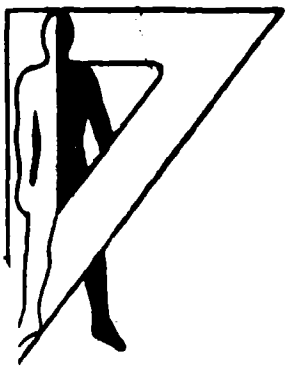

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Technical Note 7-86

AN EVALUATION OF THE UH-60 BLACK HAWK DOOR GUNNER RESTRAINT SYSTEM

William B. DeBellis

SEPTEMBER 1986

U. S. ARMY HUMAN ENGINEERING LABORATORY

Aberdeen Proving Ground, Maryland

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Note 7-86	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AN EVALUATION OF THE UH-60 BLACK HAWK DOOR GUNNER RESTRAINT SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William B. DeBellis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Human Engineering Laboratory Aberdeen Proving Ground, Maryland 21005-5001		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE September 1986 13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release;
distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aviator's Restraint System;
Seat Belts;
MOPP (Mission-Oriented Protective Posture).

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The restraint system for door gunners in a UH-60 Black Hawk helicopter is equipped with tether straps that allow them to stand up from jump seats to engage targets while still being secured to the aircraft. This freedom of motion has resulted in the restraint system being inadvertently released by the buckle contacting the M60-D machine gun and the aircraft structure. This report evaluates modifications to the restraint system handle to prevent inadvertent releases. Keywords:

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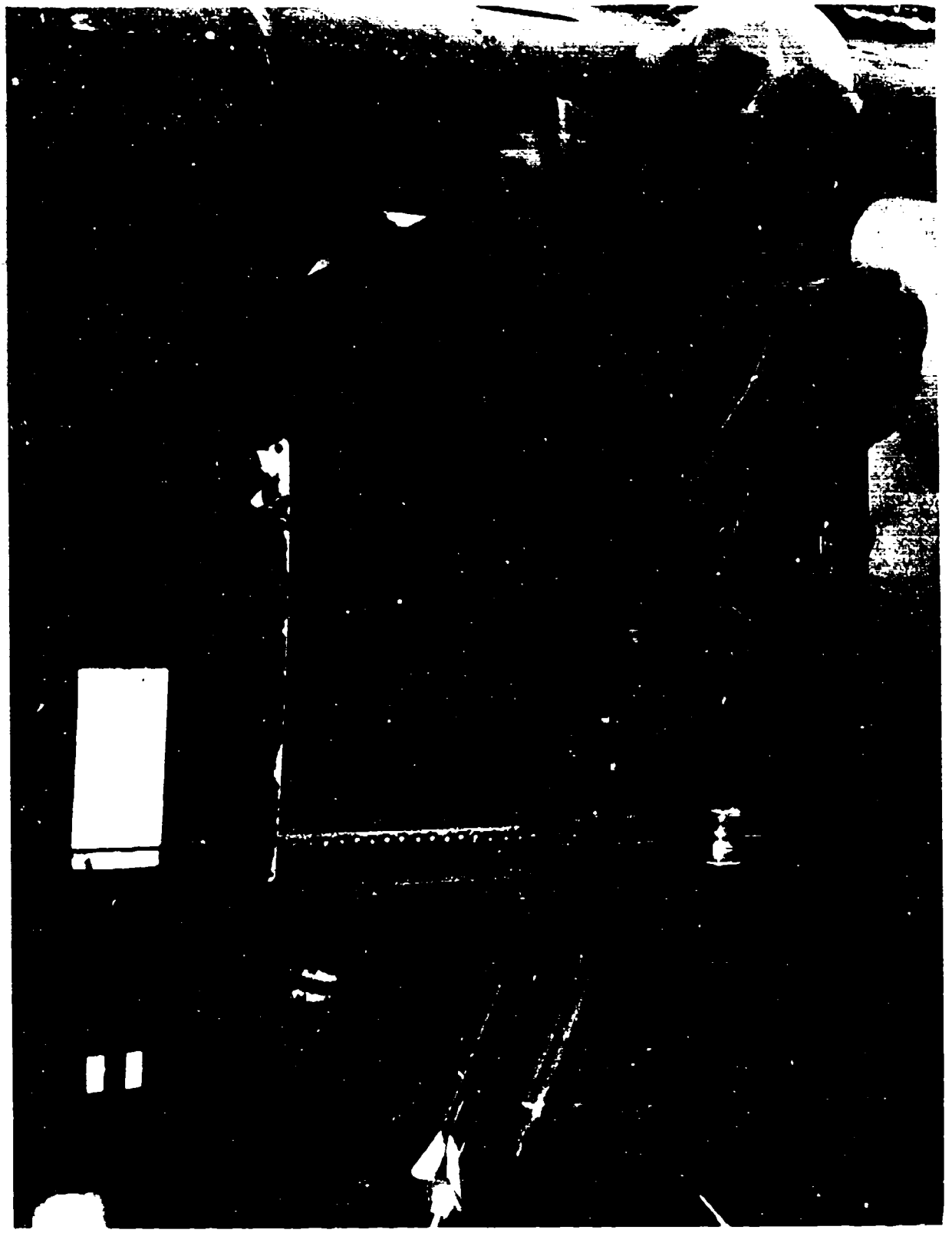

AN EVALUATION OF THE UH-60 BLACK HAWK DOOR GUNNER RESTRAINT SYSTEM

INTRODUCTION

The restraint system for door gunners in a UH-60 Black Hawk is equipped with tether straps that allow gunners to stand up from jump seats to engage targets while being secured to an aircraft (see frontispiece). This freedom of motion has resulted in the following problems being reported from the field:

A. Restraint system being inadvertently released because the release buckle contacts the M-60D machine gun or other aircraft structure.

B. Inertial reels failing to retract webbing after many uses, and

C. Inertial reel handle breaking when bumped by an occupant.

For a pilot or copilot, equipment within the crew compartment is designed to clear the release buckle when the crew is seated. However, because the door gunner has freedom to move about while wearing the restraint system, the release buckle may contact and be released by structure and equipment within the crew compartment.

