damage.

The entrance wound in the President's skull was located "approximately 2.5 cm laterally to the right and slightly above the external occipital protuberance," as quoted from the Commission report. The line of flight of the bullet was determined roentgenographically "by multiple minute metallic fragments along a line corresponding with a line joining the above described small occipital wound and the right supra-orbital ridge."

For this study, 10 human skulls were embedded in, and filled with, 20% gelatin. When the skulls were removed from the molds, the gelatin coating was trimmed away to simulate the approximate thickness of the soft tissues overlying the skull. Figure A5, part A, shows a skull in position for

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firing with a piece of unclipped goat skin placed over the target area. Figure A5, part B, shows the camera and lights used to record the sequence of events at a film speed of 4,000 frames/sec. The gunner was positioned 90 yd from the skulls, this being the approximate distance from the assassin to the President along the line of the bullet's flight. The skulls were oriented so that the path through the skull would be from the occipital region to the right supraorbital ridge. The camera was placed so as to observe the right parietal region. No velocity-recording screens were used to determine exit velocities for these tests. Bullet fragments were recovered from cotton waste and polyethylene foam placed behind the targets. An average striking velocity was determined by firing three shots through velocity-recording screens just before the skull shooting commenced.

C. (U) Human-Arm Study.

For this study, amputated arms from human cadavers were used in an attempt to simulate the wrist wound received by Governor Connally. Ten arms were used for these tests.

The operative record, as dictated by Dr. Charles Gregory in the Commission report, located the entrance wound "on the dorsal aspect of the right wrist over the junction of the distal fourth of the radius and the shaft." He further stated that it "was approximately 2 cm in length and rather oblique with the loss of tissue with some considerable contusion at the margins of it." The doctor located the exit wound "along the volar surface of the wrist about 2 cm above the flexion crease of the wrist and in the midline." The operative report does not mention the size of the exit wound, but Dr. Gregory later stated that it was a very small slit that was almost obscured by one of the creases on the volar surface of the wrist.

The cadaver wrists used for this study were positioned (figure A6) so that the path of the projectiles through the wrists would be the same as the one through the wrist of the Governor. The distance from rifle to target for these studies was 70 yd, as this was believed to be about the distance from the assassin to Governor Connally if the Governor had been struck by a second shot after President Kennedy had been struck by the first. Velocity-recording screens were placed behind the wrists (figure A6) to record the exit velocities of the bullets. The bullets were recovered from cotton waste and polyethylene foam. An average striking velocity for this distance was obtained just before the arm shooting commenced.

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~~FOR OFFICIAL USE ONLY~~D. (FOUO) Goat-Thorax Study.

(U) This study was conducted to simulate, if possible, the chest wound of Governor Connally. Dr. Shaw, the surgeon, described the entrance wound as "3 cm in its longest diameter" and the exit wound as being "a ragged wound approximately 5 cm in its greatest diameter" (Commission report). The bullet had not entered the pleural cavity but had proceeded along the fifth right rib, causing a comminuted fracture for a distance of 10 cm. Fragments from the fractured rib had entered the pleural cavity and lacerated the lung.

(FOUO) Thirteen goats were used for this study, eight on one day and five on a subsequent day. The animals were deeply anesthetized with pentobarbital sodium and were placed on their sides (figure A7). The goat's rib cage was covered with suit, shirt, and undershirt material and an aiming spot placed in such a way that the bullet, if accurate, would strike a glancing blow on a rib. These shots were extremely difficult to make, because the gunner was allowed only a fraction of an inch dispersion in any direction. At the 70-yd distance used for this study, the gun was not capable of quite such a tight pattern, so the probability of hitting the exact area was reduced.

(U) Velocity-recording screens were placed about 1 ft behind the goat, and just behind the screens was the material used to catch the bullets (figure A7).

(U) Striking velocities were obtained from bullets that missed the goat and clothing and passed through the velocity screens.

E. (C) Energy Expenditure in Gelatin.

(U) Previous studies have shown that 20% gelatin at 10°C may be substituted for animal tissues under certain conditions.* A method of obtaining quantitative estimates of probable human incapacitation (P_{hk} , or the probability that a single random hit on the body will incapacitate a man) from gelatin blocks has been devised.**

* Dziemian, A. J., and McDonald, W. C. CWLR 2349. The Effects of Missiles on Animal Tissues and Gelatin Tissue Models (U). March 1960. SECRET Report.

** Dziemian, A. J. CWLR 2391. A Provisional Casualty Criterion for Fragments and Projectiles (U). May 1960. SECRET Report.

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(U) Energy studies of the 6.5-mm Mannlicher-Carcano bullet were performed as part of the continuing program of bullet evaluation being conducted at these Laboratories.

(C) Blocks of 20% gelatin at 10°C were placed at ranges of 60 and 90 yd, and high-speed motion pictures (27,000 frames/sec) were taken as the bullets passed through the 38-cm-long blocks. The resulting films were analyzed frame by frame in a Telereadex film analyzer. The velocity at any point in the trajectory of the missile was obtained by determining the slope, at that point, of the plotted curve representing the instantaneous distance penetrated versus the time. Knowing the velocity and the mass of the projectile, the kinetic energy of the missile could be computed at any point, or points, and the transfer of energy to specific areas of the target could be determined.

(C) As mentioned previously, P_{hk} data may be obtained from the gelatin-block studies. In particular, the energy expended by a bullet in a gelatin block between 1 and 15 cm of penetration (ΔE) may be related to human incapacitation. The rationale for the exclusion of the energy imparted to the first centimeter of the block is that in most of the human body this energy would be wasted in producing surface wounds having little incapacitating value. After penetrating 15 cm, the bullet has usually struck or bypassed the major organs or has left the body.

(C) P_{hk} values were calculated from the ΔE values for two stress situations: assault, less than 30 sec; and defense, less than 30 sec.*

F. (U) Temperature Studies.

At the conclusion of these experiments, when the data were being analyzed, it was noted that the average striking velocities for the eleven 70-yd shots on May 5 were higher (1,929 ft/sec) than were the three 60-yd shots (1,904 ft/sec) on April 27. This phenomenon could possibly be accounted for by the variation in velocity inherent in the ammunition, but it was believed more likely that it was due to differences in the ambient temperature.

As a further check on the effect of temperature upon bullet velocity, a series of firings was conducted at ranges of 60 and 90 yd. For one of the tests the ammunition was precooled to a temperature of 50°F; for the other test the ammunition was fired at the ambient temperature, which was 80°F at the time of the shots.

* CWLR 2391. Op. cit.

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The Oswald rifle had been returned to the President's Commission at the time of these tests, so a similar rifle, serial no. D3414, was used. The ammunition (lot WCC 6000) was the same as was used for the previous tests.

III. (C) RESULTS.

A. (U) Tissue Retardation.

Three shots were fired to determine the striking velocity of the bullet at 60 yd. The recorded velocities were 1,940, 1,862, and 1,910 ft/sec, giving an average striking velocity of 1,904 ft/sec. For subsequent shots on this day, only the exit velocities from the gelatin and tissues were recorded. This was done so that there would be no interference with the bullet before it struck the target medium and also to facilitate aiming.

Three shots were fired through the 13.5-cm blocks of 20% gelatin covered with clothing and clipped goat skin. The exit velocities were 1,786, 1,792, and 1,760 ft/sec, with an average exit velocity of 1,779 ft/sec and an average loss in velocity, after traveling through 13.5 cm of gelatin, of 125 ft/sec.

Gelatin blocks were placed behind the velocity-recording screens to determine total penetration. The first shot missed the blocks but the second shot penetrated 72.5 cm of gelatin, emerged, and penetrated an earth bank to a depth of at least several inches and was not recovered. During the passage of the bullet through the gelatin, it remained stable for the first 38.5 cm and was unstable for the last 34.0 cm. The third gelatin shot penetrated 51.5 cm in gelatin and was stable except for the last 4 or 5 cm. It then emerged with enough remaining velocity to bury itself deeply in the mound of earth.

Two shots were fired through the box of horse meat, which was covered on the entrance side by clipped goat skin and clothing and on the exit side by clipped goat skin. The distance traversed was between 13.5 and 14.5 cm in both instances. Exit velocities were 1,808 and 1,789 ft/sec. The average loss through the horse meat was 106 ft/sec. Total penetration through horse meat and back-up blocks of gelatin was 52.8 and 47.3 cm. For both instances the remaining velocities were enough to bury the bullets deeply in a mound of earth.

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Two shots were fired through goat meat under the same conditions as the horse meat. The exit velocities were 1,775 and 1,768 ft/sec. The average loss through the goat meat was 132 ft/sec. One shot penetrated 77.5 cm of goat meat and gelatin and the other penetrated 48.7 cm. Both shots emerged and penetrated deeply into the mound of earth. Figure A8, part A, shows one of the 38-cm-long back-up blocks of gelatin in which the bullet was still stable after having already passed through a 13.5-cm block of gelatin and the velocity-recording screens. Figure A8, part B, shows one of the back-up blocks that was struck by a bullet that had become unstable after passing through about 13.5 cm of goat meat and the velocity-recording screens.

B. (U) Human-Skull Study.

Three shots were fired to determine the striking velocity of the bullet at 90 yd. The recorded velocities were 1,790, 1,833, and 1,854 ft/sec. The average striking velocity at this distance was 1,826 ft/sec.

Ten skulls were shot at this range, and extensive damage was produced in each instance. The bullets broke up to a greater or lesser degree in at least nine of the skulls. This was determined by recovered fragments (figure A9) and radiographs (figure A10). Figures A11 and A12 show some of the typical skull damage produced by this bullet. A piece of unclipped goat skin that was used to cover the target area on one of the skulls is shown in figure A13.

C. (U) Human-Arm Study.

Five shots were fired to determine the striking velocity of the bullet at 70 yd. The average striking velocity for this distance was 1,858 ft/sec. Exit velocities were obtained for 7 of the 10 shots. The average exit velocity was 1,776 ft/sec, giving an average velocity loss, through the wrist, of only 82 ft/sec.

A most interesting finding from this series of shots was the comparative sizes of the entrance and exit wounds. In every instance the exit wound was larger than the entrance wound. The average size of the entrance wound for the 10 shots was 0.7 by 3.3 cm, the longer dimension being caused by the acute striking angle of the bullet. The average size of the 10 exit wounds was 2.0 by 6.7 cm. In contrast, the entrance wound in the Governor's wrist was described as being larger than the exit wound. It is quite certain that

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the larger of the Governor's wrist wounds was the entrance wound for the following reasons: (1) because fibers from his suit were found in this area; (2) because of the small slit-like nature of the other wound, indicating a low velocity; and (3) because it would be impossible for the Governor to orient his wrist in such a fashion that the wounds would be reversed without holding his arm in such a position that it would be easily noticeable in the movie films of the shooting.

Figure A14, parts A and B, shows some of the recovered bullets. The bullets in part A are more flattened than those in part B, because the former hit the hard cortical bone of the shaft, and the latter hit nearer the epiphysis, where the cortical bone thins out and the softer cancellous bone is present.

Figures A15 and A16 show some typical wrist wounds produced by this bullet. In every instance, the wounds that were produced in the wrists of the cadavers were larger than the wound of Governor Connally's wrist.

Figure A17 shows some of the clothing swatches used to cover the target area of the wrists. Both prints in figure A18 are from radiographs of wrist wounds.

D. (FOUO) Goat-Thorax Study.

(U) To conserve ammunition, the striking velocities were obtained from shots that passed above the goat. On 30 April, three striking velocities were obtained: 1,855, 1,880, and 1,881 ft/sec, to give an average striking velocity of 1,872 ft/sec. On 5 May, 11 striking velocities varying from 1,906 to 1,945 ft/sec were obtained; they averaged 1,929 ft/sec. This difference is accounted for by the difference in ambient temperatures for the 2 days.

(FOUO) Of the 13 goats that were wounded, 7 received fractured ribs from direct hits and 2 received fractured ribs from near misses. Because of the obliquity at which the bullets struck the goats, five of the animals had larger entrance wounds than exit wounds. In two animals, the bullets made long superficial lacerations with no definite entrance and exit holes. In only one animal, goat no. 12965, did the bullet strike and pass along the rib in a manner similar to the one that wounded Governor Connally. This goat received a comminuted fracture along 13 cm of the rib's length (figures A19, parts A and B, and A20) as compared to the 10-cm-long comminuted fracture of the Governor's rib. The goat's lung (figure A21, part A) was wounded, and two small bone chips were found in the lung. The diaphragm had a laceration (figure A21, part B) from which four bone chips were removed at autopsy.

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the fastest bullet at 50°F was slower than the slowest bullet at 80°F. At 90 yd only one shot overlapped; the fastest bullet at 50°F was 6 ft/sec faster than the slowest bullet at 80°F. The second rifle tended to have slightly lower striking velocities than did the Oswald rifle.

IV. (FOUO) DISCUSSION.

A. (U) Tissue-Retardation Study.

The seven shots through the 13.5 to 14.5 cm of gelatin, horse meat, and goat meat demonstrated that the bullet that passed through the neck of President Kennedy had a very high remaining velocity and would have been able to inflict severe damage had it struck a person or any part of the automobile.

B. (U) Human-Skull Study.

The 10 shots at the gelatin-filled and coated human skulls removed any doubts that the full-jacketed 6.5-mm Mannlicher-Carcano bullets were capable of causing massive skull damage. Some of the recovered fragments, particularly those shown in figure A9, resemble the fragments found in the presidential car (Commission report).

C. (U) Human-Arm Study.

The human-arm study revealed several interesting facts.

1. The average velocity loss through the wrist for the seven shots for which exit velocities were obtained was only 82 ft/sec.
2. For the 10 cadaver wrists, the entrance wound was smaller than the exit wound in every instance: Governor Connally's wrist had a larger entrance wound than exit wound.
3. The damage done to the cadaver wrists was greater than was the damage done to the wrist of Governor Connally.
4. The bullets that struck the bones in the cadaver wrists were deformed on the front end (figure A14). The bullet found on Governor Connally's stretcher was slightly flattened but the front end was not deformed.

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From the preceding facts, it can be deduced that the bullet that struck the Governor's wrist was probably yawing (larger entrance wound than exit wound) and was probably traveling at a much reduced velocity, because even though yawing it did less damage (and suffered less deformation) than would a high-velocity, pristine bullet.

Another wound not mentioned before was a small wound in the Governor's thigh. This was described as a shallow puncture wound. This wound was compatible with a nearly spent bullet, but not one traveling at a high speed, as were the bullets that exited the wrists of the cadavers.

