TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA AM- 72-7		

4. Title and Subtitle
EVALUATION OF A FIBERGLASS INSTRUMENT GLARE SHIELD FOR PROTECTION AGAINST HEAD INJURY

5. Report Date
February 1972

6. Performing Organization Code

7. Author(s)
E. D. Langston
John J. Swearingen, D. Av. T.

8. Performing Organization Report No.

9. Performing Organization Name and Address
FAA Civil Aeromedical Institute
P. O. Box 25082
Oklahoma City, Oklahoma 73125

10. Work Unit No.

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
Office of Aviation Medicine
Federal Aviation Administration
800 Independence Avenue, S. W.
Washington, D. C. 20591

13. Type of Report and Period Covered
OAM

14. Sponsoring Agency Code

15. Supplementary Notes
Research leading to preparation of this report was performed under Project NO. AM-A-71-PRS-47.

16. Abstract

An all fiberglass prototype glare shield has been evaluated in terms of head injury protection. In 30-ft./sec. head impacts, the 9-1/2-inch protrusion folded down over the heavy instruments, offering significant improvement in head injury protection when compared to current aircraft instrument panel design. However, in this particular design the fiberglass broke, allowing the forehead to contact a thin, sharp edge with sufficient force to produce fatal head injuries. Design changes to eliminate this fracture point and incorporation of fiberglass glare shields of similar design in future general aviation aircraft could lead to a significant reduction of head injuries during crash decelerations.

17. Key Words	18. Distribution Statement
Crash safety, engineering design, crashworthiness	Availability is unlimited. Document may be released to the National Technical Information Service, Springfield, Virginia, 22151, for sale to the public.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	10	$3.00

Form DOT F 1700.7 (8-69)

EVALUATION OF A FIBERGLASS INSTRUMENT GLARE SHIELD FOR PROTECTION AGAINST HEAD INJURY

I. Introduction.

In view of the large number of serious or fatal head injuries resulting from head impact against upper instrument panels during crashes of general aviation aircraft,[1 2 3 4] the Protection and Survival Laboratory at CAMI maintains interest in new design concepts which may offer protection against head trauma.

II. Test Equipment and Procedures.

Two fiberglass instrument panels (without instruments), along with their integrated glare shields, were submitted to the laboratory for evaluation. These were mounted at the end of the CAMI crash decelerator (Figure 1). The position of the glare shield was adjusted to conform with measurements provided by the manufacturer. An instrumented dummy head, taken from an Alderson F–50 anthropometric dummy, was rigidly attached to a weighted arm which was free to swing about a pivot on the decelerator sled. The sled was braked prior to impact, allowing the head to swing forward in an arc, impacting the protruding edge of the glare shield in the orientation shown in Figure 2. Yellow chalk applied to this protruding edge allowed determination of maximum area of initial face contact and strips of adhesive tape indicated depth of head penetration. Sled decelerations were calibrated to produce head impact velocities of 30 and 35 ft./sec. since these head impact velocities will occur in crashes of approximately 7–G magnitude as measured on the floor structure under the seat.[5 6] Head impact deceleration was measured by a single 250–G CEC Model 4–202–0001 strain gage accelerometer mounted in the dummy head with data recorded using a Sanborn 550 M signal conditioning system and a CEC Model 5–124A oscillographic recorder. Time lines on the oscillograph paper, a sweep-second clock and time marks on all high-speed motion picture film allowed synchronization of deceleration peaks on the tracing with structural collapse of the fiberglass glare shield. Motion picture coverage was provided by four cameras, one operating at 24 fps, two at 400 fps, and one at 2,000 fps.

III. Description of Glare Shield.

The glare shield shown in Figure 3 consisted of a basic structure of a thin fiberglass layer covered with a ¼-inch thick layer of Ensolite and a thin layer of plastic vinyl. It extended 9½ inches from the instrument panel toward the pilot and was elevated about 13 degrees above the horizontal. On the protruding edge nearest the pilot the shield was rolled down and under with an inside radius of curvature of approximately ¼-inch. After impact testing had been completed, the covering was removed from a portion of the shield so that the thickness of the fiberglass could be measured. The first five inches (nearest the pilot) were of a uniform thickness of .020 inches, increasing to 0.025 inches at six inches, to .050 inches at seven inches, and .065 at eight. At nine inches the thickness abruptly increased to 0.200 inches due to the lap with the instrument panel.

