

USAARL Report No. 83-1



**Modified Faceplate for AN/PVS-5
Night Vision Goggles**

By

William E. McLean

**Sensory Research Division
Visual Sciences Research Group**

October 1982

Approved for public release; distribution unlimited.

**United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-5292**

NOTICE

Qualified Requesters

Qualified requesters may obtain copies from the Defense Documentation Center (DDC), Cameron Station, Alexandria, Virginia. Orders will be expedited if placed through the librarian or other person designated to request documents from DDC.

Change of Address

Organizations receiving reports from the US Army Aeromedical Research Laboratory on automatic mailing lists should confirm correct address when corresponding about laboratory reports.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

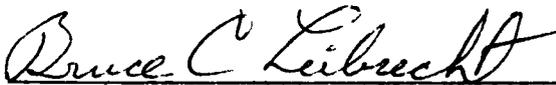
Disclaimer

The views, opinions, and/or findings contained in this report are those of the author and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation. Citation of trade names in this report does not constitute an official Department of the Army endorsement or approval of the use of such commercial items.

Human Use

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Reg 70-25 on Use of Volunteers in Research.

Reviewed:



Bruce C. Leibrecht, MAJ, MSC
Director, Sensory Research Division

Released for Publication:



Roger W. Wiley, LTC, MSC
Chairman, Scientific Review
Committee



DUDLEY R. PRICE
Colonel, MC
Commanding

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAARL Report No. 83-1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MODIFIED FACEPLATE FOR AN/PVS-5 NIGHT VISION GOGGLES	5. TYPE OF REPORT & PERIOD COVERED Final Report	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) William E. McLean	8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Aeromedical Research Laboratory Fort Rucker, AL 36362	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6.27.77.A, 3E162777A879 BG, 164	
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Medical Research & Development Command Fort Detrick Frederick, MD 21701	12. REPORT DATE October 1982	
	13. NUMBER OF PAGES 62	
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 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) AN/PVS-5 Night Vision Goggles, modified NVG faceplate, NVG field of view, flight safety		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Lack of peripheral vision while flying with the AN/PVS-5 night vision goggles (NVG) was a contributing factor in an aircraft accident. Because of this accident, a modified faceplate (MFP) for NVG was configured to allow pilots unaided lateral and lower vision. Twenty MFP NVG were worn during flight by 47 NVG qualified aviators for an average of 18 hours per aviator. The average recorded flight hours for each of the 20 MFP NVG was 43.5 hours.		

NVG aviators indicated that the MFP significantly enhanced intruder aircraft detection, inside-the-cockpit vision, and comfort. Spectacles can be worn with the MFP, and less fogging of the eyepieces occur. There were deficiencies reported during the study which were corrected with modifications to the mounting apparatus, thorough preflight briefings, and required familiarization flights.

The proposed modification is being considered for adoption by the proper authorities.

TABLE OF CONTENTS

	<u>Page No.</u>
List of Figures	4
Introduction.	5
Description of Faceplate Modifications.	6
Reconfiguring the Faceplate.	6
Mounting Faceplate to Helmet	6
Evaluation Procedures	14
Results	14
UH-1 Study (Lowe).	14
OH-58 Study (Hanchey).	16
Directorate of Evaluation and Standardization (DES) Study.	17
Summary Results of the Three Studies	17
Discussion.	19
Disadvantages.	19
Mounting.	19
Dismounting	20
Battery Container (Arctic Adapter) Inconvenient	20
Tubes Too Far Away.	20
Alignment of Goggles.	21
No Safety Cord.	21
IR Switch (AN/PVS-5 and 5A) Difficult to Use.	21
Eye Discomfort.	21
Peripheral Vision Distractions.	22
Increased Weight Forward.	22
V-Strap Too Short	22
Advantages	22
Conclusions	23
Recommendations	23
Appendixes	
Appendix A. Modified Faceplate Field of View.	25
Appendix B. Summary of Significant Chronological Events in Evaluation of MFP NVG.	27
Appendix C. Conversion of Standard Faceplate to Modified Faceplate	29
Appendix D. Modified Faceplate (MFP) AN/PVS-5 Briefing.	51
Appendix E. Evaluation of Modified Faceplate for AN/PVS-5 Night Vision Goggle - Questionnaire.	55