D. (FOUO) Goat-Thorax Study.

In only 1 of the 13 goats that were used for these tests was the path of the bullet along the rib similar to the one that wounded the Governor. In both instances the bullet did not enter the pleural cavity but grazed the rib, throwing secondary bone fragments into the pleural cavity. The only striking difference between the two shots was that the bullet that was recovered after passing through the goat was flatter than was the bullet that was recovered from the Governor's stretcher. Possibly, the bullet that struck Governor Connally struck at a slower velocity, because of passage through the President's neck, than the one that hit the goat.

Although it was felt by the authors that the bullet that struck Governor Connally was the same one that wounded President Kennedy, there was not enough experimental evidence to verify this. It was strongly recommended that a very careful reenactment of the assassination be done to establish the line of flight of the bullet that hit the President in the neck to see whether it could possibly have passed through his neck and then missed the car and its occupants completely.

The reenactment was conducted and tended to support the theory that the one bullet wounded both the President and the Governor (Warren Report).

E. (U) Energy Expenditure in Gelatin.

This study furnished little or no information for the President's Commission but was important in that it furnished basic information on a very stable type of military-bullet design.

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F. (U) Temperature Studies.

These shoots merely confirmed the well-known fact that an increase in ammunition temperature will result in an increase in velocity. These tests were conducted to demonstrate this to the satisfaction of non-ballistics personnel.

V. (U) CONCLUSIONS.

The results indicated that the wounds sustained by the President and by Governor Connally, including the massive head wound of the President, could be produced by the above type of bullet and rifle.

Tissue-retardation studies showed that the bullet that wounded the President in the neck had enough remaining velocity to account for all of the Governor's wounds. If it had struck the car, the damage would have been very evident and much greater than the slight damage that was found on the windshield.

Shots at human skulls demonstrated that this stable, blunt-nosed, military bullet was capable of inflicting massive head wounds. Some of the recovered bullet fragments greatly resembled those that were found in the President's car. It was probably a fragment of this type that damaged the windshield.

It is more difficult to draw a firm conclusion from shots at the goat thorax. The wound received by Governor Connally could have been produced by either the shot that hit President Kennedy in the neck or by a separate shot. If it was a separate shot, then the bullet that hit the President in the neck must be accounted for.

The bullet that struck Governor Connally in the wrist was probably the same bullet that produced the chest wound and subsequently produced the small wound in the thigh. The comparative sizes of entrance and exit wounds, the amount of bone damage, and the lack of bullet deformation all indicate that the wrist was struck by a tumbling bullet traveling at a reduced velocity.

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(C)

APPENDIXES

<u>Appendix</u>		<u>Page</u>
A.	Figures, A1 through A24 (U).....	22
B.	Tables, B1 through B4 (U).....	46

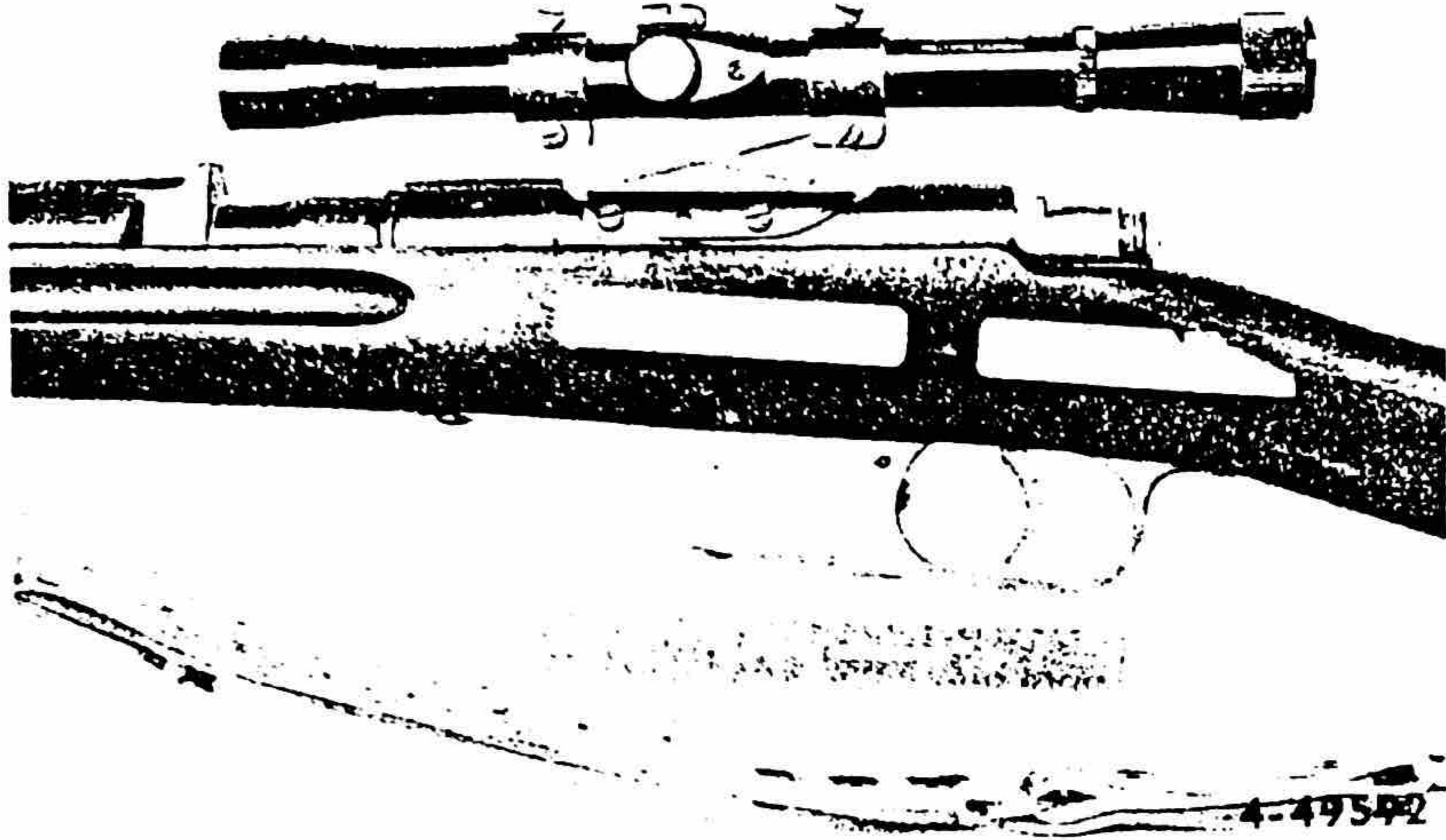
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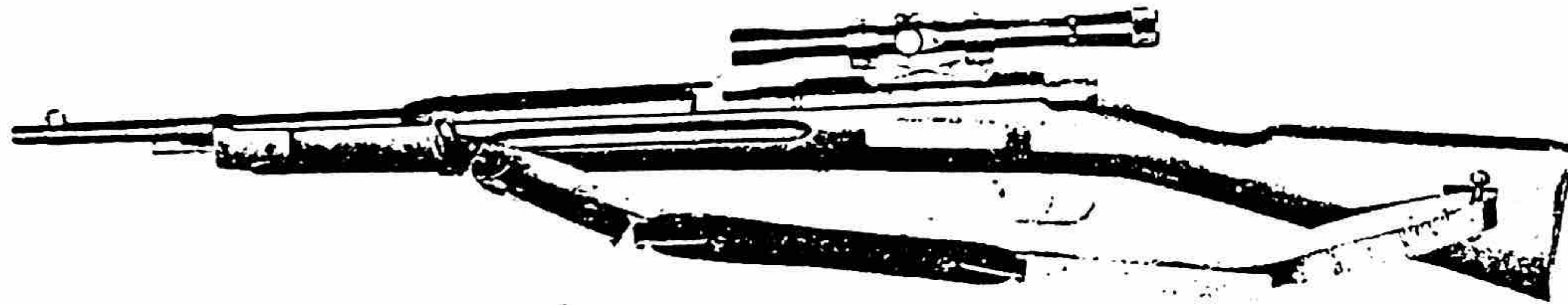
APPENDIX A

FIGURES (U)



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(U)

FIGURE A1

THE 6.5-MM MANNLICHER-CARCANO ASSASSINATION RIFLE, SERIAL NO. C2766, COMMISSION EXHIBIT 139

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A

4-49601



B

4-52590

FIGURE A2

THE 6.5-MM MANNLICHER-CARCANO AMMUNITION

- A. Round and bullet
- B. Western Cartridge Company ammunition, lot 6000

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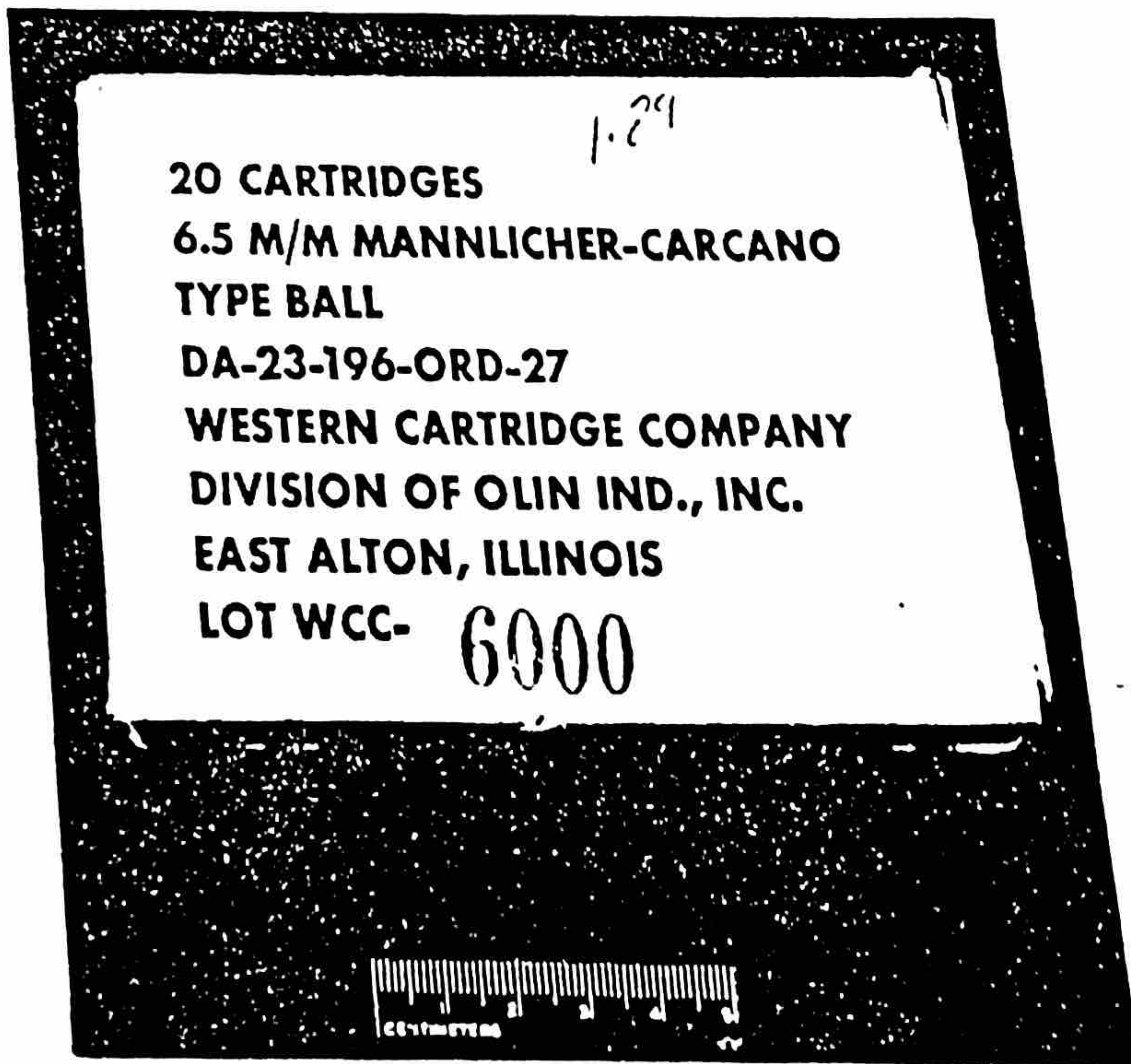
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A

4-49601



B

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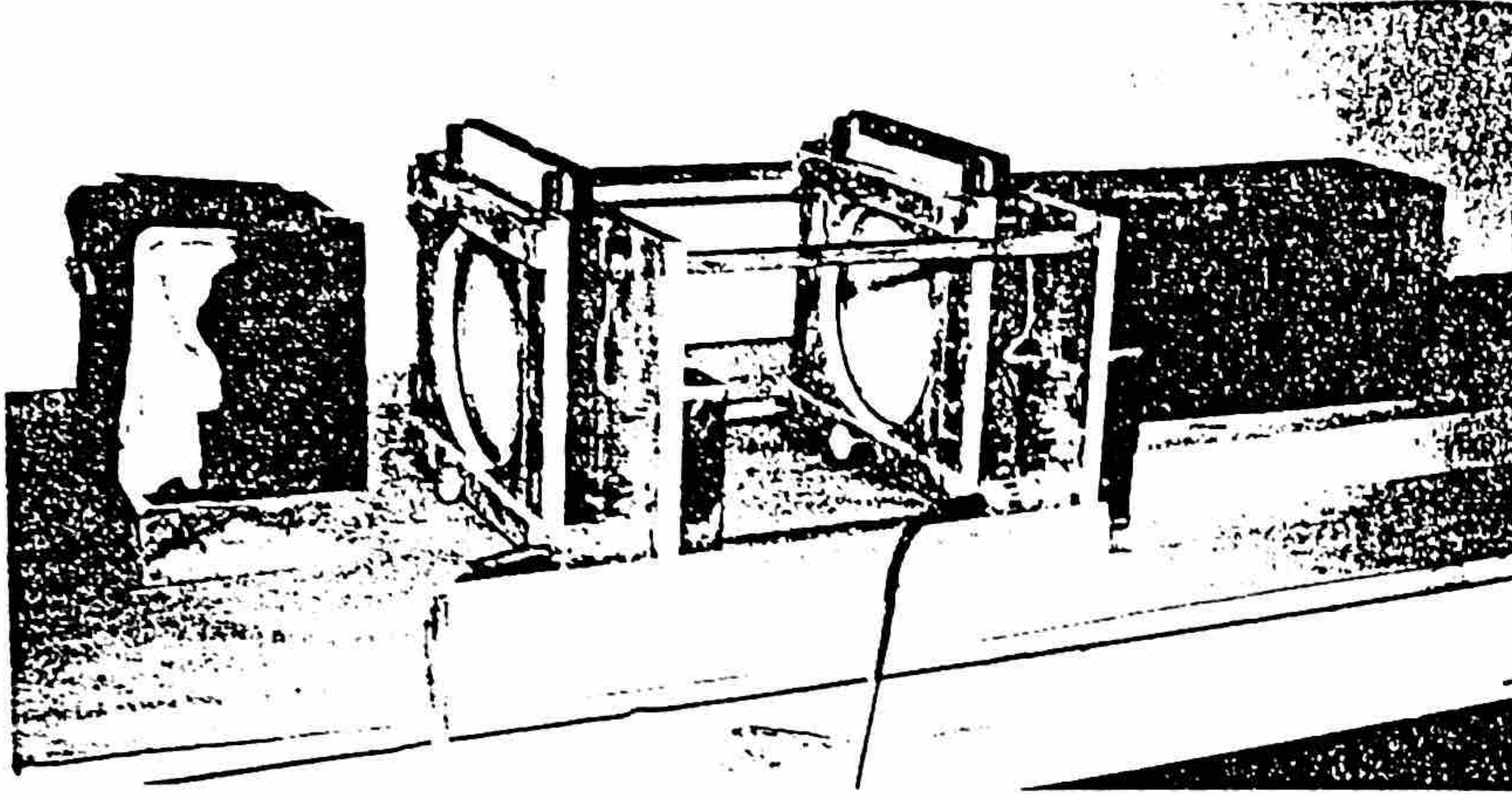
FIGURE A2