It should be noted at this point that the glare shield protruded only in front of the left pilot and that the right side dropped back such that the head impact area for the right seat occupant consisted of a layer of the thin padding over a rigid structure at the top of the instrument panel (Figure 1).

IV. Results.

Figure 4 presents a pictorial sequence of events correlated with deceleration measured during Test One (30 ft./sec. head impact velocity). The initial head contact with the edge of the glare shield was with the maxilla just below the nose producing an initial deceleration peak of 10 G's followed by a second peak of 30 G's as the shield began to collapse. Chalk deposited on the head form from the edge of the glare shield during this phase of the impact was lifted by means of masking tape and the area of facial contact determined to be 3.75 square inches. Based on previous research,[7] it appears unlikely that major facial fractures would occur during this initial head impact. From 0.025 seconds to 0.04 seconds, the glare shield folded down over the instruments and prevented head contact with them. However, beginning at about 0.04 seconds, the fiberglass broke about 6½ inches from the edge of the glare shield. The thin edge of the shield, supported by the instrument panel flange penetrated the ¼-inch padding and cut the rubber head form covering, as shown in Figures 5 through 8. A peak head form deceleration of 60 G's was produced as the rigid head form contacted this thin edge. In Reference 7 it is stated that the forehead can tolerate 80 G's on one square inch without bone fracture. If we assume that the forehead contacted a four-inch length of this 0.035-inch-thick fiberglass edge, we can calculate a contact area of 0.14 square inch and any impact deceleration in excess of 12 G's would be expected to produce injuries. The impact of 60 G's in this test would produce severe lacerations (Figure 8) and extensive fracture of the anterior cranium.

The results of this test were confirmed by a second test which produced almost identical failure patterns and head form decelerations.

V. Conclusions.

Since the fiberglass glare shield folded down over the heavy instruments and sharp knobs and edges and produced a maximum deceleration force on the head of only 60 G's while distributing the load over large facial areas, as compared to 300-G forces produced on small areas of the head in similar impact tests of conventional light aircraft instrument panels without the glare shield (Reference 2), it must be concluded that a glare shield constructed of fiberglass or of some similar material could substantially reduce the large number of severe head injuries now occurring in general aviation crashes. The failure of the glare shield in these tests exposing a relatively rigid sharp edge to the head could cause fatal injuries, even in the relatively low impact velocities represented by these tests. Correction of this fault by a minor design modification could lead to a significant improvement in crashworthiness.