To address these problems, the manufacturer of the restraint system provided two modifications to the restraint system buckle and inertial reel handles for testing. In addition, a modification to the web straps was also provided. The U.S. Army Aviation Systems Command (AVSCOM) requested that the Human Engineering Laboratory (HEL) evaluate the proposed modifications and provide data which could be used to process a modification work order (MWO) for the restraint system.

Since the problems as reported from the field had no details except that inadvertent releases had occurred, the problems had to be recreated; and criteria had to be established for comparing the current and modified buckles. Because it was assumed that any protection for the buckle would hinder release, release time was established as a measure for evaluation. Additionally, HEL provided a buckle modification designed for faster operation to establish additional data for comparison.

The HEL delineated the effort in two phases: Phase one was a laboratory effort to establish the release times of the modified buckles and the fit consistency of the restraint system with mission-oriented protective posture (MOPP), ballistic, and survival gear. Phase two was a field investigation conducted at Fort Campbell, Kentucky, on an operational helicopter using experienced door gunners. The data for the field investigation were mostly observational.

OBJECTIVES

The objectives of this investigation were:

A. To determine the release times of the restraint system using a current and two alternate buckle handles.

B. To document the problems being reported from the field.

C. To investigate the adequacy of the restraint system worn by a door gunner with MOPP clothing.

METHOD

Subjects

Six test participants from HEL personnel were used in the laboratory phase of the investigation. For the field phase, two test participants, one of large stature and the second of small stature, were provided by the 158th Aviation Battalion at Fort Campbell, Kentucky.

Description

Figures 1 and 2 show a test participant wearing the current restraint system. Figure 3 shows the test participant standing and the three tether straps which are attached to the seat that allow the door gunner limited freedom to move about the cabin area. The seat shown in these pictures is a standard UH-60 jump seat attached to a tip frame which is used to rotate the seat to various positions up to 90 degrees (Figure 4). The handle on the release buckle is a four-vane handle which can be released by either the fingers or the palm of either hand through a partial turn in either direction (Figure 5).

Figure 6 shows the standard buckle, a three-vane buckle, and a dual-action buckle. The three-vane buckle is an HEL design which was constructed to facilitate release when wearing MOPP gloves. It does not solve the problem of inadvertent release but was designed with more pronounced vanes for easier grasp and more secure contact with the palm of the hand. The dual-action buckle requires the bottom vane to be pulled or lifted before the buckle can be turned. It was designed to prevent inadvertent release but cannot be operated by the palm of the hand.

Figure 7 shows a 2-inch webbing extension which was added to the standard straps to facilitate cinching the restraint system. As frequently occurs, the cinch straps stop at the webbing fold and unintentionally retract into the adjusters. This leaves only about 1/2-inch of webbing that the crew can grab onto to cinch up the restraint system. With the webbing extension, the cinch straps can only be pulled into the adjusters as far as the first webbing fold, leaving the 2-inch extension exposed.

Figure 1. Front view of test participant with current release system.

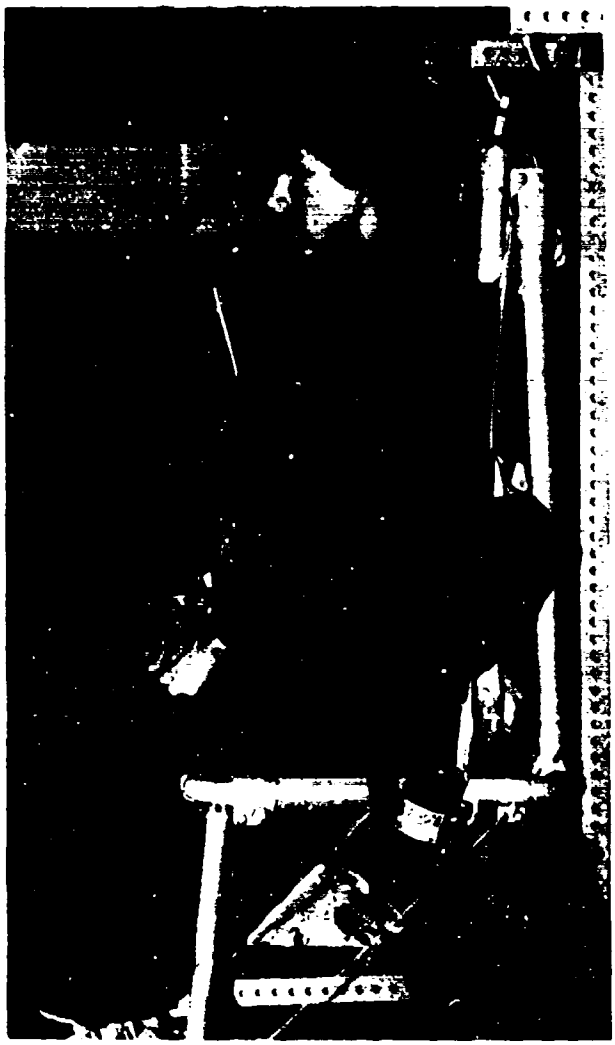

Figure 2. Side view of test participant with current release system.