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page No.</u>
1	Standard AN/PVS-5 Night Vision Goggles	7
2	Rotary switch is relocated from the lower left to the upper-center position on the faceplate. Hole for battery case is cut in the upper right of the faceplate	8
3	Lower portion of faceplate is cut away using template pattern	9
4	Battery case is mounted and electrically connected. Wires are tucked, glued, and taped. Custom straps (side and vertical) are attached and taped. Arctic adapter is attached and binocular assembly connected.	10
5	Attachment of MFP NVG with surgical tubing on the sides. Upper rear lip of MFP is positioned between helmet shell and visor cover; NVG is secured vertically with Velcro straps. Surgical tubing is connected to side straps of MFP. Counterbalance weight is used as required.	11
6	Attachment of MFP NVG with standard side straps. A helmet snap is placed in the back position and the quick release tab end snaps are connected to the MFP side straps. The extra Velcro pads are not used with the present MFP system. Typical eye pieces of MFP NVG are located approximately 20 mm from the eye to achieve full field of view with the NVG and maximum unaided peripheral field of view.	12
7	Standard AN/PVS-5 NVG limited the field of view of 40 degrees through the goggles with no unaided vision possible	13

INTRODUCTION

The Army recognizes that the use of night vision goggles (NVGs) for night flight compromises certain concepts for standard safe operations. NVG limitations include a reduced visual field (40°), decreased visual resolution (20/50), lack of color discrimination, manual focusing to adjust from far vision to near and back, increased weight and a forward shift of the center of gravity. The midair collision between two OH-58 aircraft at Fort Rucker in December 1981 underscored the limitations of the standard AN/PVS-5 NVG and stimulated positive corrective actions focusing on air traffic procedures and operations, stage field markings, configuration of the standard NVG and its attachment to the helmet, and NVG accessory equipment.

As part of the quick-fix efforts to improve NVG flight safety until the AN/PVS-6 (ANVIS) becomes available, a cutaway faceplate converted from the standard AN/PVS-5 faceplate was investigated. After relocating the electrical components, the lower portion of the standard faceplate is cut away to enable (a) unaided vision for the lateral and lower viewing fields (Appendix A), allowing color discrimination of aircraft and ground lights and map reading, (b) spectacle wear, (c) reduced lens fogging, and (d) improved comfort. The modified faceplate (MFP) is compatible with the proposed standard counterbalance system, which can provide optimum stability.

The NVG faceplates used in this study were obtained from property disposal. Faceplates that were damaged in the lower portion, but were otherwise functional, were modified at the US Army Aeromedical Research Laboratory (USAARL). With practice, proper tools, and templates, the MFP modifications required about .5 manhours each. The side and vertical straps were made at the fabric shop by the Directorate of Industrial Operations (DIO).

In order to rapidly provide data on the feasibility of the MFP, a preliminary field study was conducted and expanded. The purpose of the study was to determine if the MFP offers safety and flight performance advantages over the standard faceplate. Questionnaire techniques were used to determine experienced NVG pilots' ratings and observations of the advantages and shortcomings of the MFP. The study involved in-flight evaluations by NVG qualified pilots during routine training.

A summary of significant chronological events involved in the study is provided in Appendix B. At the time the study was concluded, results had been collected using four types of helicopters, 47 NVG qualified aviators, 20 individual MFP NVG, and included more than 850 hours of MFP use.

DESCRIPTION OF FACEPLATE MODIFICATIONS

RECONFIGURING THE FACEPLATE

Figure 1 shows the AN/PVS-5 NVG with the standard faceplate. In selecting a cutaway configuration, several modified versions of the standard faceplate were considered with respect to peripheral vision, battery case and switch location, structural and electrical integrity, mounting attachments and stability. The sequence followed during reconfiguration is shown in abbreviated fashion in Figures 2-4. Figure 4 shows the faceplate design used in the initial feasibility study. The complete sequence followed in modifying the faceplates is described and illustrated in Appendix C.

The rotary switch was moved from the lower left to the upper center portion of the plate where the V-strap was located. The battery case was moved from the lower right to the upper right portion of the plate, with the battery case attachment flange on the outside. The location and alignment of the battery case are critical for visor cover and tube clearance. The lower portion of the faceplate was removed and shaped as shown in Figure 3, and the cut edges were smoothed. The clamp tilt knob holes were enlarged to increase tube rearward movement. Wires were reconnected, tucked, glued, and taped. Upper and side straps were attached to the remaining face pad snaps. The arctic battery adapter was attached to improve battery changing ability.