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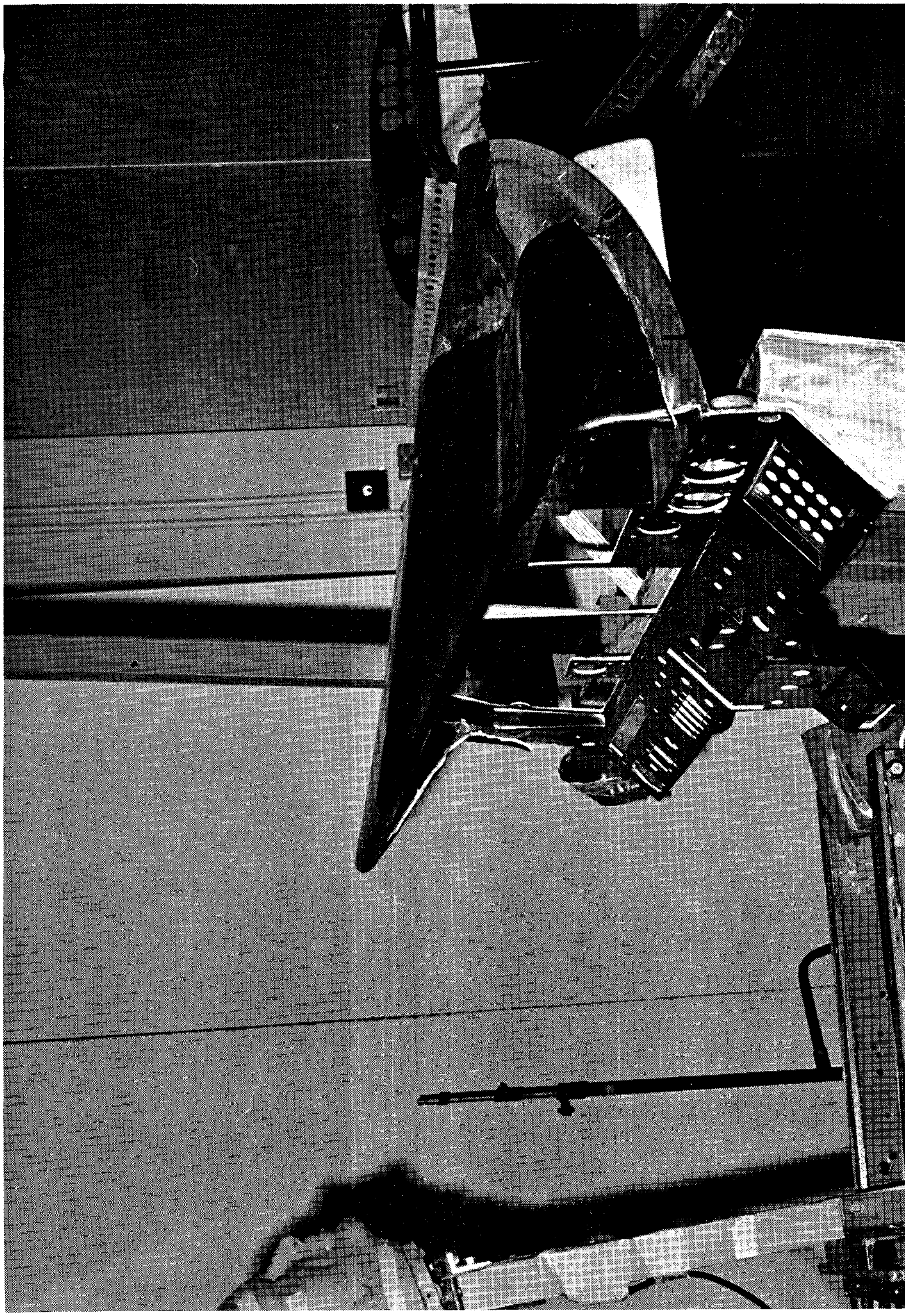

FIGURE 1. Fiberglass instrument panel and glare shield mounted at the end of the crash sled.