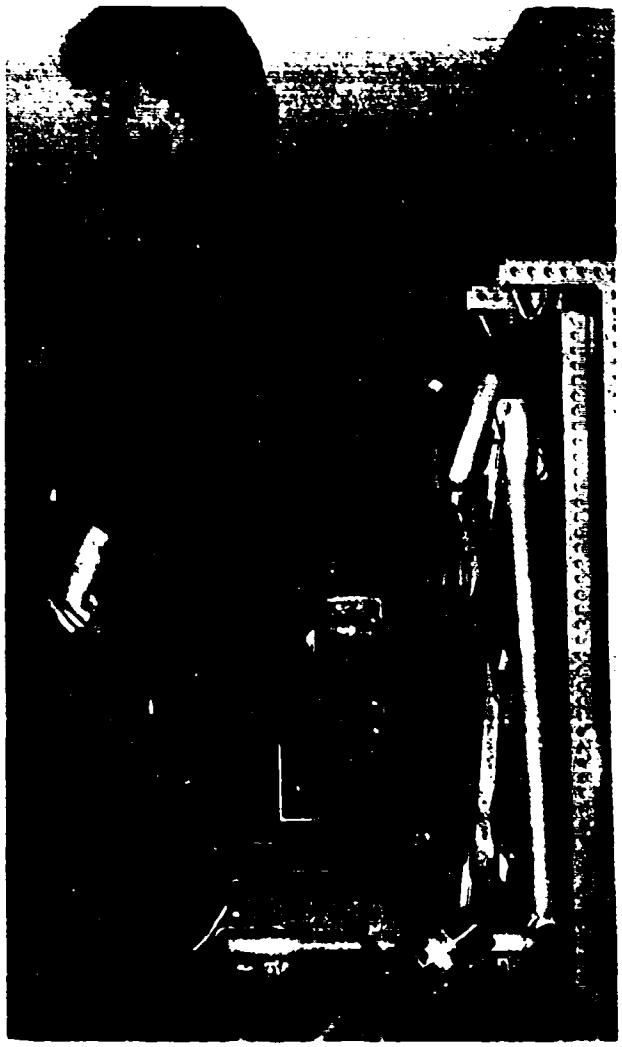

Figure 3. Standing test participant with tether straps extended.

Figure 4. Seat rotation horizontally.

Figure 5. Test participant releasing buckle.

Figure 6. Buckle handles of current (back row), HEL (left), and dual-motion (right) release systems.

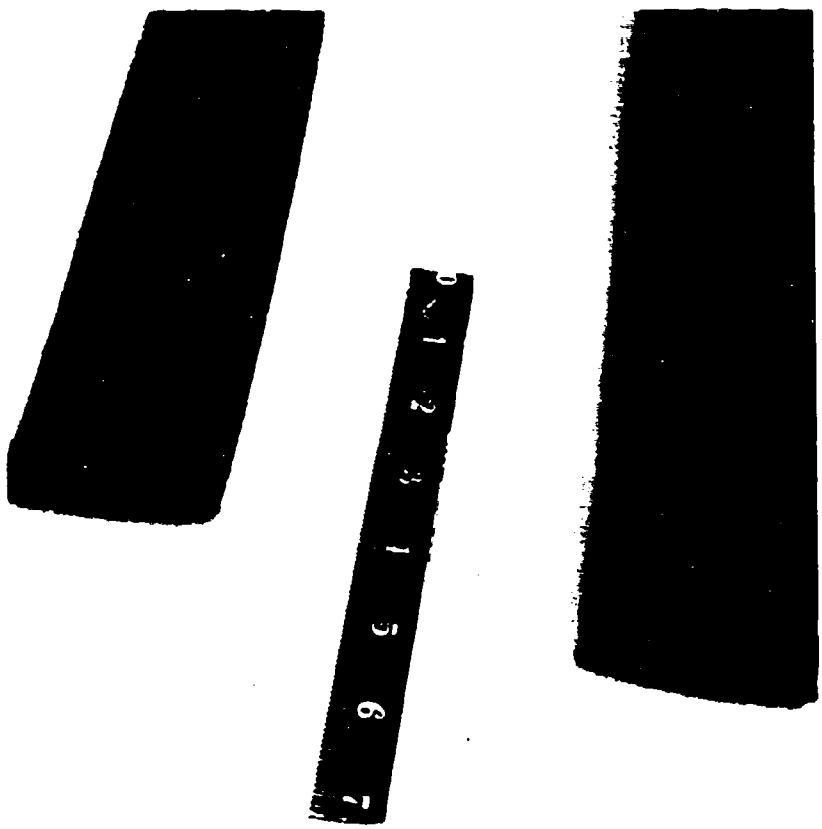

Figure 7. Webbing straps of current (left) and modified (right) release systems.

Figure 8 shows the current and modified inertial reels used to spool two of the three tether straps. As shown, the modified reel has a shorter handle for greater strength and a smaller protrusion. The handle is used to lock the reel from spooling, thereby securing the door gunner in the seated position.

Procedures

Laboratory Phase

In the laboratory phase the investigators evaluated the three buckle handles shown in Figure 6 with the jump seat in both the vertical and horizontal positions. The test participants were clothed in MOPP (jacket, pants, and gloves only) worn over street clothes. Ballistic protection, front and back plates, and a fully configured survival vest including radio and first aid kit were worn. The chemical-biological mask bag was strapped over the survival vest and worn on the test participant's left side.

Each of the six test participants was provided 10 releases per buckle, 5 in the vertical and 5 in the horizontal positions, for a total of 30 releases. The experimental design is shown in Table 1.

TABLE 1

Experimental Design

Test Participant	Buckle Order	Seat Angle Order
1	A B C	Vertical/Horizontal
2	B C A	Horizontal/Vertical
3	C A B	Vertical/Horizontal
4	A B C	Horizontal/Vertical
5	B C A	Vertical/Horizontal
6	C A B	Horizontal/Vertical

For the horizontal test condition, the test participants started in the vertical position with the restraint system in place and the inertial reels locked. A safety harness was threaded under the shoulder straps and across the upper torso and made snug but not tight enough to alleviate the tension in the restraint system. The seat was then rotated to the horizontal position. When the restraint system was released, the test participants dropped about 2 inches, and their weight was transferred to the safety harness.