THE 6.5-MM MANNLICHER-CARCANO AMMUNITION

- A. Round and bullet
- B. Western Cartridge Company ammunition, lot 6000

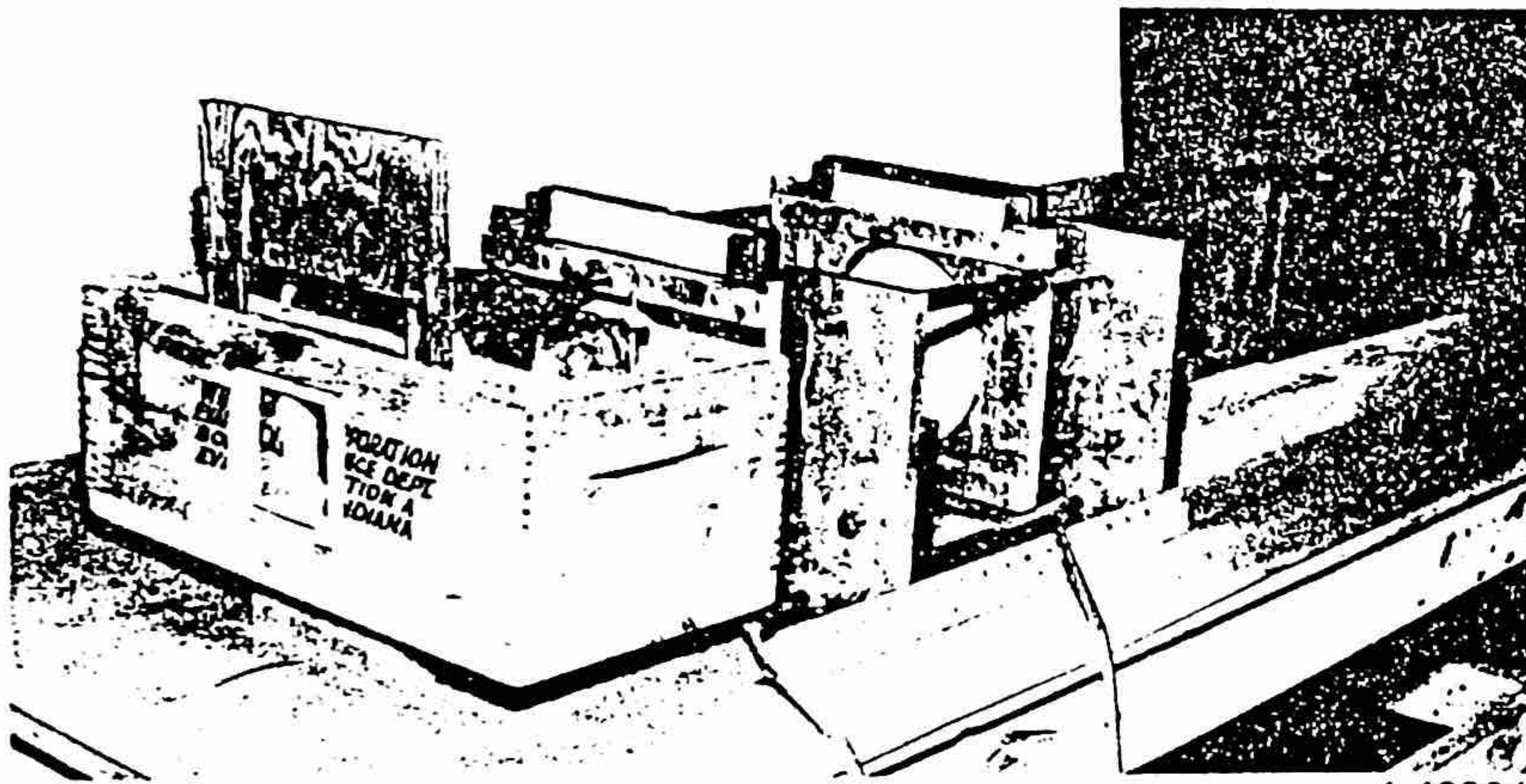
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A

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B

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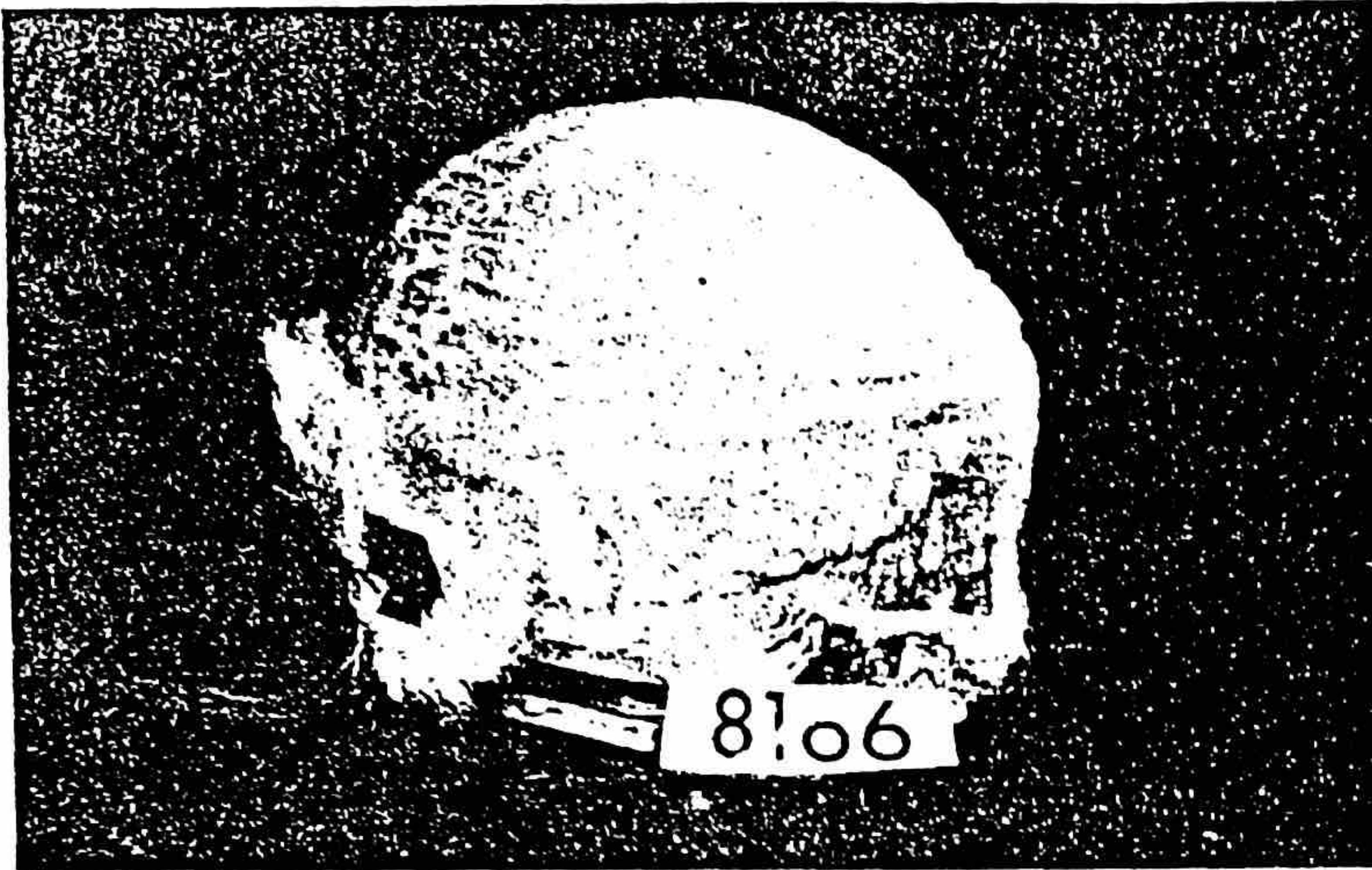
FIGURE A4

EXPERIMENTAL SETUPS FOR RETARDATION STUDIES

- A. Apparatus for measuring retardation through 13.5-cm blocks of 20% gelatin
- B. Apparatus for measuring retardation through 13.5 to 14.5 cm of goat meat or horse meat

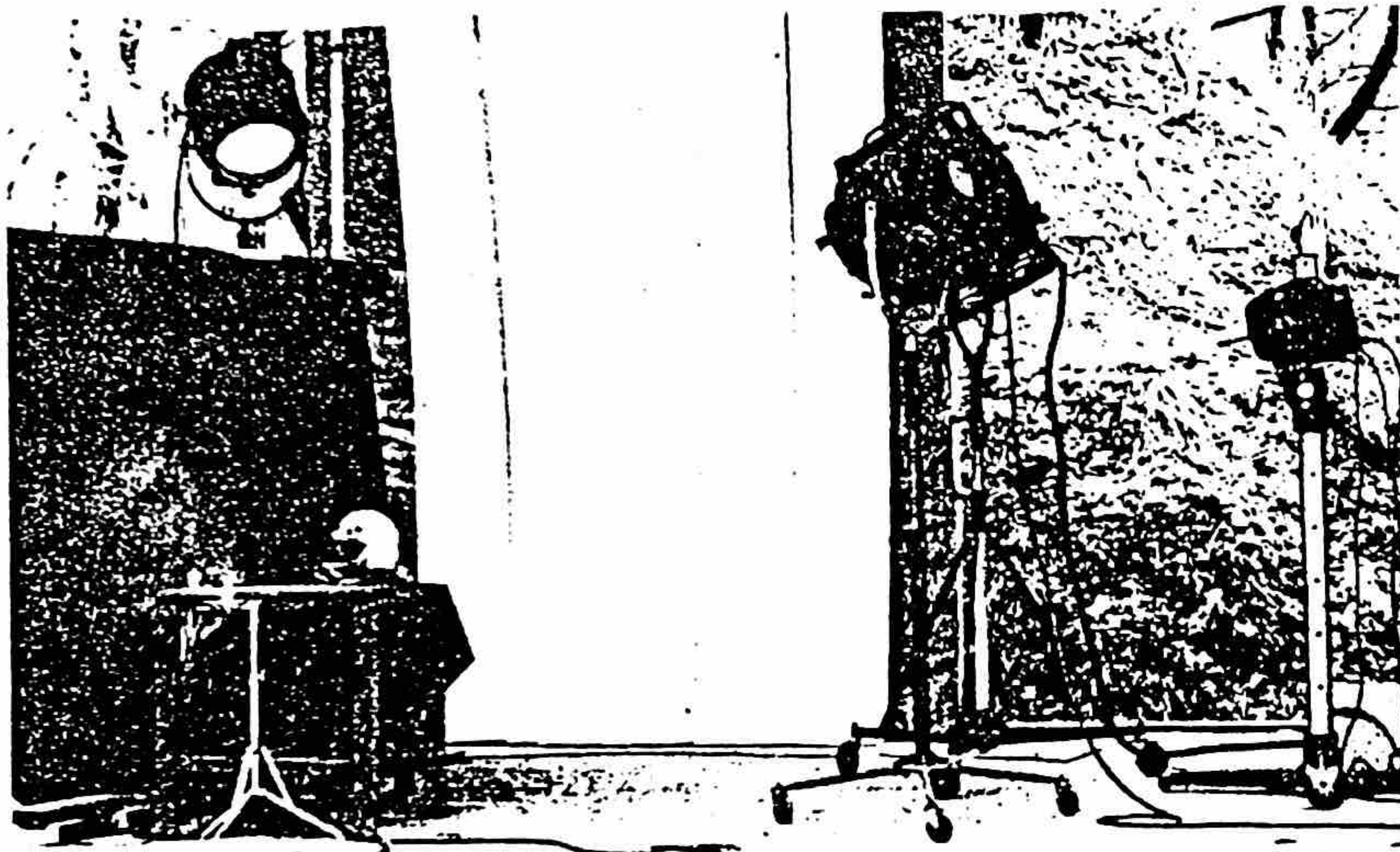
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A