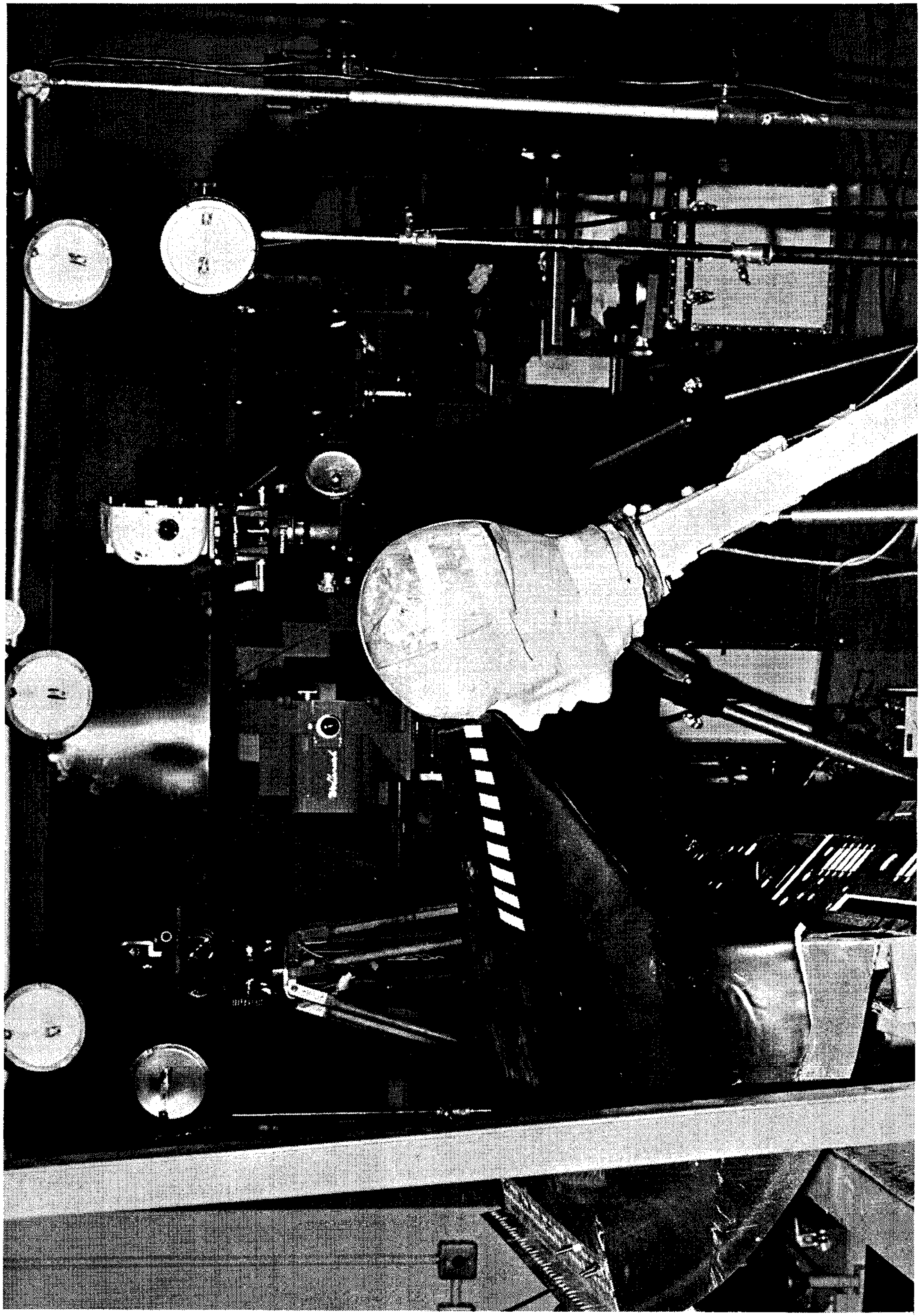

FIGURE 2. Strips of adhesive tape were added to show depth of head penetration.