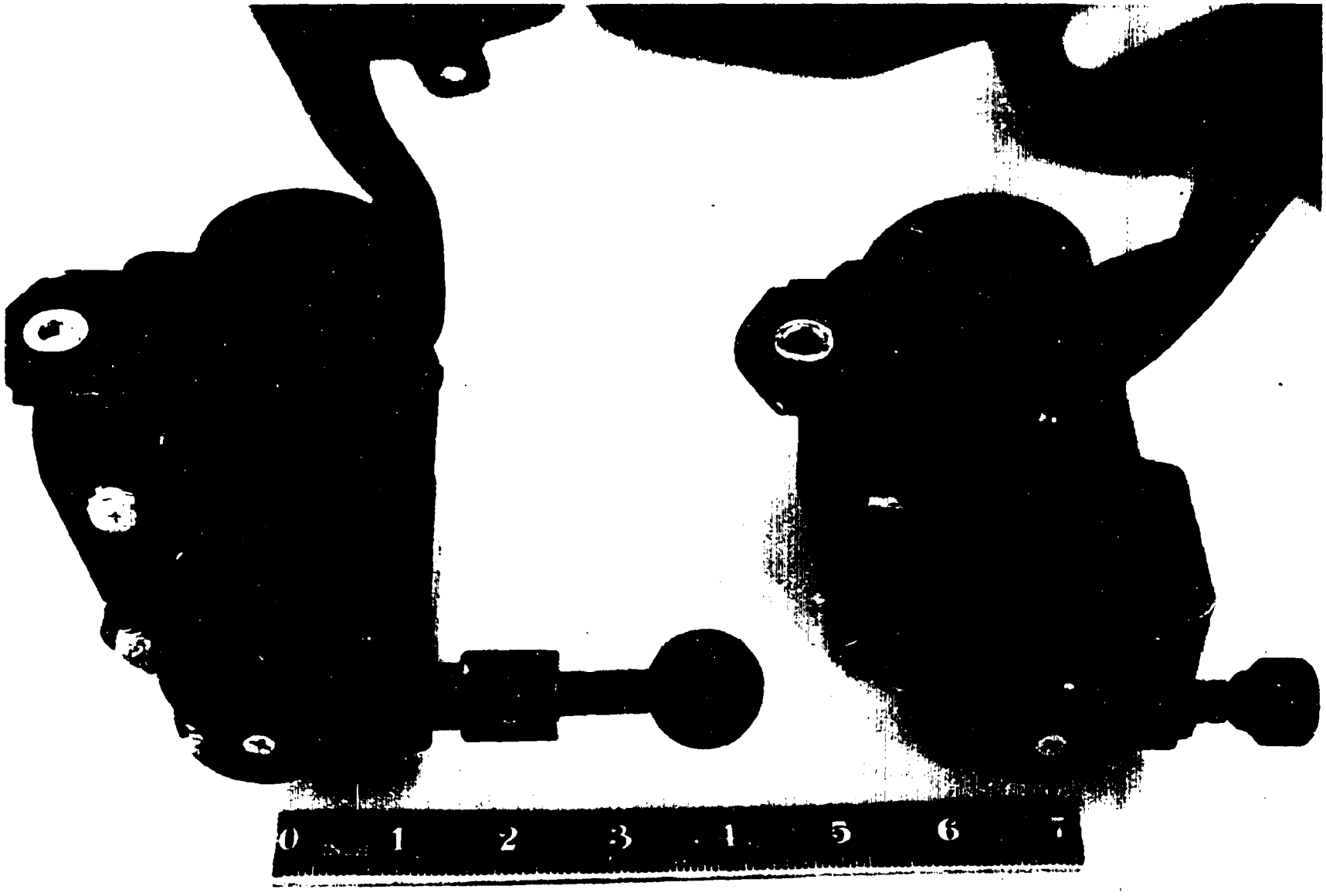

Figure 8. Inertial reels of current (left) and modified (right) release systems.

For training, test participants were shown a recommended way of how to release each buckle handle. When they could release the buckle within 3 seconds three times in succession, training was complete.

Release times were recorded by an electric event timer. Electrical leads were attached to a web belt end and the release buckle. The test participants were asked to assume a standard starting posture with their hand holding the starting switch, attached either to the right or left handle. A verbal signal (go) was given, and the timer started as the test participants began their release motions. As the web belt separated from the release buckle, the connection broke and timing stopped.

Release times were evaluated using a multivariate analysis of variance. Duncan's multiple range test was used for individual comparisons.

Field Evaluation

The field portion of the investigation took place at Fort Campbell, Kentucky. The two test participants wearing ballistic protection and a survival vest simulated normal manipulation of the M60-D door gun from the starboard side of a Black Hawk helicopter while on the ground. As the test participants slewed the weapon to engage targets, the release buckle was observed to see if it came in contact with anything which might release it. The web belts and handles were also observed.

RESULTS AND DISCUSSION

Laboratory Phase

Table 2 displays the mean release times for the three buckles and the two seat positions. Buckles A, B, and C are the current, dual-motion, and HEL designs respectively.

TABLE 2

Mean Release Times (seconds)

Seat Position	Buckle Types A	B	C
Vertical	0.64[a]	1.50	0.60
Horizontal	0.78	1.77	0.72

[a]N = 30

The dual-motion buckle (B) release time was statistically longer than both the standard (A) and HEL design (C) (Table 3). Similarly, a difference is shown for the release times when the seat was tipped over the 90-degree position (Table 4). The test participant pool showed differences from the slowest to the fastest (Table 5). There were no differences in the release times as the trials progressed (Table 6). Although differences were shown, a 1-second difference was not considered operationally significant.

TABLE 3

Individual Comparison on Buckle Type
(mean times with the same symbol are not significant)

Alpha = 0.05 MSE = 0.2302 DF = 140 N = 60

Buckle Type		Mean	
B	=	1.63	*
A	=	0.71	
C	=	0.66	

TABLE 4

Individual Comparison on Seat Angle
(mean times with the same symbol are not significant)

Alpha = 0.05 MSE =0.2302 DF = 140 N = 90

Seat Position		Mean	
(horizontal)	=	1.09	*
(vertical)	=	0.91	

TABLE 5

Individual Comparison on Test Participants
(mean times with the same symbol are not significant)

Alpha = 0.05 MSE =0.2302 DF = 140 N = 30

Test Participant	Mean	
2 =	1.42	*
6 =	1.06	
1 =	1.05	
4 =	1.00	@
3 =	0.76	# @
5 =	0.73	#