4-49278

B

FIGURE A5

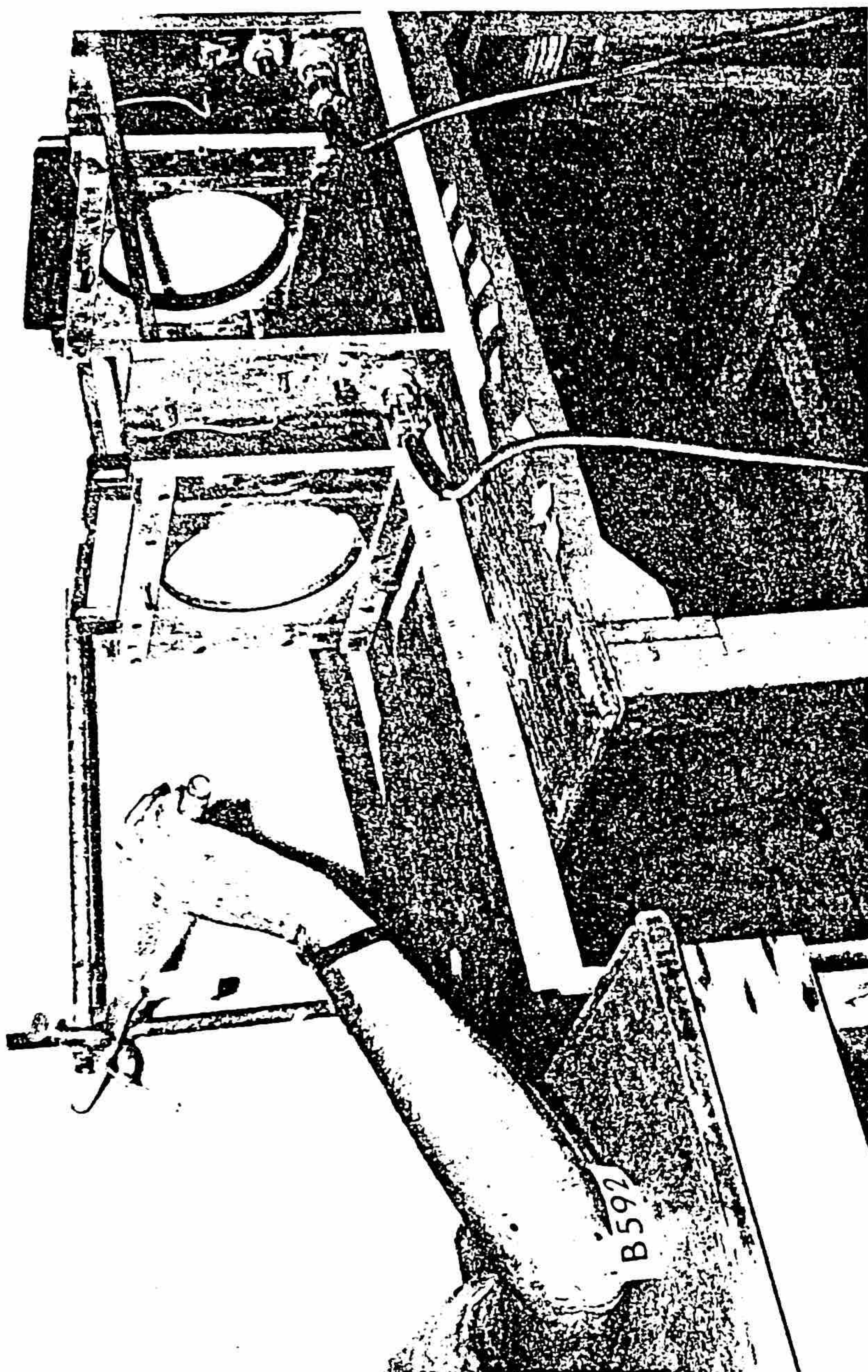
EXPERIMENTAL SETUPS FOR HUMAN-SKULL STUDIES

- A. Skull in position for firing
- B. High-speed camera and lights

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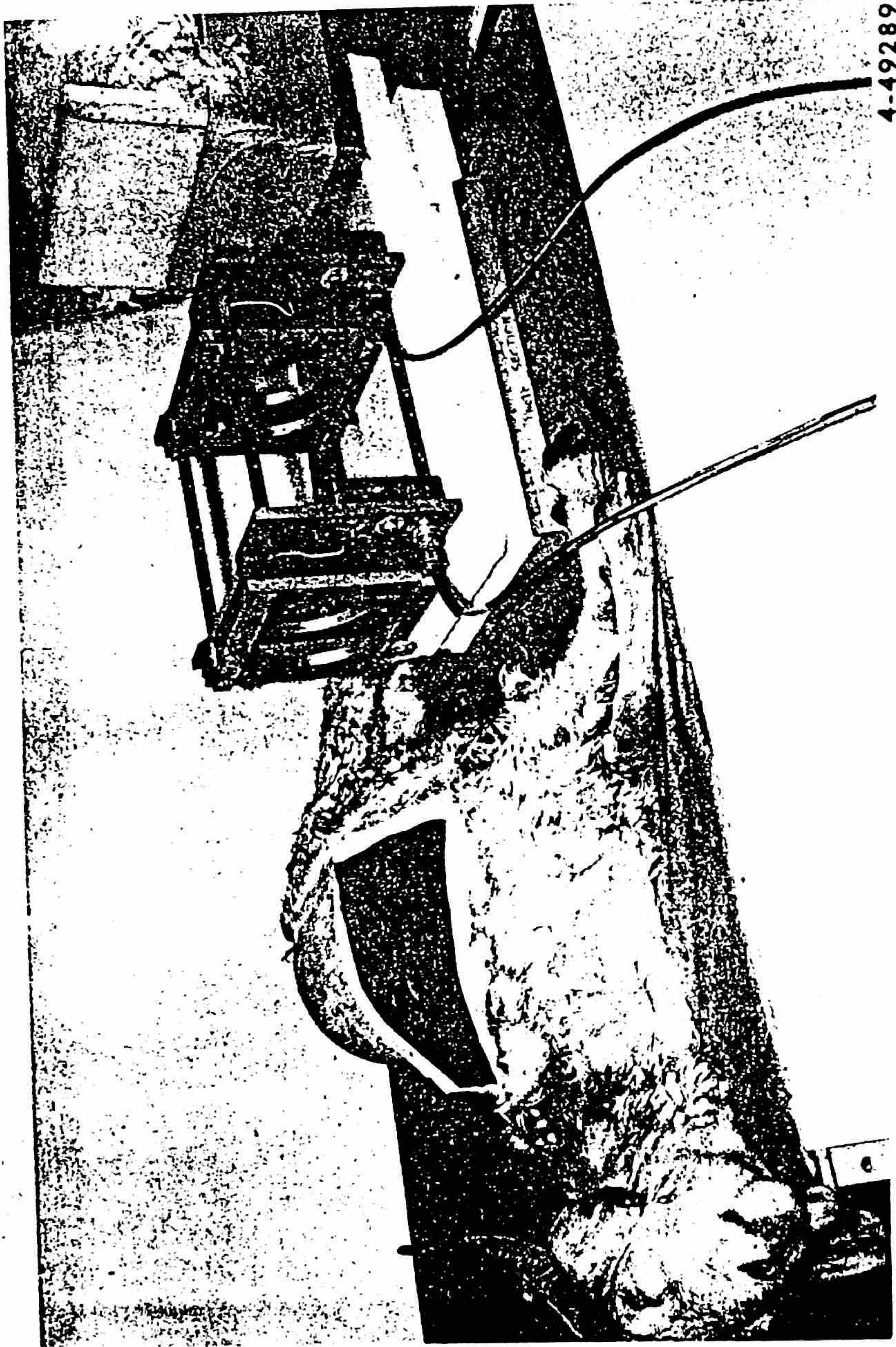
FIGURE A6

EXPERIMENTAL SETUP FOR ARM STUDIES WITH CADAVER ARM
IN POSITION FOR FIRING

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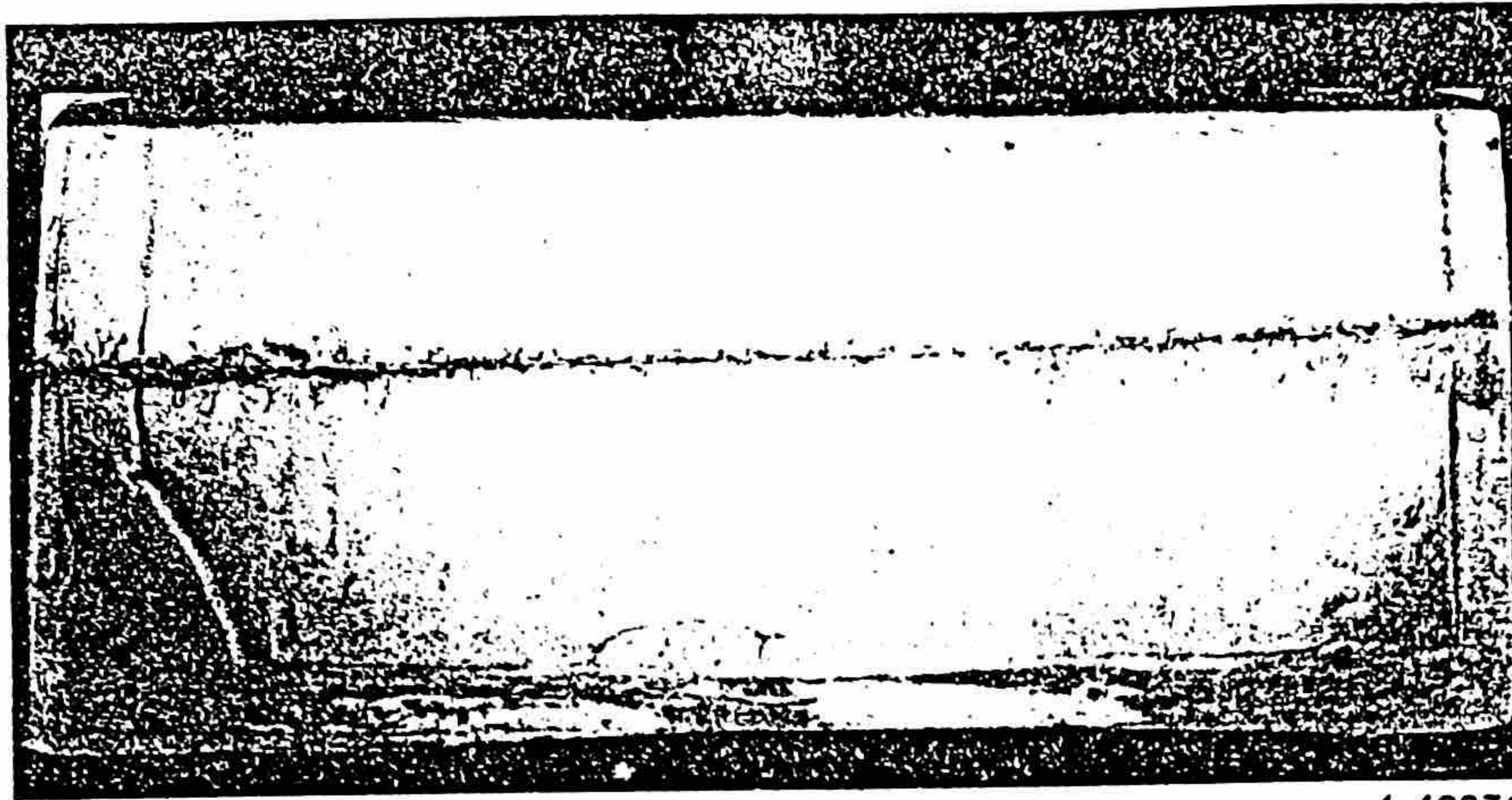
FIGURE A7

EXPERIMENTAL SETUP FOR GOAT-THORAX STUDIES SHOWING
GOAT IN POSITION FOR FIRING (U)

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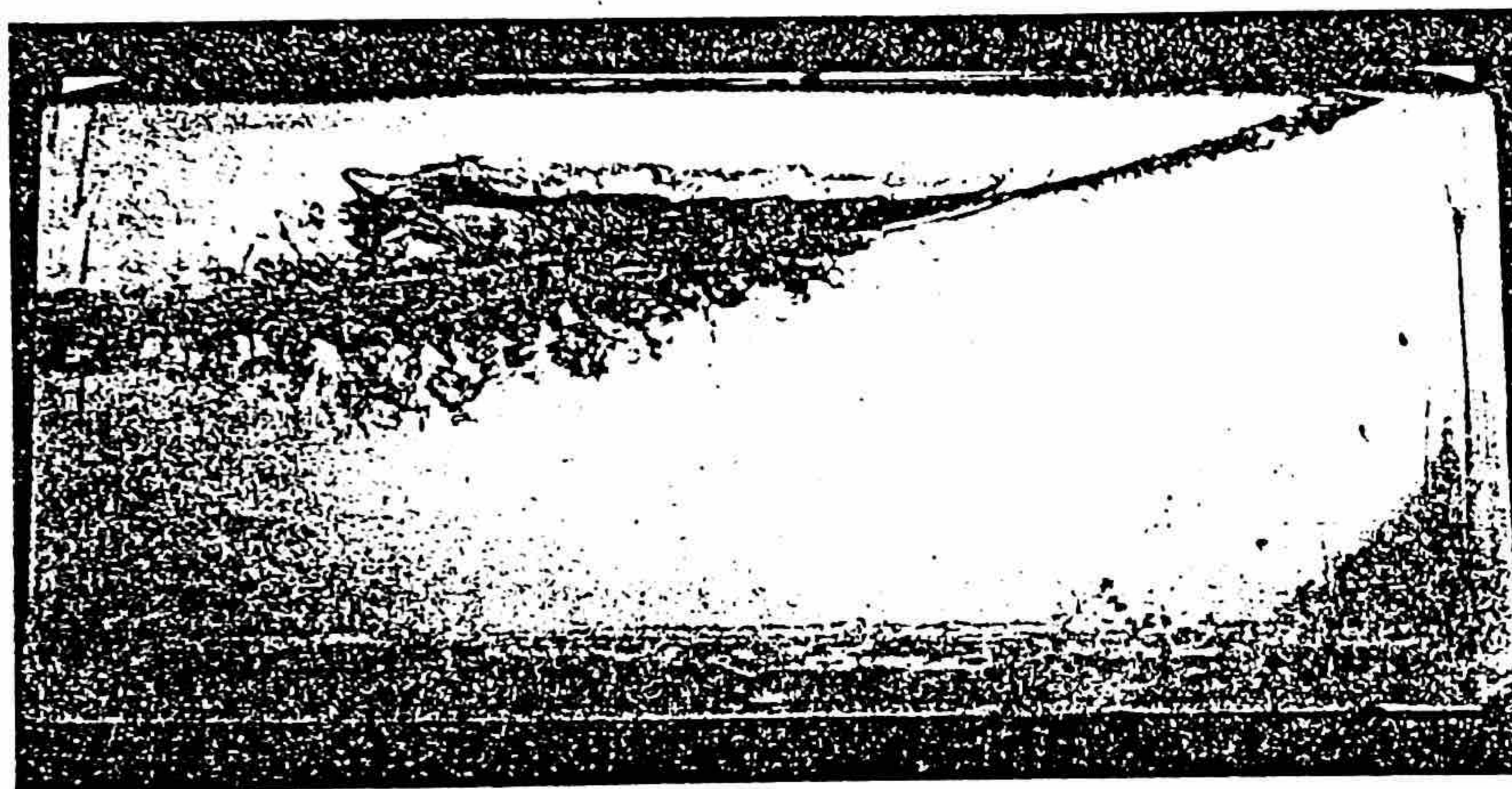
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A