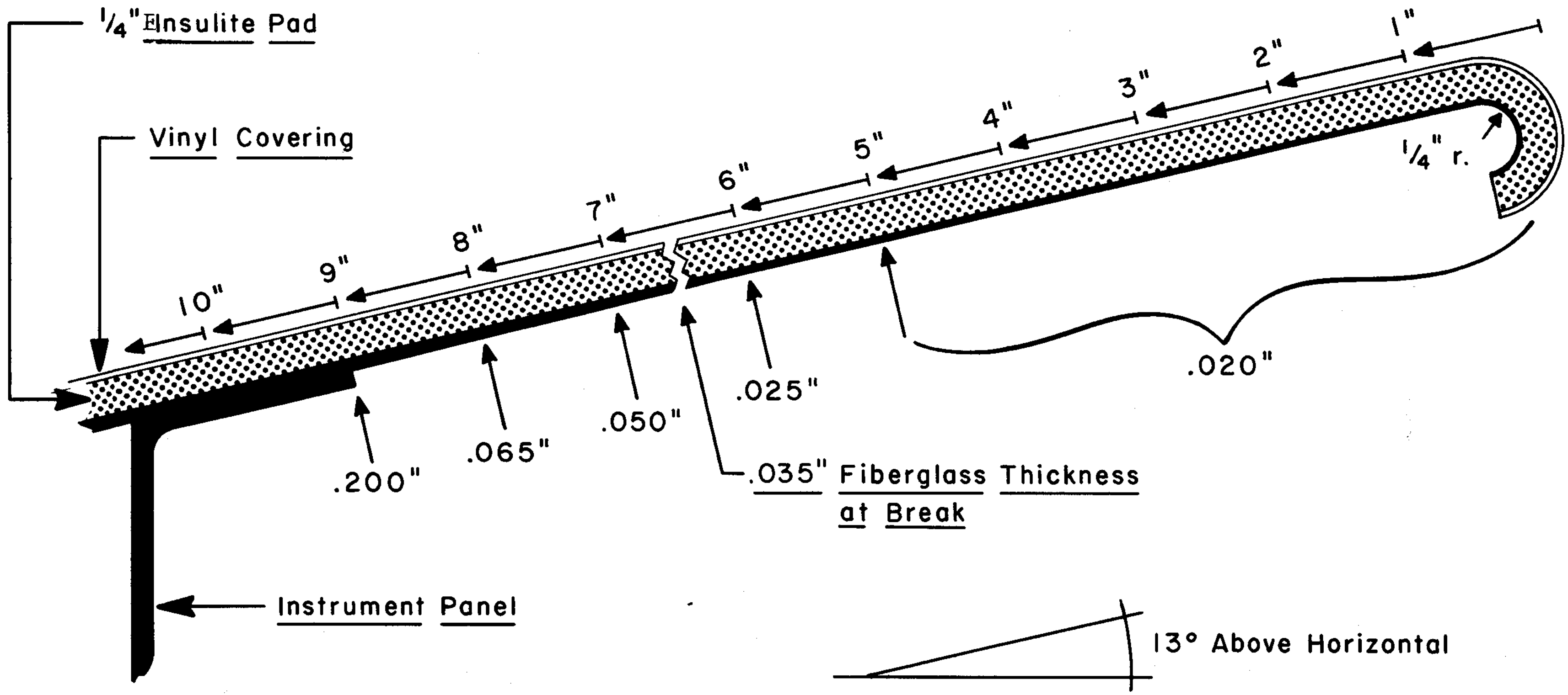

FIGURE 3. Cross section of the glare shield showing thicknesses at various points.