TABLE 6

Individual Comparison on Trials
(mean times with the same symbol are not significant)

Alpha = 0.05 MSE =0.2302 DF = 140 N = 36

Test Participant	Mean	
2 =	1.08	*
1 =	1.06	*
5 =	0.99	*
3 =	0.98	*
4 =	0.90	*

During the trials, there were 11 occurrences of nonrelease where one of the shoulder web belt ends did not separate from the buckle. On four of these occasions, the test participants initiated an immediate second release action before the problem could be investigated. The problem of the nonreleases is not related to a malfunction or failure of the buckle, but to the fit of the restraint system over the survival vest and unequal tension in the shoulder straps as they are cinched tight. As shown in Figure 1, the release buckle is situated between the survival radio and the first aid kit (see arrows). As the test participants started to release the buckle, they applied sideways pressure to the buckle, forcing the web belt ends into either the radio, if using their right hand, or into the first aid kit, if using their left hand. This pressure held the web belt ends in place as the remaining three web belt ends separated normally. When the buckle handle rotated closed, the web belt end locked in place, restraining the test participant by a shoulder strap and two crotch straps which are permanently attached to the release buckle.

The release buckles for UH-60 door gunners do not have a cushion pad behind the buckle. Whether this pad would have provided protection for the web belt ends was not investigated.

There were numerous instances in which the two side inertial reels failed to retract as the test participants were being secured in the tip seat. When a jam of this type occurs, a door gunner cannot be secured safely in the jump seat. As shown in Figure 8, a single twist of the webbing jams the spool, leaving the tether straps loose. The inertial reel, located on the back of the jump seat behind the door gunner's head, contains a web guide which helps to eliminate the jamming. This guide is not included with the two inertial reels which spool the two side tether straps. To clear the jam, the tether straps must be pulled out and fed back into the spools.

Field Evaluation

Figures 9 through 12 show both door gunners exercising the M60-D door gun throughout the full field of fire. When at the limits of the field of fire, the weapon system provides unaimed fire. When aimed fire is required, especially at extreme downward angles, both large and small door gunners must place themselves outside the aircraft. To provide fire both fore and aft, door gunners must come forward off the jump seat and reach out of the window. In doing so, the buckle of the small door gunner contacts the windowsill (Figures 9 and 10) and can be inadvertently turned and released. For the small door gunners, sitting in the jump seat to provide any type of fire is awkward. As a result, this particular door gunner knelt on the cabin floor to fire the weapon. As shown in Figure 11, the buckle was in contact with the windowsill.

Figure 12 shows the large door gunner leaning out of the helicopter window to provide downward fire. However, to get into this position he climbed out over the weapon and inadvertently released the buckle when it contacted the handgrips of the M60-D machine gun, as shown in Figures 13 and 14.

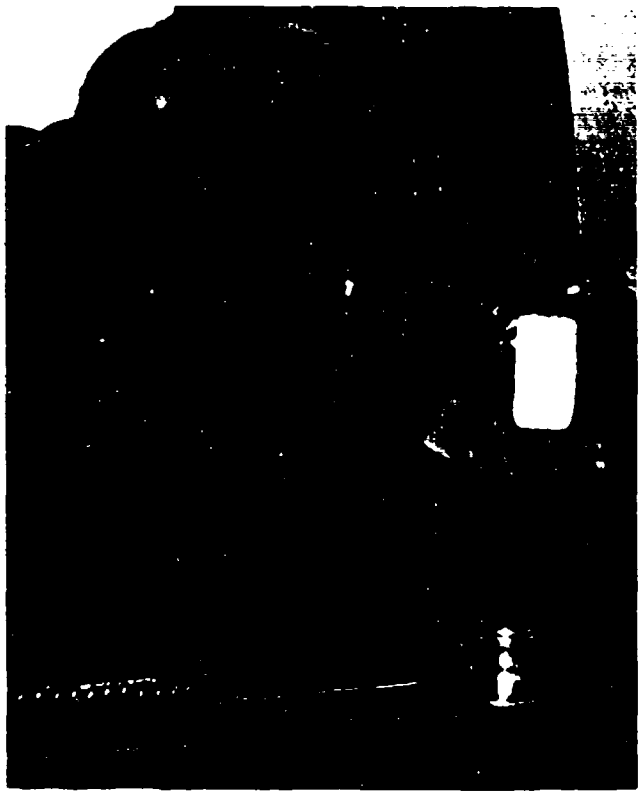

Figure 9. Door gunner firing aft.

Figure 10. Door gunner firing forward.