4-49271

B

FIGURE A8

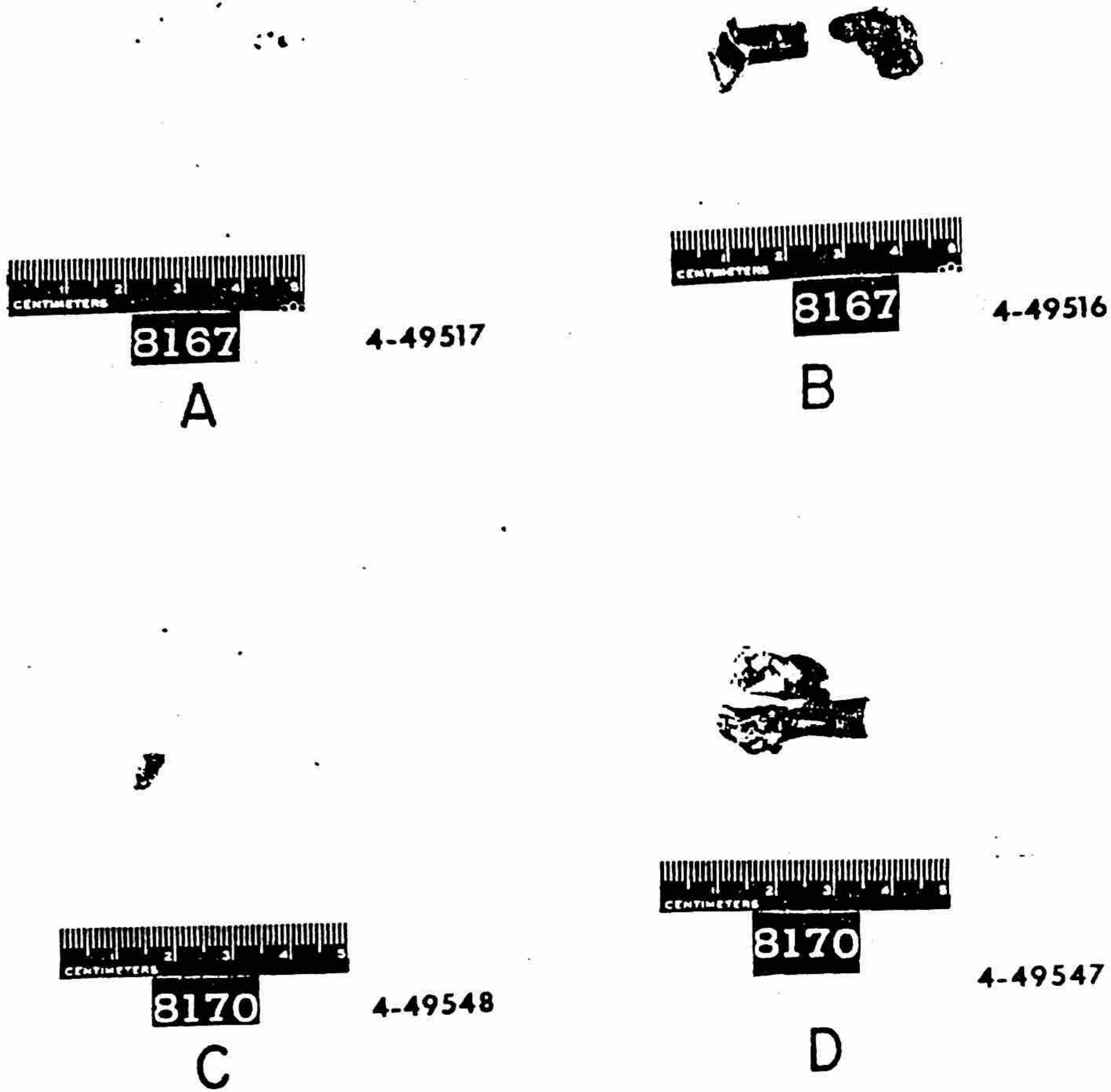
PERMANENT TRACTS LEFT BY 6.5-MM BULLETS IN 20% GELATIN AFTER PERFORATING RETARDATION TARGETS

- A. Tract left by stable bullet
- B. Tract left by unstable bullet

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UNCLASSIFIED



Reference copy, JFK Collection: HSCA (RG 233)

FIGURE A9

BREAKUP OF 6.5-MM MANNLICHER-CARCANO BULLETS BY GELATIN-FILLED AND COATED SKULLS

- A. Fragments recovered within skull 8167
- B. Fragments recovered outside of skull 8167
- C. Fragments recovered within skull 8170
- D. Fragments recovered outside of skull 8170

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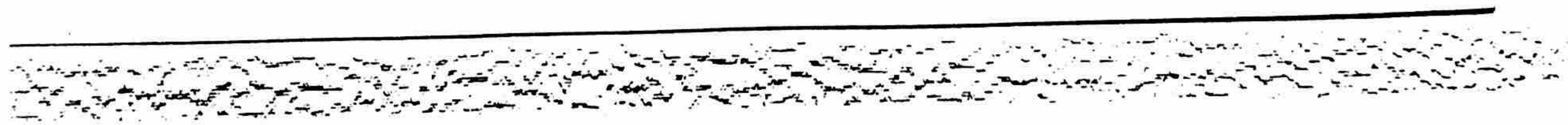
4-52590

FIGURE A10

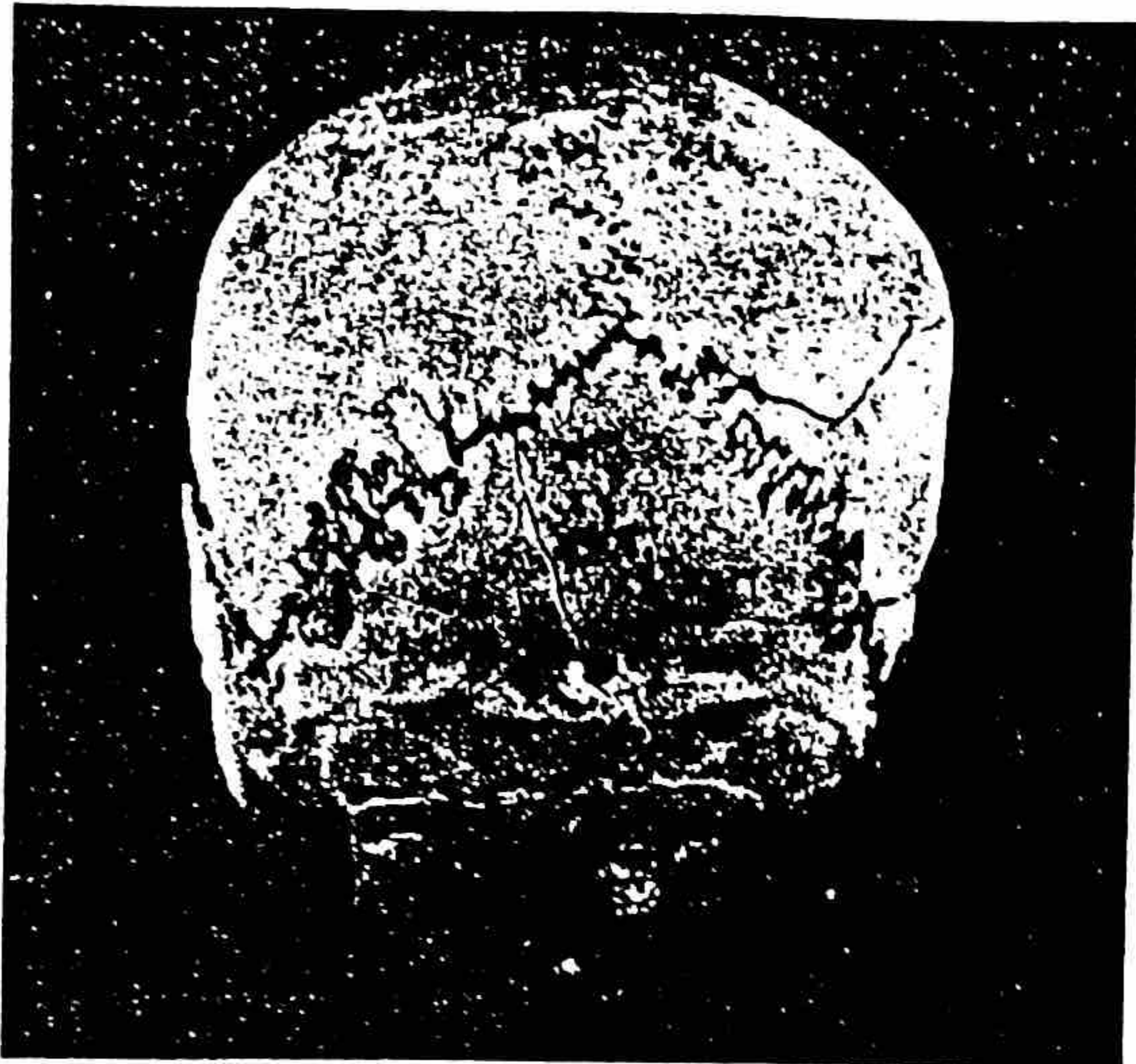
RADIOGRAPHS OF GELATIN-FILLED AND COATED SKULLS SHOWING BULLET FRAGMENTS WITHIN THE CRANIAL CAVITY