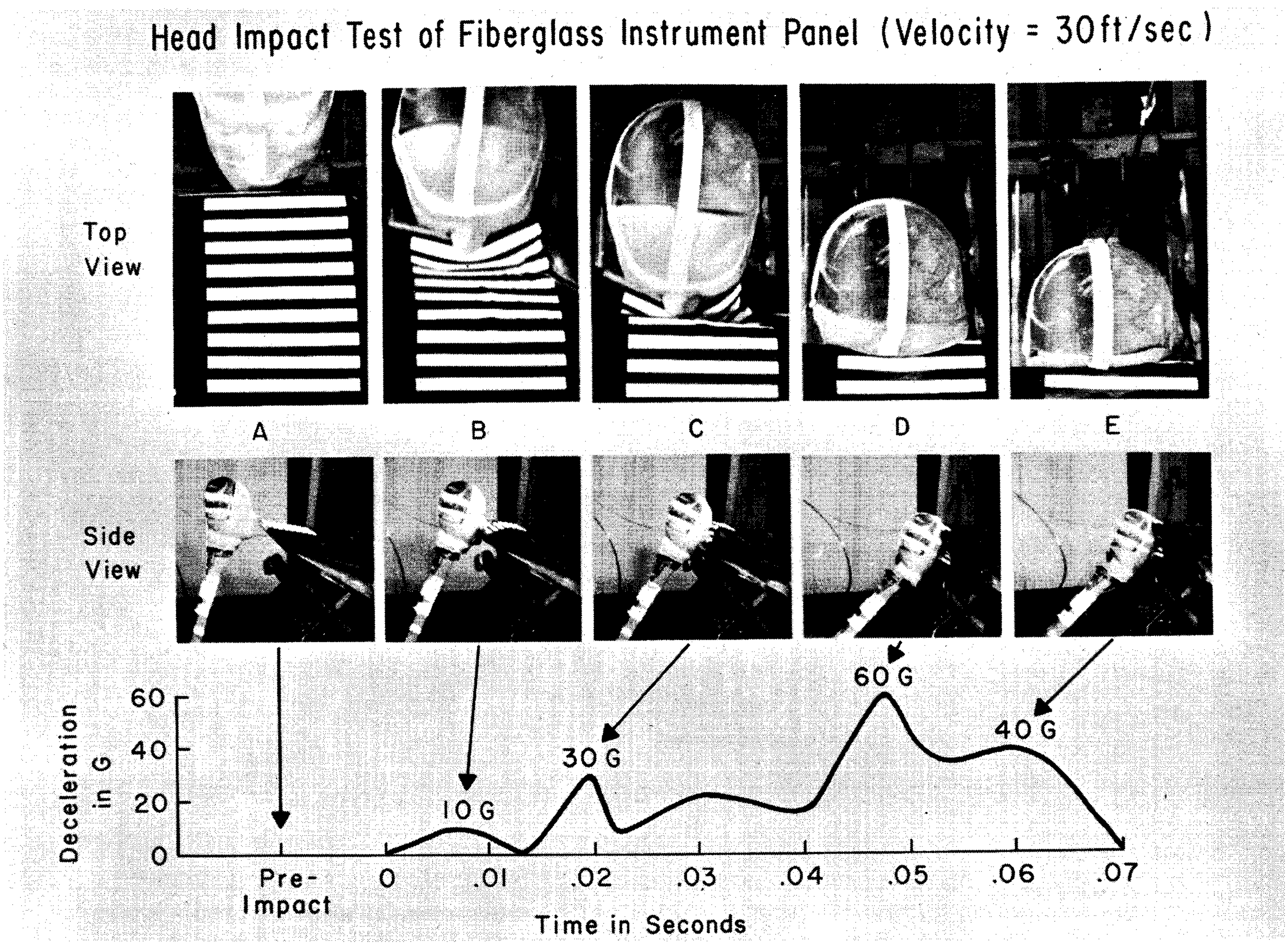

FIGURE 4. Results of a 30-ft./sec. head impact against the fiberglass glare shield.

FIGURE 5. Broken edge of fiberglass cut through thin padding (note arrow).

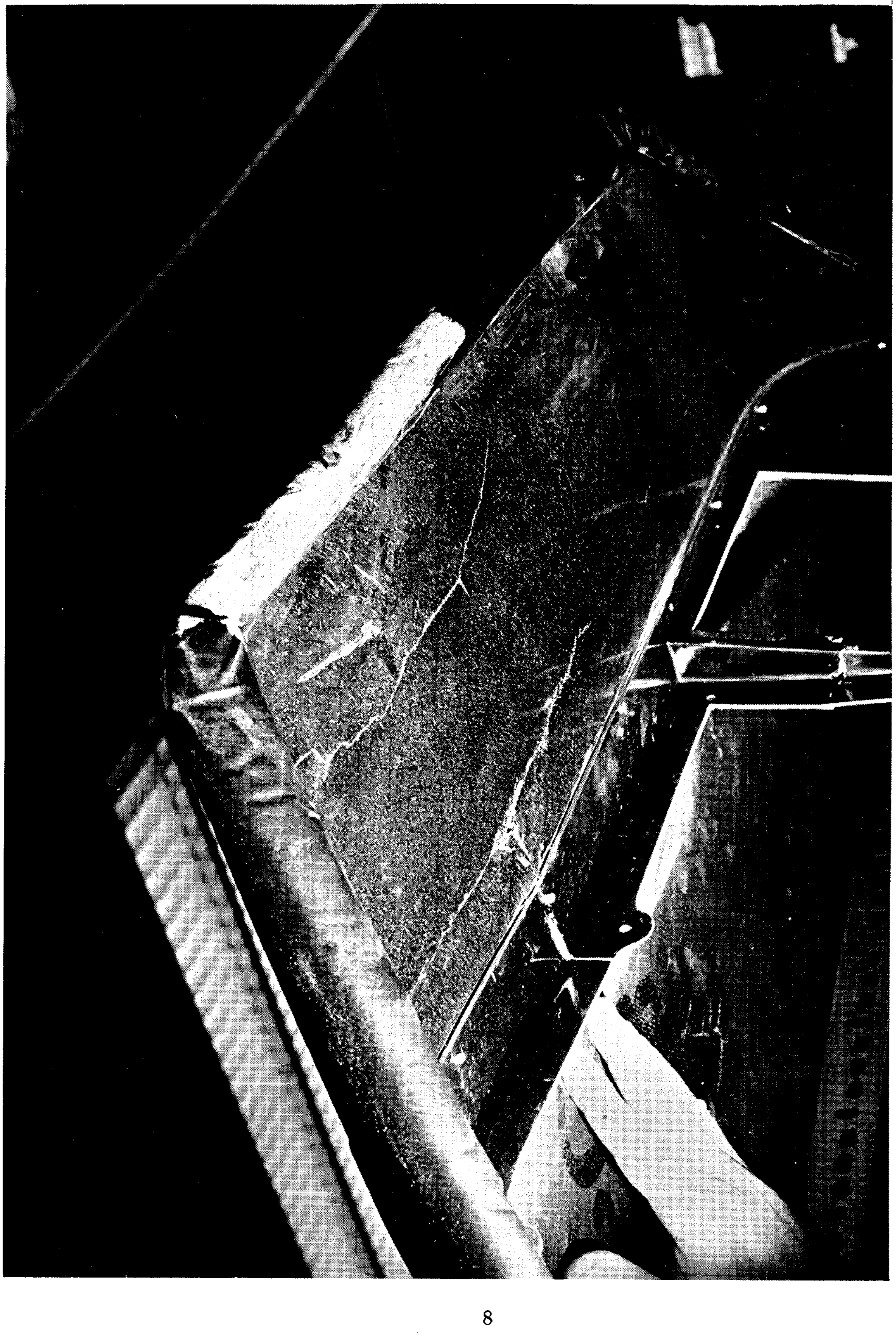

FIGURE 6. Lower view showing fractures in fiberglass.