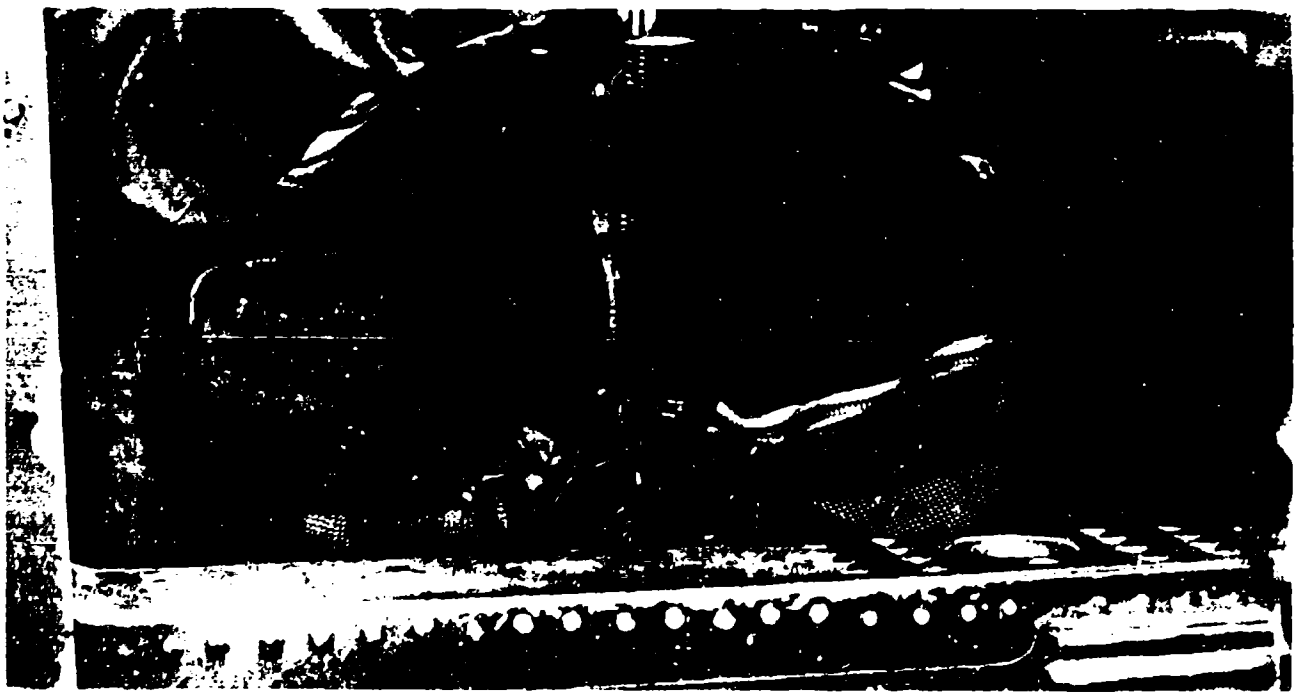

Figure 11. Buckle in contact with windowsill.

Figure 12. Larger door gunner providing downward fire.

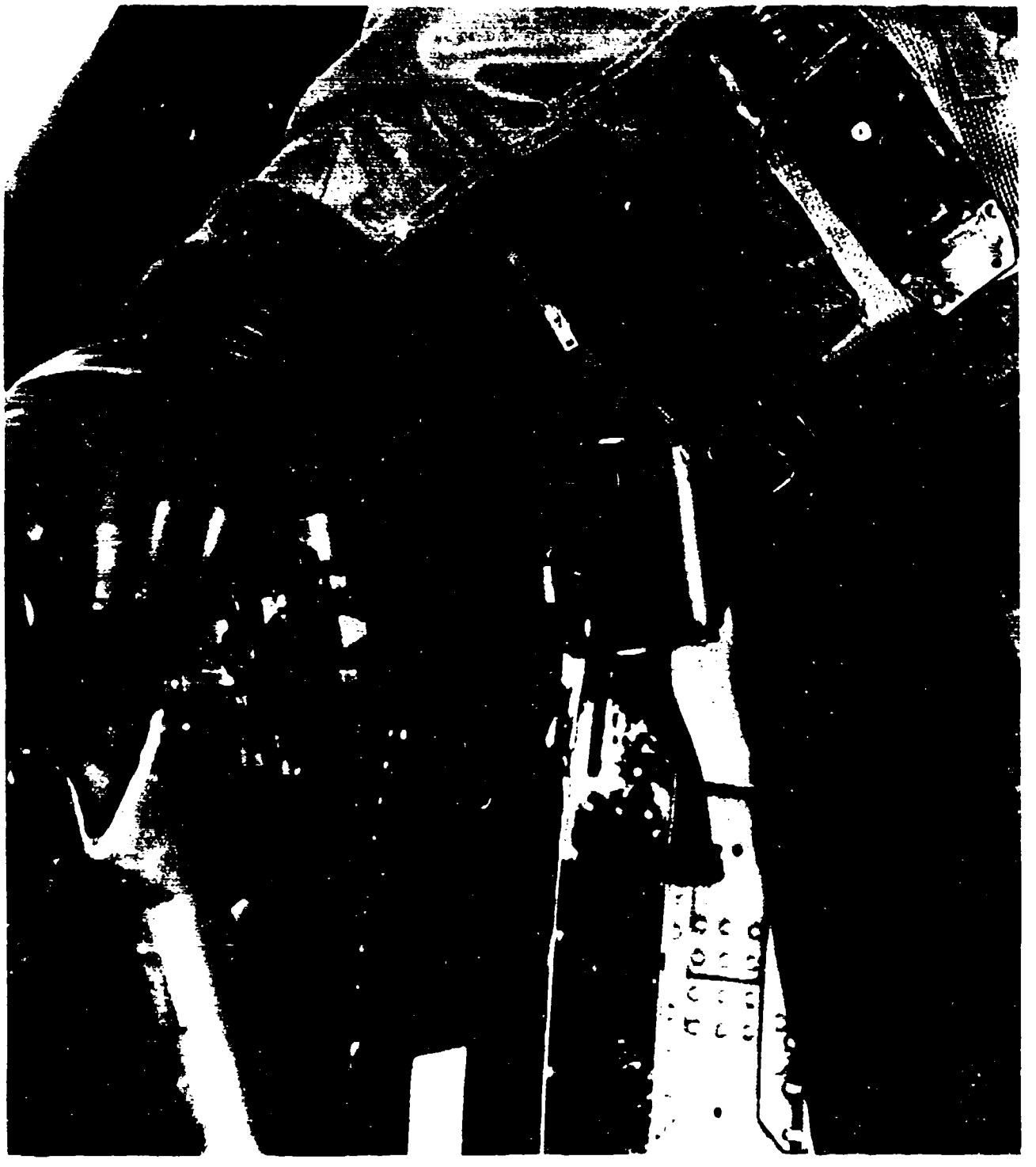

Figure 13. Handle interference as viewed from the right.

Figure 14. Handle interference as viewed from the left.

Figures 15 and 16 show that the buckle can be released if the door gunners climb sideways out of the window. Both door gunners said that there would be little reason to climb out of the window when the helicopter rotor is turning.

Figure 17 shows the dual-motion buckle being released when the lip of the bottom vane caught on the edge of the windowsill. However, this particular buckle modification was not able to be released when forced in contact with the M60-D handgrips (Figure 18).