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4-49542

A



4-49539

B

FIGURE A11

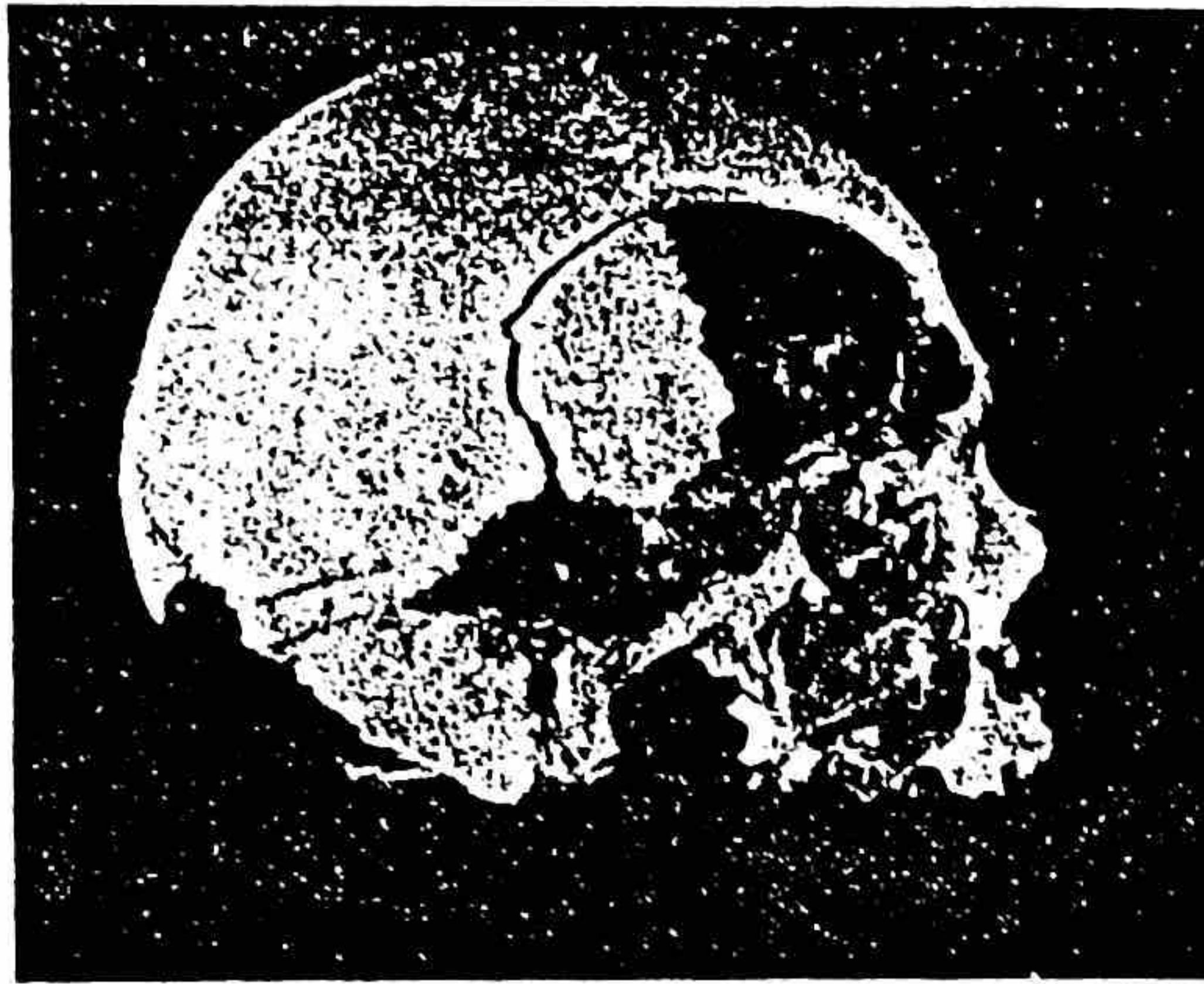
SKULL DAMAGE PRODUCED BY THE 6.5-MM MANNLICHER-CARCANO BULLET AT 90-YD RANGE

- A. Entrance wound
- B. Exit wound

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4-49504



4-49513



4-49562

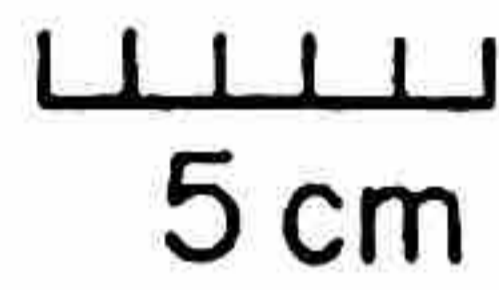


FIGURE A12

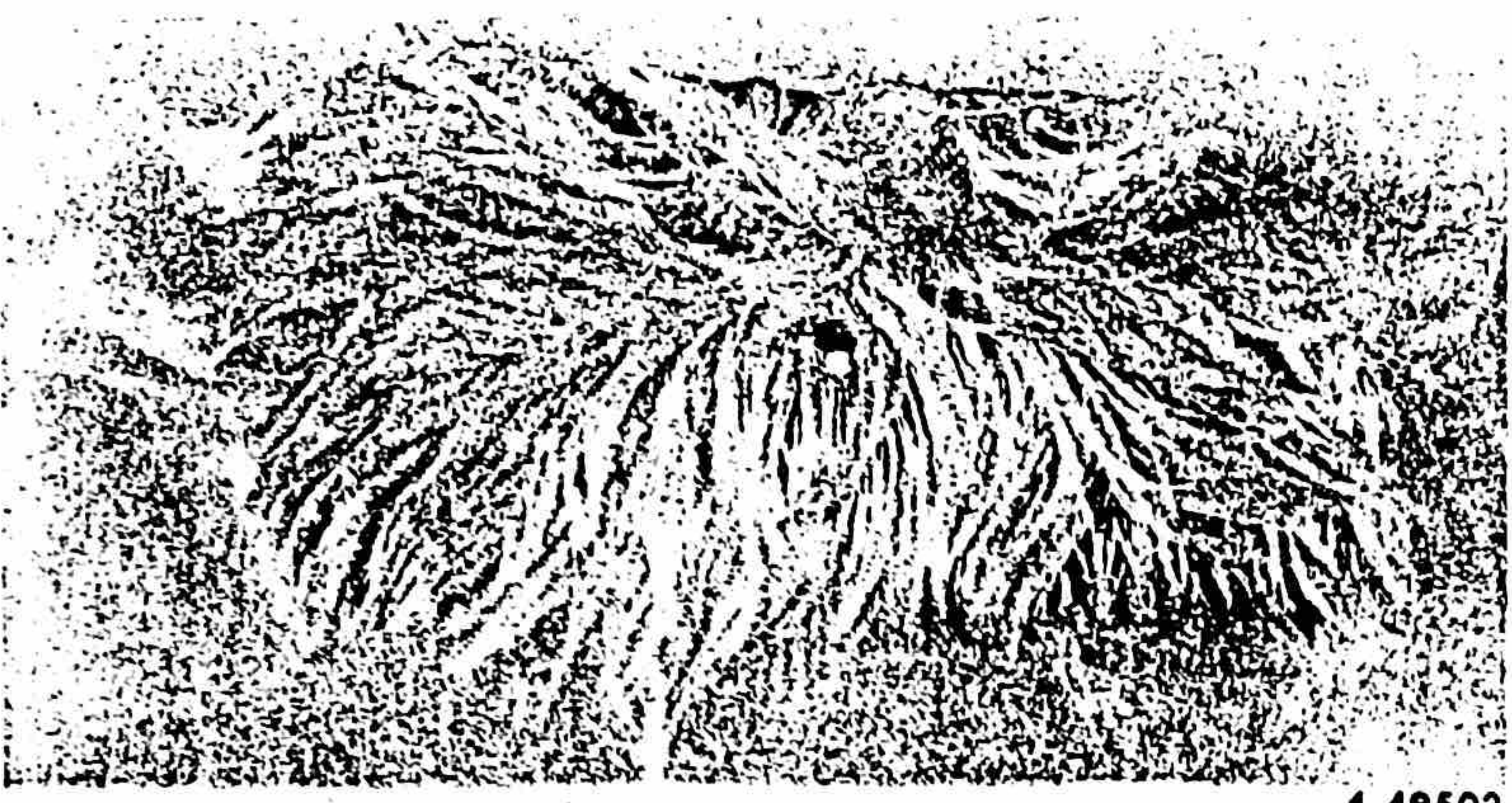
DAMAGE PRODUCED BY 6.5-MM MANNLICHER-CARCANO BULLETS IN FOUR SKULLS AT 90-YD RANGE

(Outer coating of gelatin removed before photography)

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4-49502

A



4-49491

B

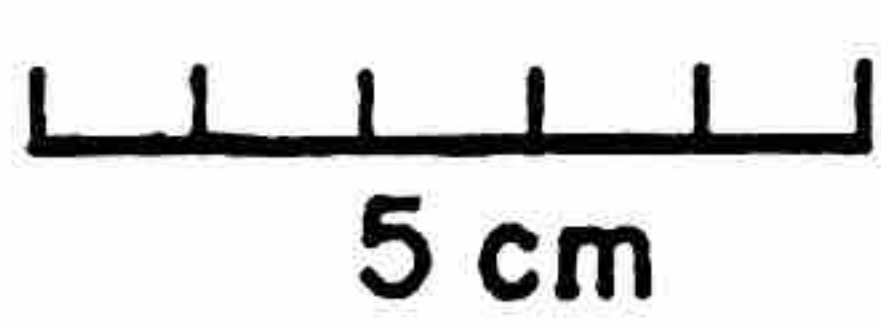


FIGURE A13

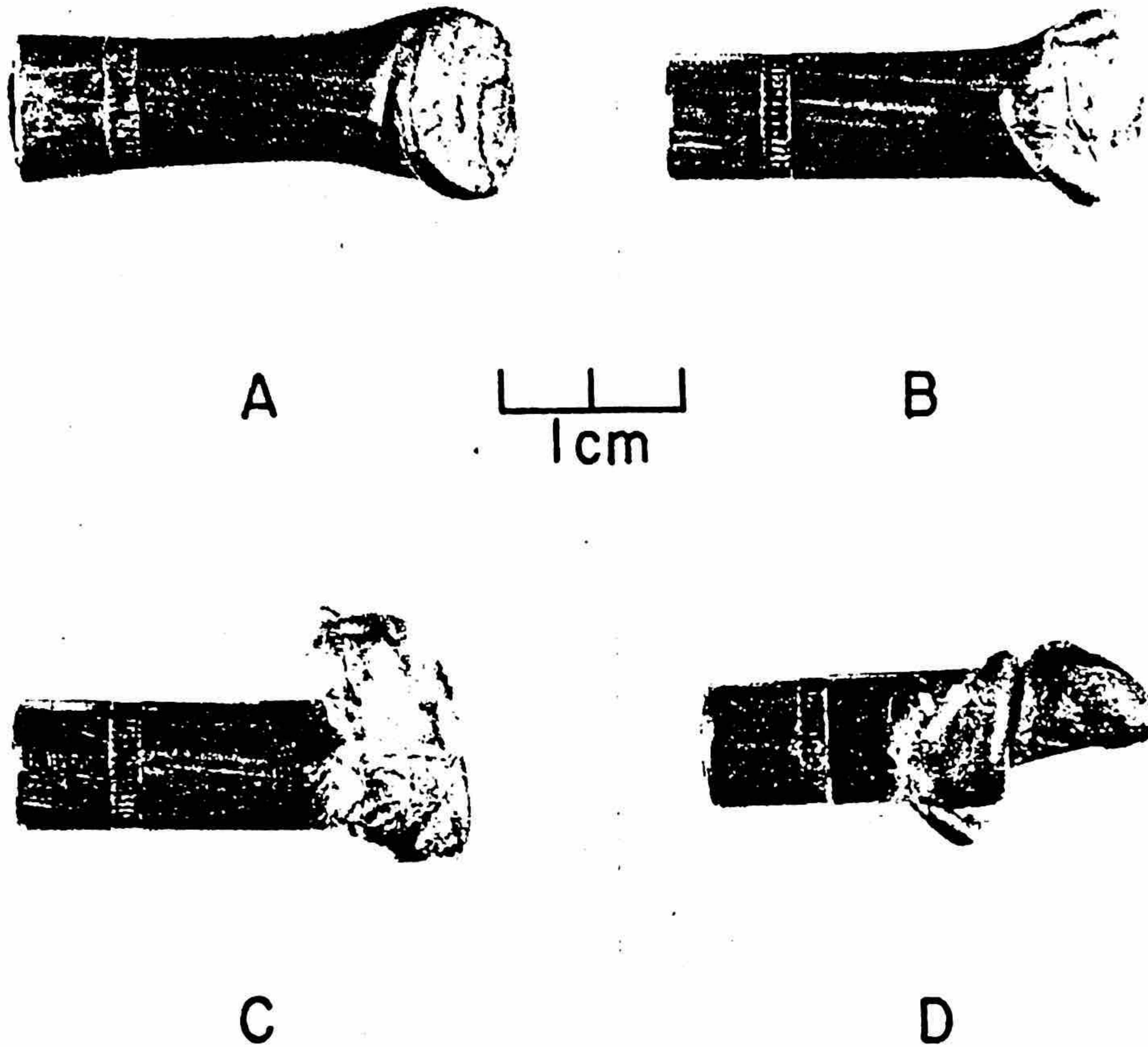
WOUND IN GOAT SKIN USED IN LIEU OF HUMAN SCALP

- A. Entrance side
- B. Flesh side

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Reference copy, JFK Collection: HSCA (RG 233)

FIGURE A14

6.5-MM MANNLICHER-CARCANO BULLETS RECOVERED AFTER BEING FIRED THROUGH DISTAL ENDS OF RADII OF CADAVER WRISTS

- A, B. Bullet deformation from striking cancellous bone
- C, D. Bullet deformation from striking cortical bone

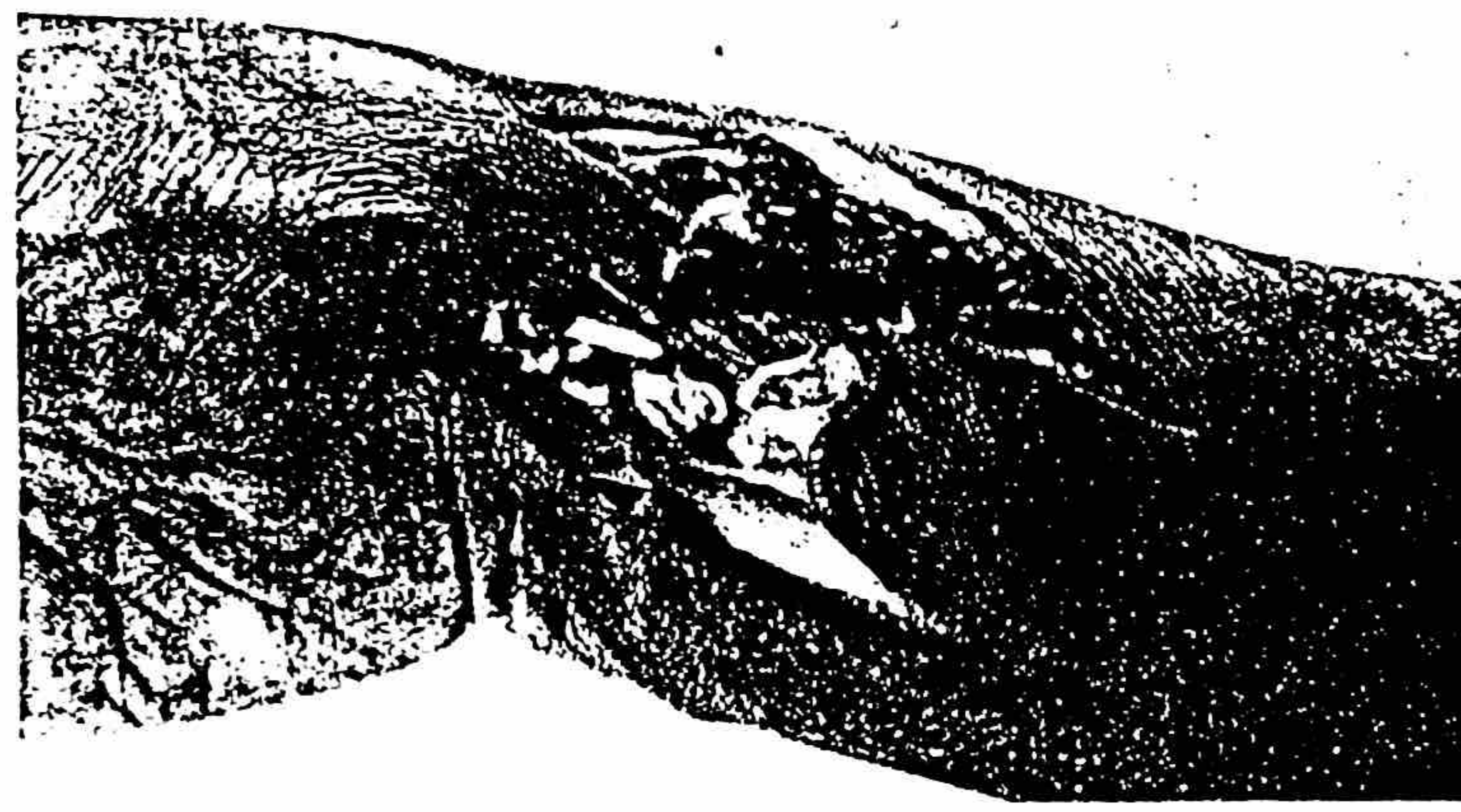
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4-49303