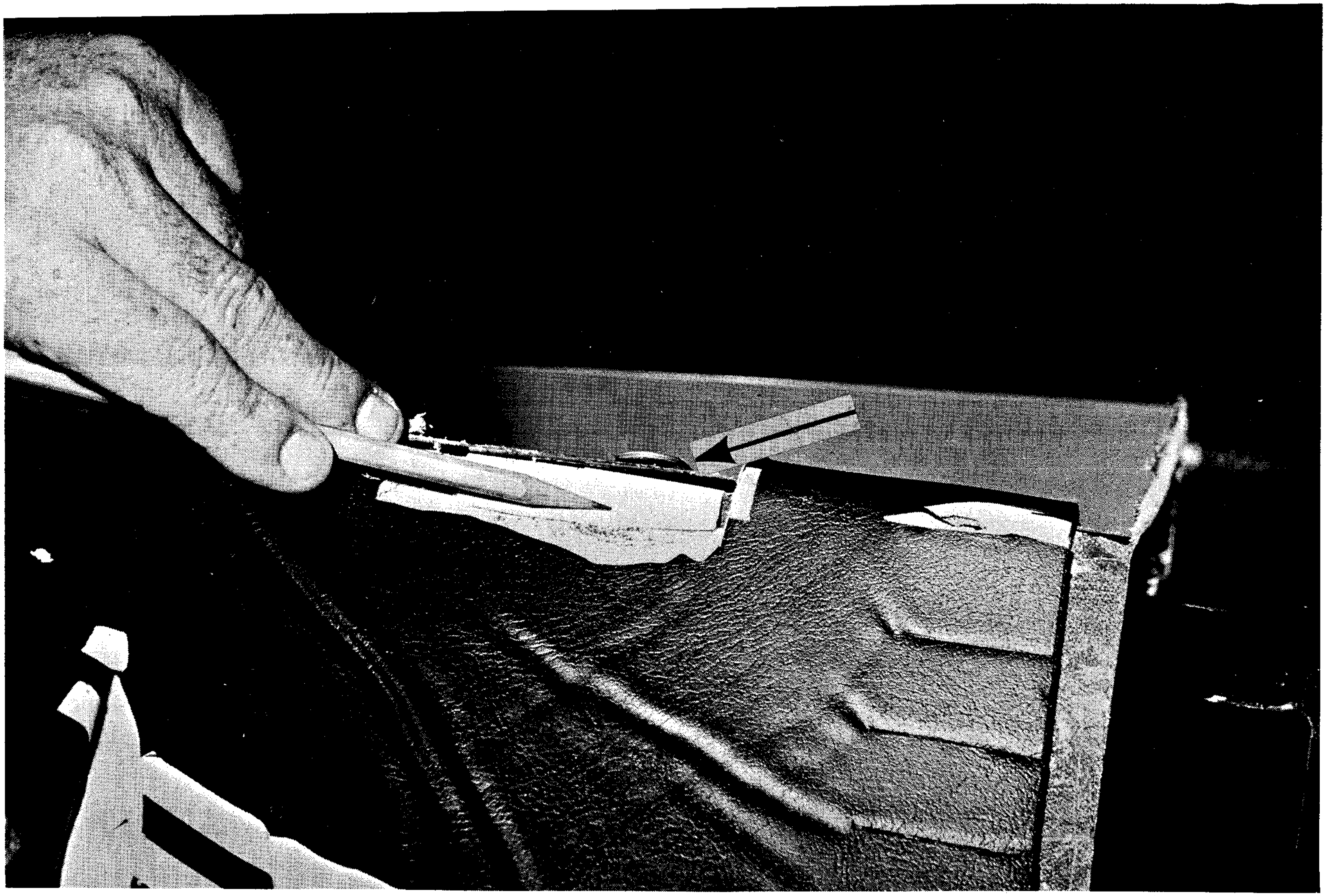

FIGURE 7. Fiberglass edge at break (see arrow). Dime is shown for thickness reference.