Observation showed that the restraint system would not retract when unused. When investigated, the retracting action was sluggish and seemed to contain sand or grit. The upper inertial reel is supplied with a dust cover which covers the entire reel except for the web strap opening. This cover could not be used with the jump seat because a small bracket which holds the reel to the seat interfered with the cover. As a result, the upper inertial reel was damaged (Figure 19) and the rest of the system, left on the cabin floor, received further damage by being walked upon.

CONCLUSIONS

Both buckle modifications as well as the current design could be released with either hand by test participants wearing MOPP. Differences in release times between the three designs were not considered operationally significant.

Furthermore, both the current and the dual-motion buckles failed to prevent inadvertent release when they contacted either the windowsill or the handgrips of the M60-D machine gun.

The operation of the locking handles was not jeopardized by any action by the door gunner. However, when jump seats are taken in and out of helicopters with the restraint system attached, it is possible that the handles could be damaged if the jump seat is allowed to lie on its side or is roughly handled.

The web belt end extensions which provided for grasping aided the door gunner in donning the restraint system.

The fit of the restraint system over the door gunner's protective gear, especially the survival vest, is not uniform and can result in a loosening of the straps as the door gunner moves about and the straps shift back and forth over the vest. A loose strap coupled with the awkward location of the release buckle, situated between the radio and first aid kit on the vest, can result in a strap not releasing when the buckle handle is activated.

An immediate fix has to be provided to prevent inadvertent releases without jeopardizing normal release.

An effort should be initiated to reevaluate the method with which the door gunner is protected and secured. The current method is not adequate. The problem of nonrelease is as serious as an inadvertent release.

Figure 15. Handle interference with window frame.

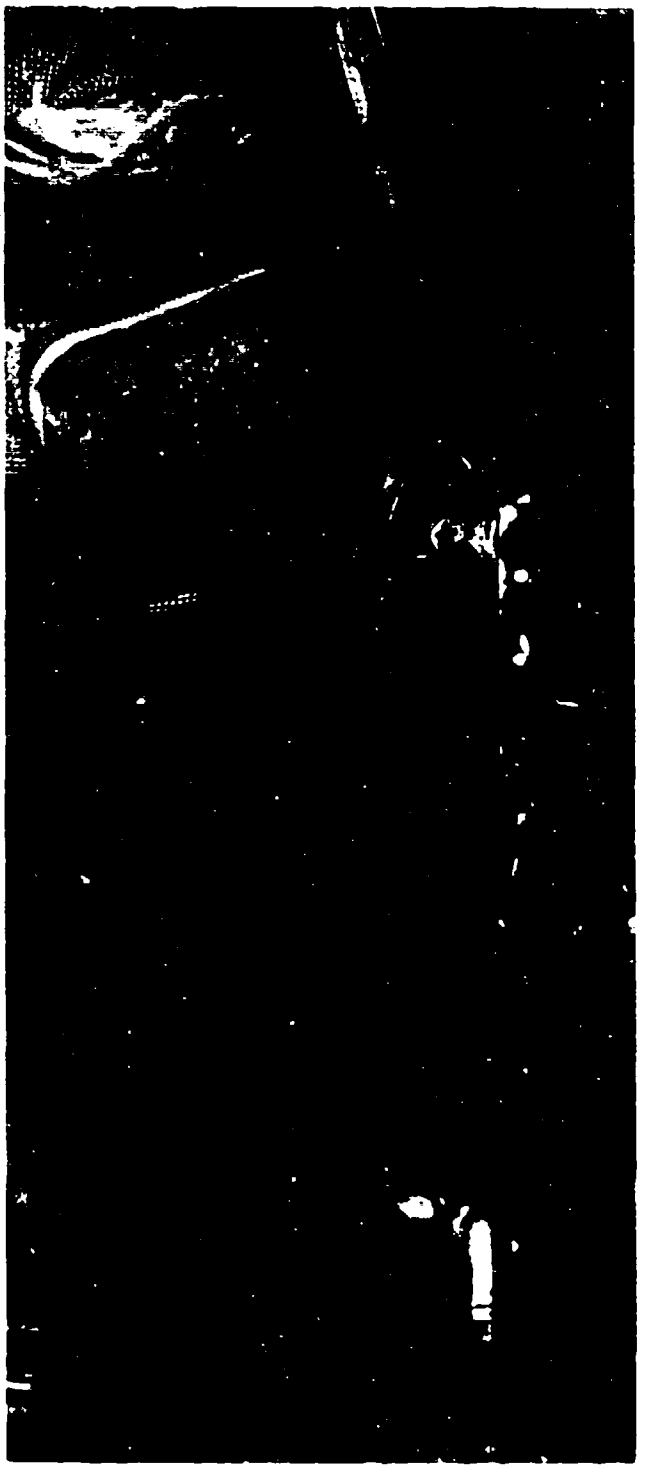

Figure 16. Handle interference with latch.