A



B

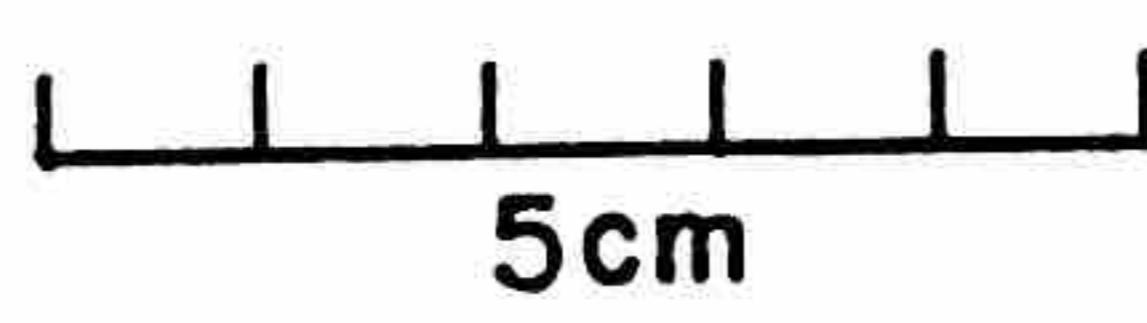


FIGURE A15

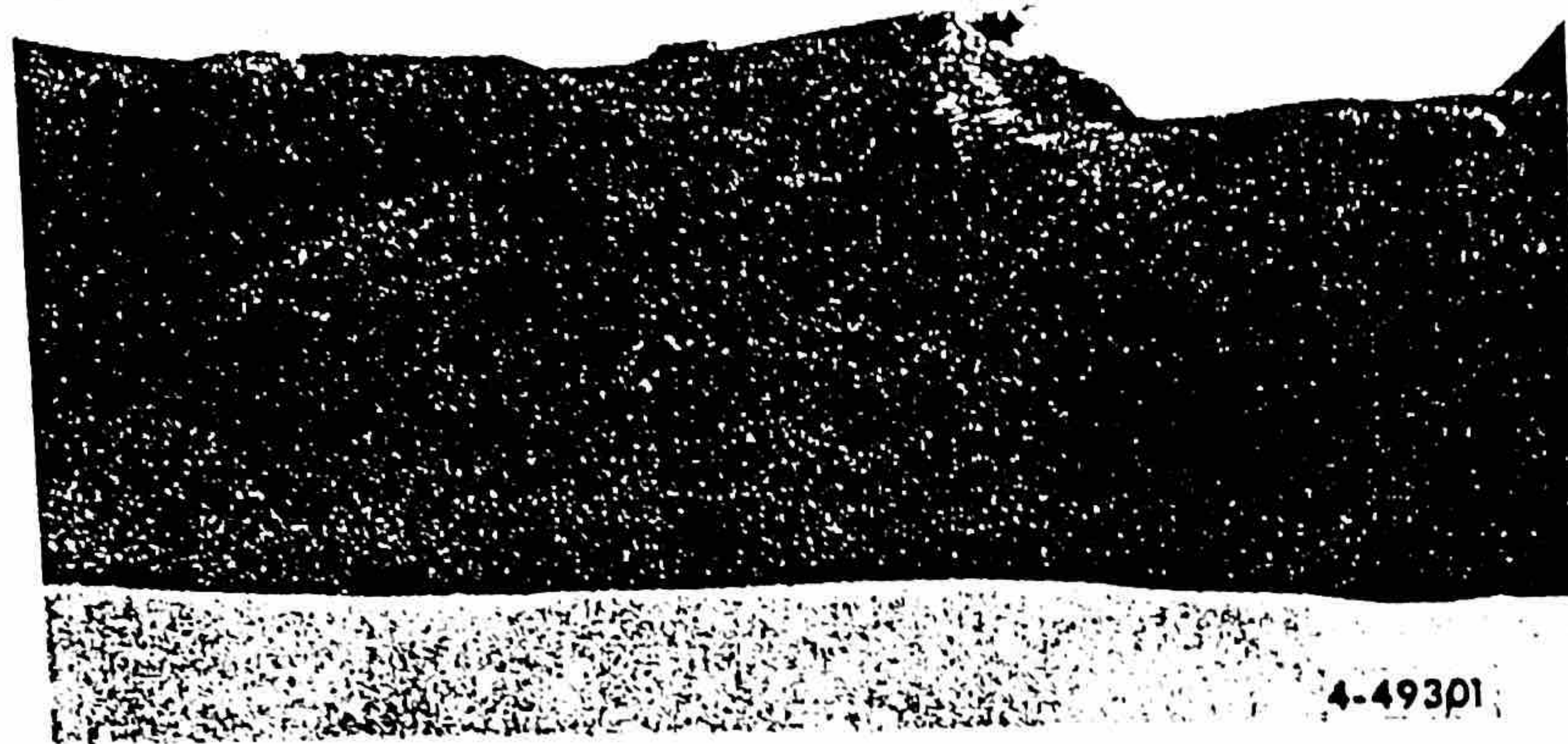
WRIST WOUNDS PRODUCED BY THE 6.5-MM MANNLICHER-CARCANO BULLET AT 70-YD RANGE

- A. Entrance wound
- B. Exit wound

UNCLASSIFIED

Reference copy, JFK Collection: HSCA (RG 233)

UNCLASSIFIED



A



B

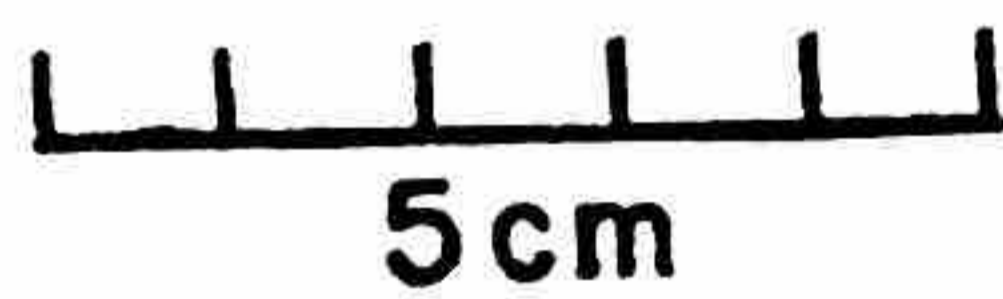


FIGURE A16

WRIST WOUNDS PRODUCED BY THE 6.5-MM MANNLICHER-CARCANO
BULLET AT 70-YD RANGE

- A. Entrance wound
- B. Exit wound

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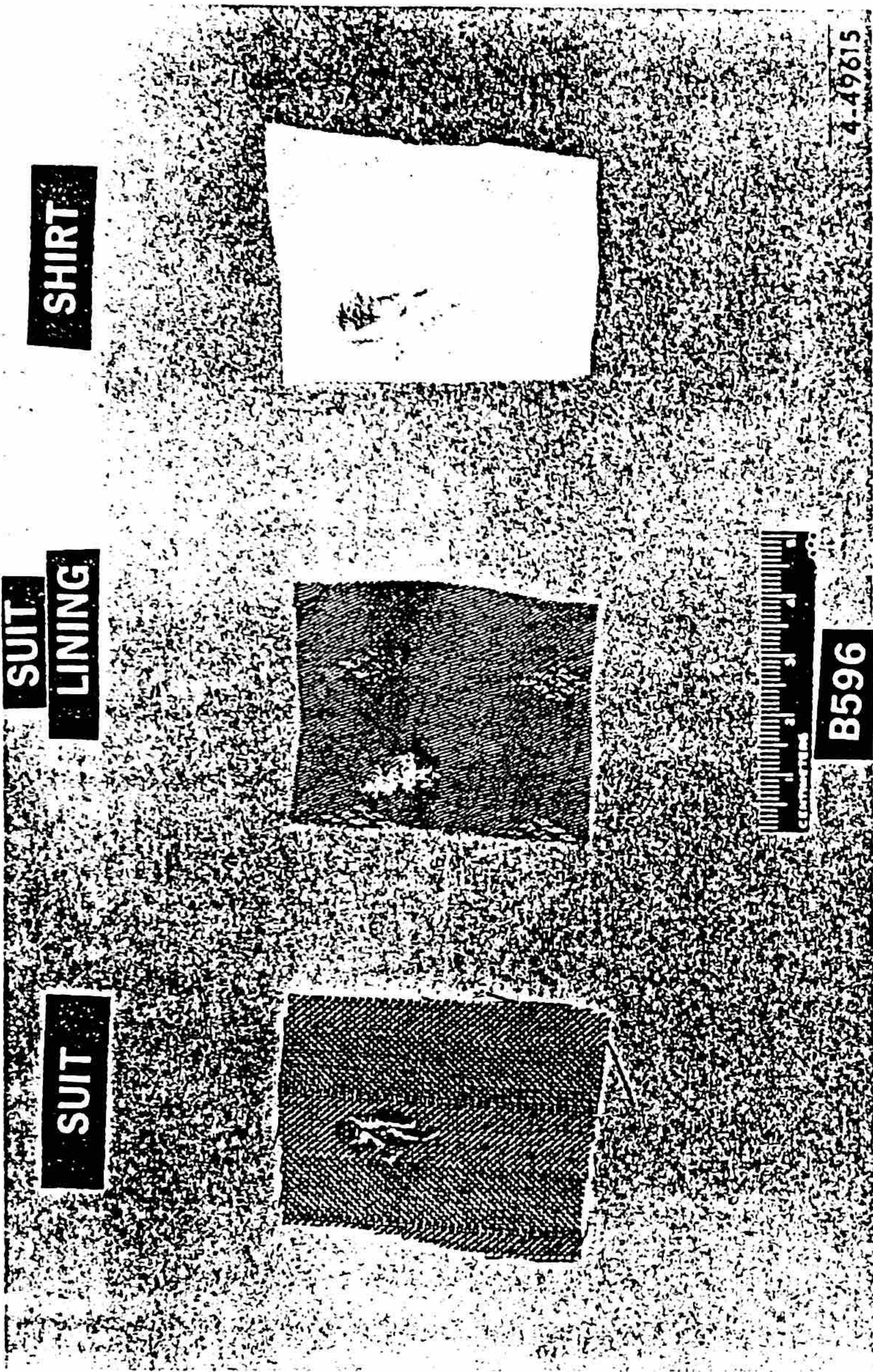


FIGURE A17

BULLET HOLES IN CLOTHING SWATCHES USED TO COVER CADAVER WRISTS

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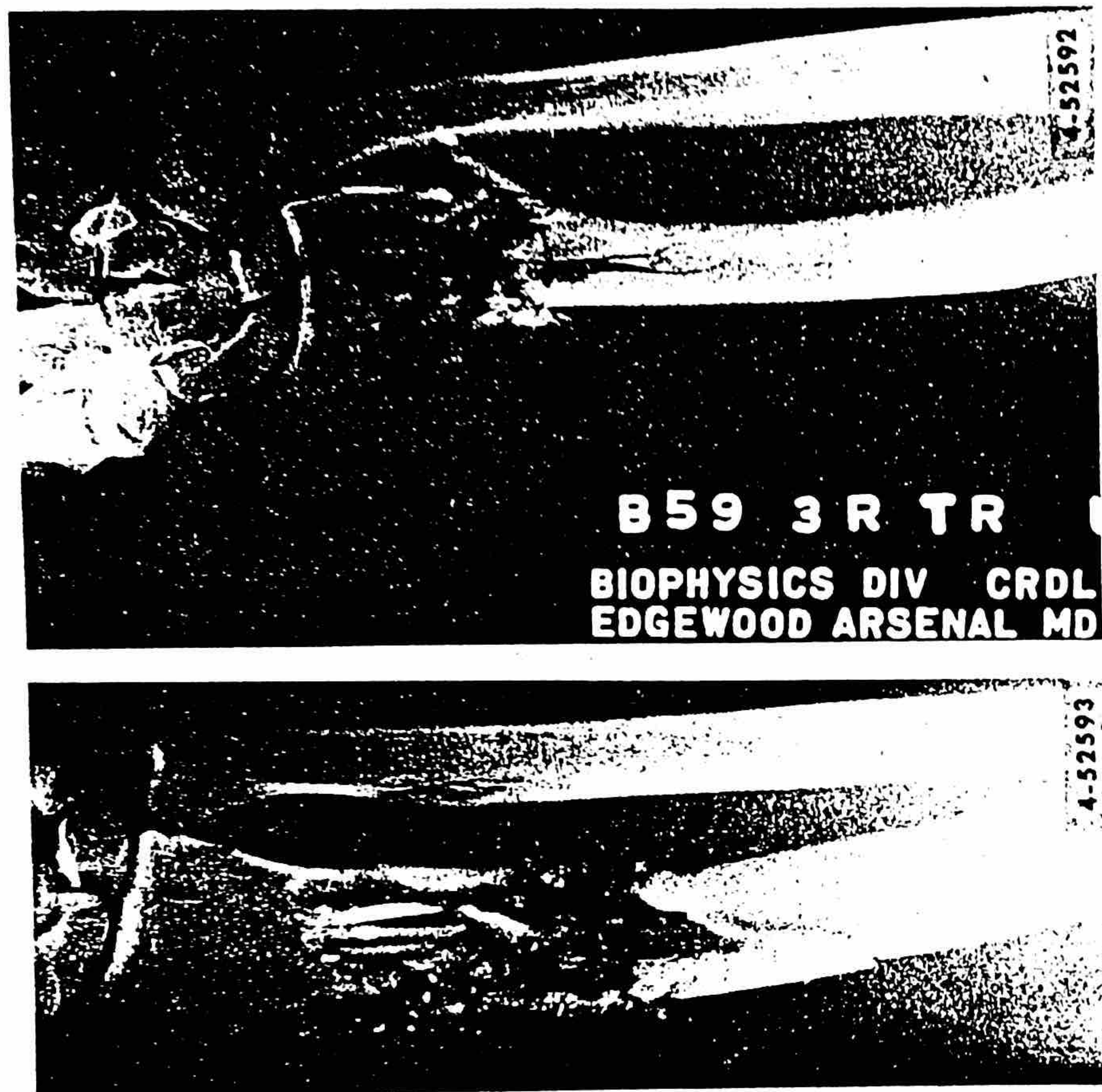


FIGURE A18

RADIOGRAPHS OF TYPICAL FRACTURES OF RADII PRODUCED BY PRISTINE
6.5-MM MANNLICHER-CARGANO BULLETS

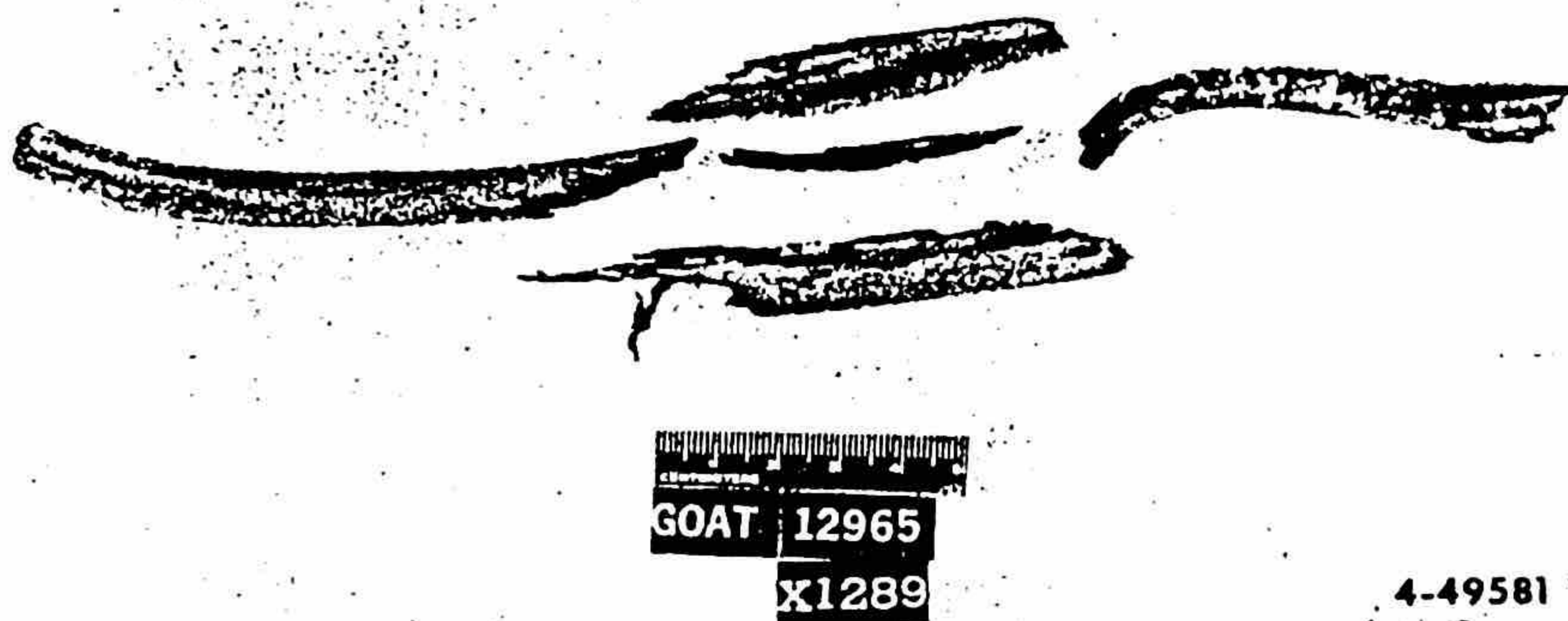
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A