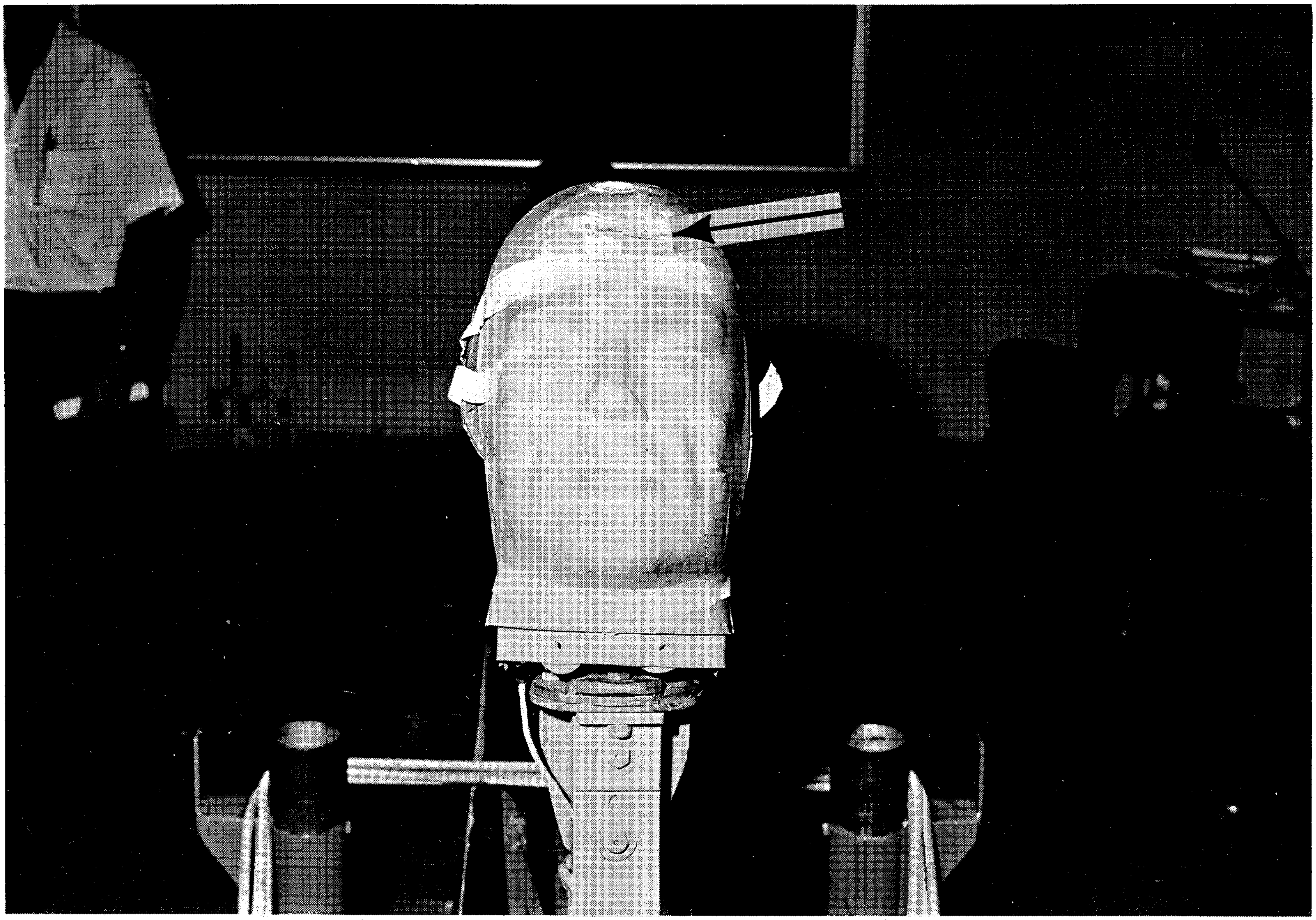

FIGURE 8. Lacerations (at arrow) in rubber covering on dummy head forehead from impacting broken fiberglass.