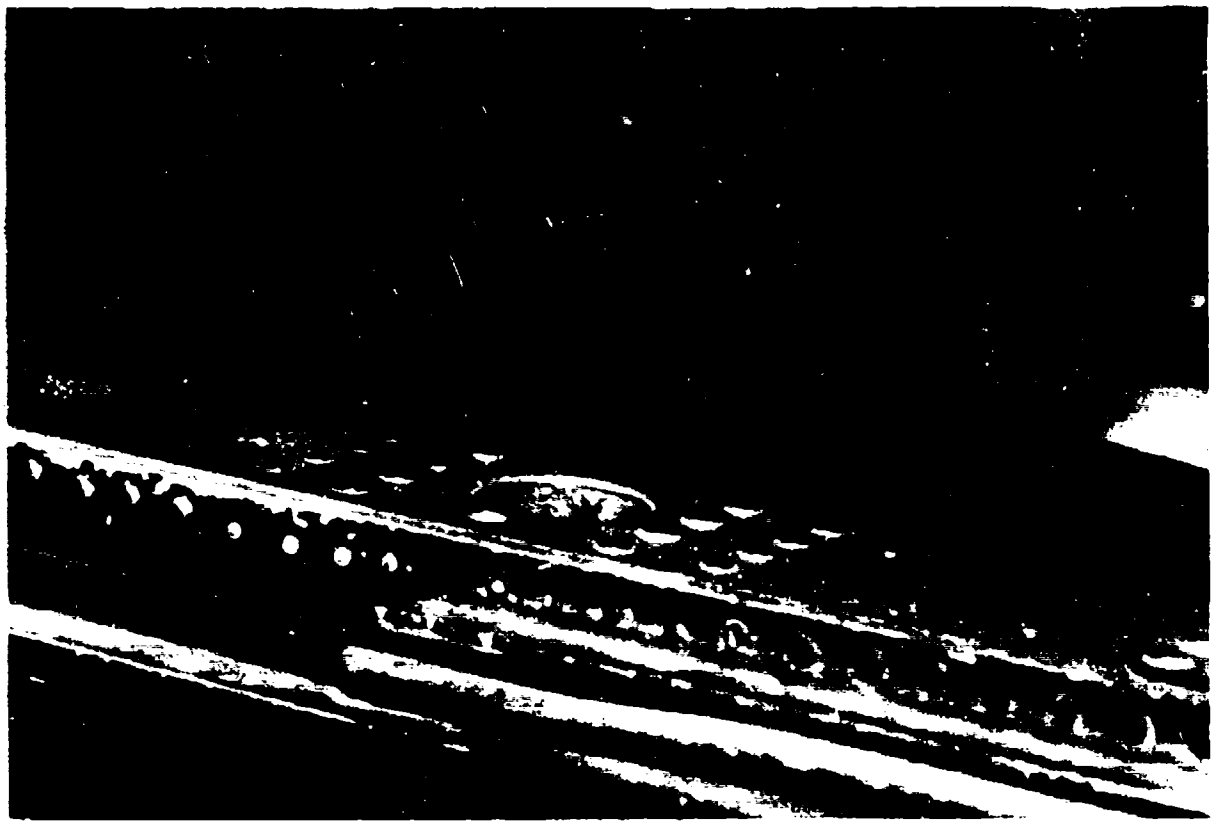

Figure 17. Dual-motion buckle in contact with the windowsill.

Figure 18. Dual-motion buckle in contact with handgrips.

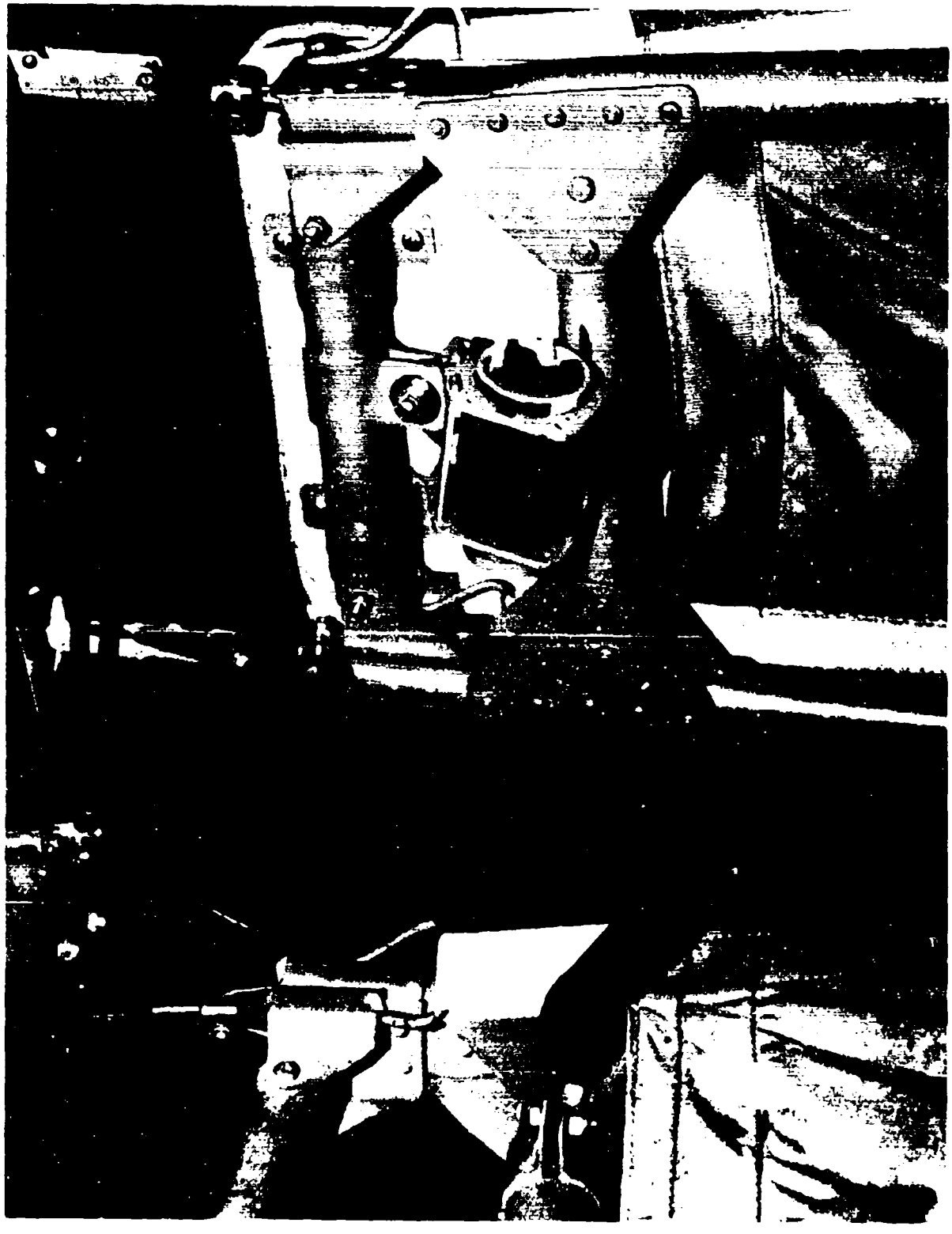

Figure 19. Upper inertial reel.