The binocular assembly of the NVG was attached to the cutaway faceplate for subsequent mounting to the helmet.

MOUNTING FACEPLATE TO HELMET

Figure 5 depicts the MFP NVG mounted to the helmet. The upper rear lip of the faceplate is placed between the visor cover and shell, and the vertical straps are attached to the existing Velcro pads. The short side straps are connected to the snaps of the surgical tubing, and the tension of the surgical tubing is adjusted to produce a secure attachment. A counterweight is usually required on the back of the helmet to prevent forward rotation of the goggles. An arctic adapter cord is attached with tape or Velcro to the back of the helmet.

For helmets that have not been modified with surgical tubing, the existing side straps can be attached to the modified faceplate side straps (Figure 6). However, the quick release tabs should be forward and a helmet snap added on each side in the rearward position. Difference between the MFP NVG mounted to the helmet with the standard side straps and the standard AN/PVS-5 NVG mounted to the helmet can be seen by comparing Figures 6 and 7.



FIGURE 1. Standard AN/PVS-5 Night Vision Goggles.

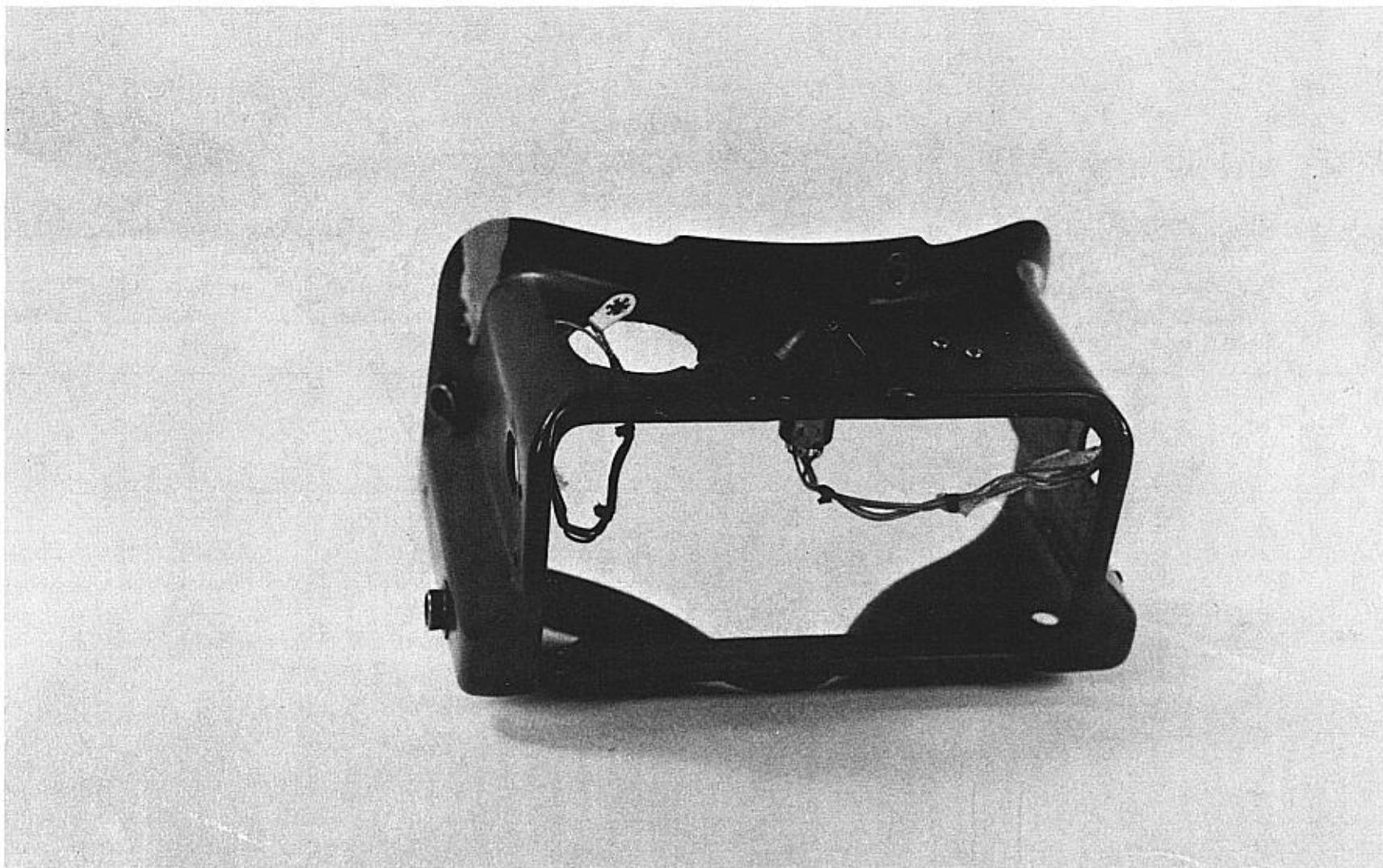


FIGURE 2. Rotary switch is relocated from the lower left to the upper-center position on the faceplate. Hole for battery case is cut in the upper right of the faceplate.

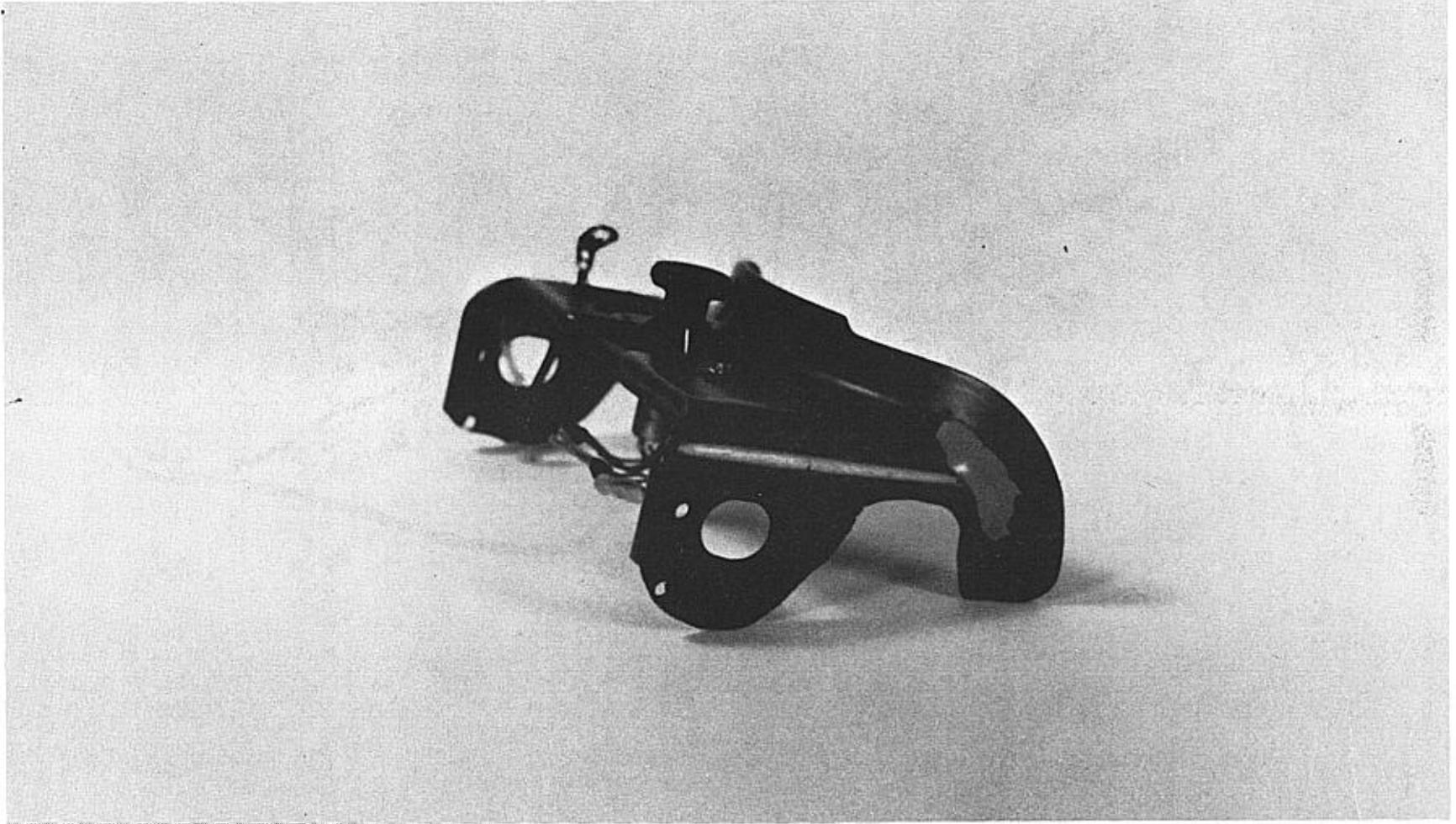


FIGURE 3. Lower portion of faceplate is cut away using template pattern.