B

FIGURE A19

FRACTURED RIB PRODUCED BY GLANCING BLOW FROM A 6.5-MM MANNLICHER-CARCANO BULLET (FOUO)

- A. Fractured rib in situ
- B. Fractured rib removed from goat

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FIGURE A20

RADIOGRAPH OF COMMINUTED FRACTURE PRODUCED BY GLANCING BLOW OF A 6.5-MM MANNLICHER-CARCANO BULLET ON A GOAT RIB (FOUO)

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4-49590

A



4-49577

B

FIGURE A21

WOUNDS PRODUCED BY FRAGMENTS OF FRACTURED RIB IN GOAT
STRUCK GLANCING BLOW BY A 6.5-MM MANNLICHER-
CARCANO BULLET (FOUO)

- A. Lung wound
- B. Diaphragm wound

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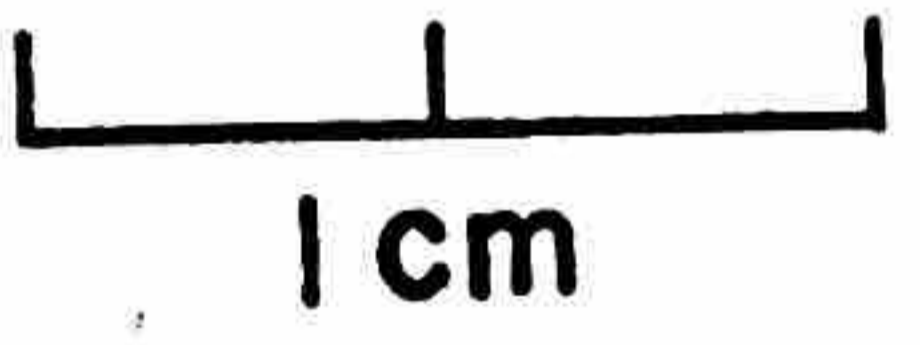
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A



B



4-49602

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FIGURE A22

RECOVERED 6.5-MM MANNLICHER-CARCANO BULLET

- A. Bullet flattened by glancing blow on rib
- B. Undeformed bullet recovered from gelatin tissue model

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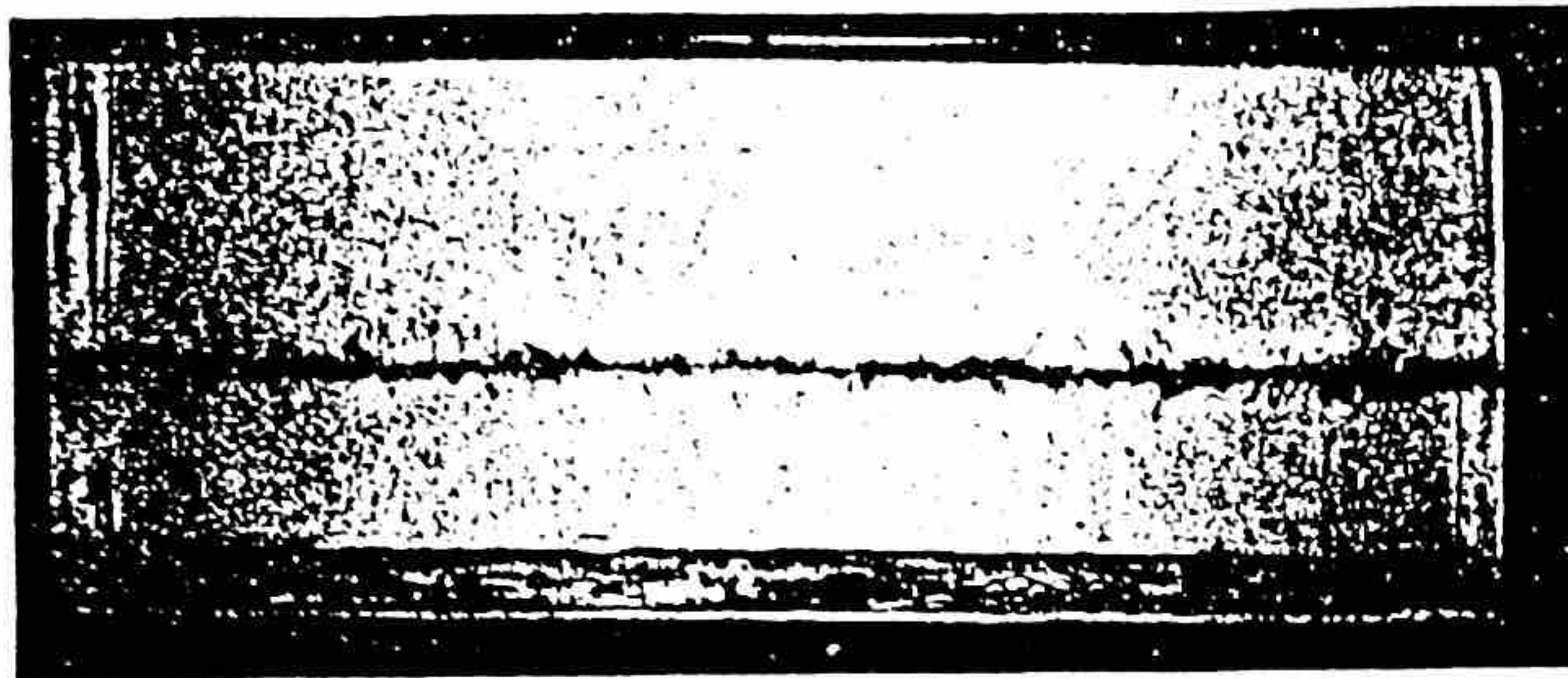


FIGURE A23

HOLE LEFT IN EXIT VELOCITY SCREEN BY 6.5-MM MANNLICHER-CARCANO BULLET TUMBLING AFTER IT PERFORATED TARGET

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A

4-49522



B

4-40416



C

4-38181

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FIGURE A24

PERMANENT CAVITIES LEFT IN GELATIN TISSUE MODELS BY BULLETS

- A. 6.5-mm Mannlicher-Carcano ball at 60-yd range
- B. 7.62-mm M80 ball at 55-yd range
- C. Cal .257 Winchester-Roberts soft-nosed hunting bullet at 55-yd range

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APPENDIX B

TABLES (U)

TABLE B1
HOURLY AMBIENT TEMPERATURES ON SHOOTING DAYS USING
6.5-MM MANNLICHER-CARCANO RIFLE

(U)

Time	27 April 64 Tissue retardation	28 April 64 Human-skull studies	29 April 64 Human-arm studies	30 April 64 Goat-thorax studies	4 May 64 Gelatin energy studies	5 May 64 Goat-thorax studies	11 May 64 Temperature studies
0800	55	57	48	45	54	54	66
0900	56	57	48	46	58	58	70
1000	56 a/	57 a/	49 b/	46	63 c/	63 d/	72
1100	58	57	49	46	65	66	74
1200	60	58	49	46	68	69	76
1300	62	59	48	47	71	70 e/	77
1400	63	62	48	48	73 c/	72	80 f/
1500	64	63	48	48	73	73	80 f/
1600	64	64	48	48	73	73	81

a/ Three velocities recorded at this time.

b/ Five velocities recorded at this time.

c/ Six velocities recorded over this period of time.

d/ Three velocities recorded over this period of time.

e/ Eight velocities recorded over this period of time.

f/ Nine velocities recorded over this period of time.

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TABLE B2

P_{hk} VALUES FOR SEVERAL MILITARY BULLETS (U)

(P_{hk} is probability that a single random hit on a man will incapacitate him)

Rifle	Bullet	Range	Striking velocity	P _{hk}	
				Assault <30 sec	Defense <30 sec
		yd	ft/sec		
M14	7.62-mm, M80	55	2,536		
		109	2,441		
M16 (AR-15)	Cal .223, Remington	55	2,700		
		109	2,554		
Soviet AK	7.62-mm, type PS	55	2,042		
		109	1,902		
Mannlicher-Carcano	6.5-mm, M-C	60	1,829		
		90	1,746		

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(U) TABLE B3

EFFECTS OF TEMPERATURE ON STRIKING VELOCITIES OF BULLETS
FIRED FROM 6.5-MM MANNLICHER-CARCANO RIFLE,
SERIAL NO. C2766

Date	Range	Temperature	Number of shots	Striking velocity	
				Average	Range
	yd	°F		ft/sec	
27 April 64	60	56	3	1,904	1,862 - 1,910
4 May 64	60	71 - 73	6	1,968	1,949 - 1,985
29, 30 April 64	70	48 - 49	8	1,863	1,825 - 1,881
5 May 64	70	63 - 66	3	1,920	1,912 - 1,932
5 May 64	70	69 - 72	8*	1,932	1,906 - 1,945
28 April 64	90	57	3	1,826	1,790 - 1,854
4 May 64	90	63 - 65	6	1,880	1,847 - 1,916

* One aberrant shot, probably a defective round, gave a velocity of 1,739 ft/sec, which is not included in the table.

(U) TABLE B4

EFFECTS OF TEMPERATURE ON STRIKING VELOCITIES OF BULLETS
FIRED FROM 6.5-MM MANNLICHER-CARCANO RIFLE,
SERIAL NO. D3414

Range	Temperature	Number of shots	Striking velocity	
			Average	Range
yd	°F		ft/sec	
60	50	4	1,870	1,863 - 1,877
60	80	4	1,895	1,880 - 1,909
90	50	7	1,791	1,755 - 1,827
90	80	5	1,842	1,821 - 1,854

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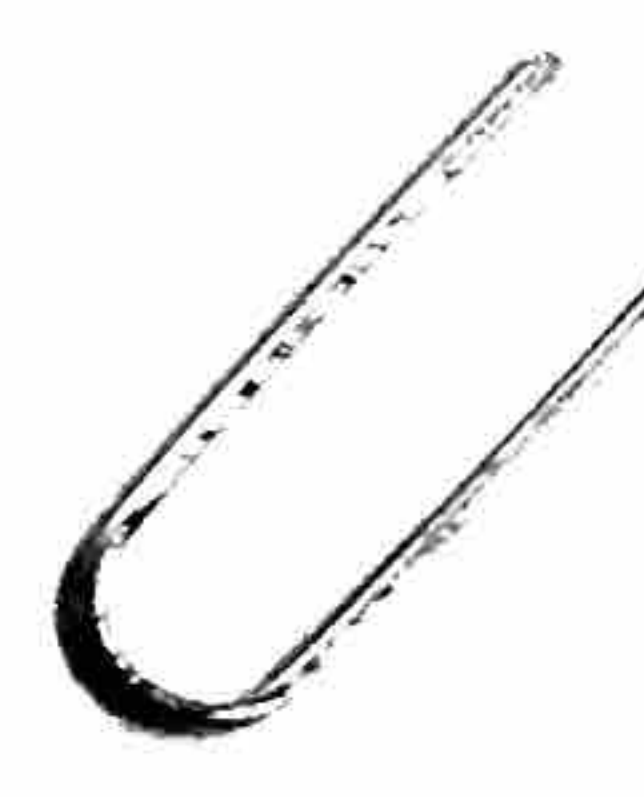
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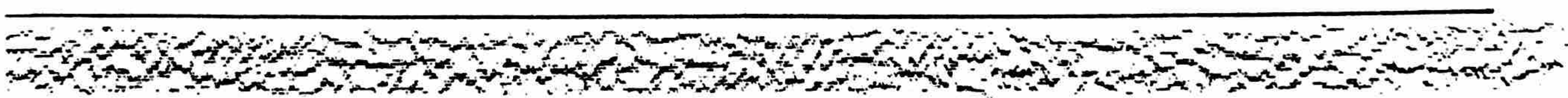
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11. SUPPLEMENTARY NOTES Wound ballistics	12. SPONSORING MILITARY ACTIVITY N/A																
13. ABSTRACT (FOUO) This report describes experiments with the 6.5-mm Mannlicher-Carcano assassination rifle (serial no. C2766) and 6.5-mm Western Cartridge Company lot WCC 6000 Mannlicher-Carcano ball ammunition to reproduce the conditions that occurred at President Kennedy's assassination on 22 November 1963. Tissue-retardation, human-skull, human-arm, goat-thorax, and temperature studies indicated that this bullet-rifle combination was capable of inflicting bullet wounds similar to those sustained by the President and Governor Connally. The wounds received by Governor Connally could have been, and probably were, caused by the same bullet that wounded President Kennedy in the neck. Governor Connally's wrist wound was made by the same bullet that produced his chest wound.																	
14. KEYWORDS <table border="0"> <tr> <td>Rifle</td> <td>Wounds</td> <td>Trauma</td> </tr> <tr> <td>6.5-mm Bullet</td> <td>Assassination</td> <td>Wound ballistics</td> </tr> <tr> <td>Governor Connally</td> <td>Tissue retardation</td> <td>Gelatin tissue model</td> </tr> <tr> <td>Warren Commission</td> <td>Mannlicher-Carcano rifle</td> <td>President John F. Kennedy</td> </tr> <tr> <td>President's Commission on the Assassination of President John F. Kennedy</td> <td></td> <td></td> </tr> </table>			Rifle	Wounds	Trauma	6.5-mm Bullet	Assassination	Wound ballistics	Governor Connally	Tissue retardation	Gelatin tissue model	Warren Commission	Mannlicher-Carcano rifle	President John F. Kennedy	President's Commission on the Assassination of President John F. Kennedy		
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