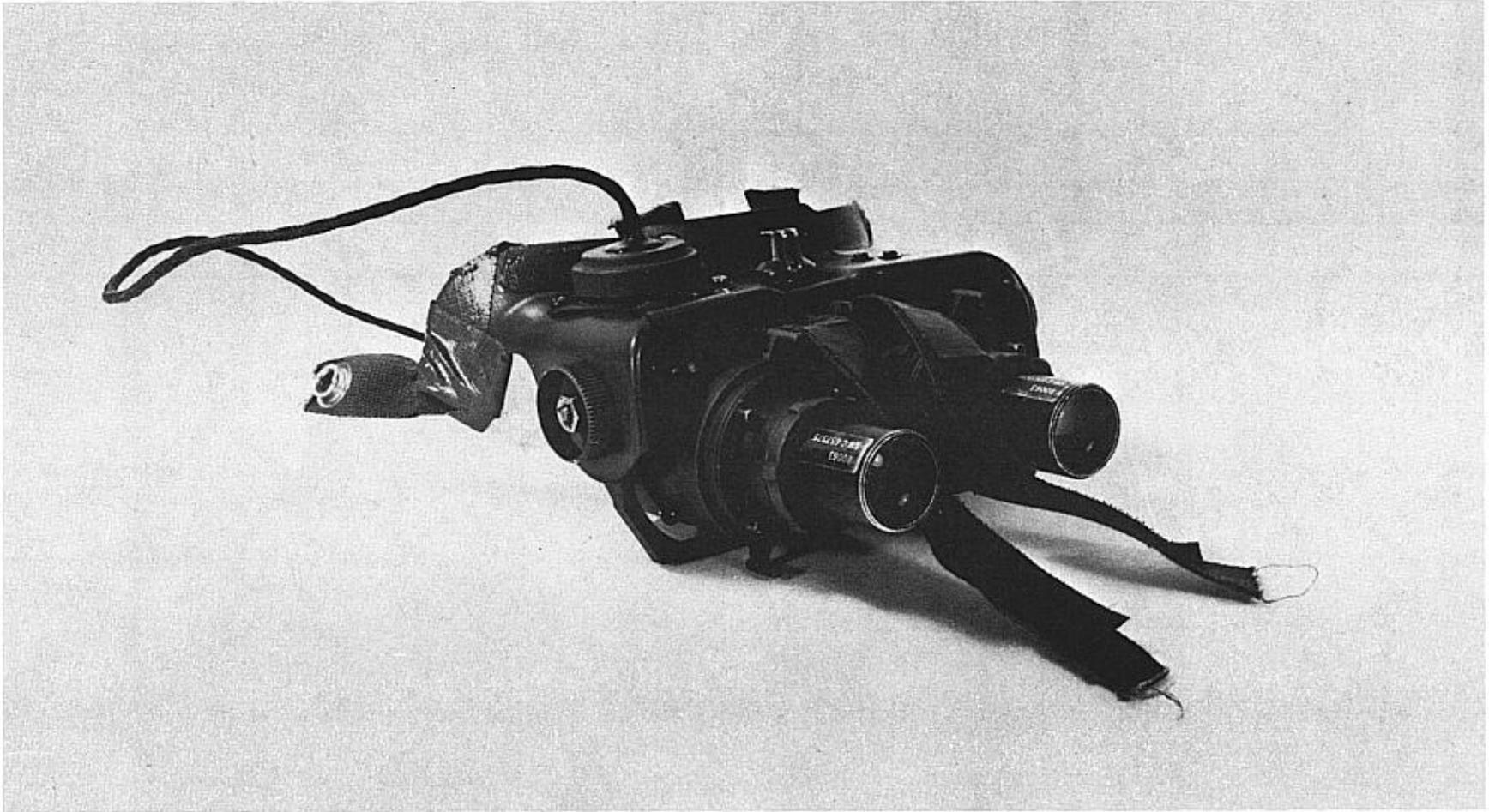


FIGURE 4. Battery case is mounted and electrically connected. Wires are tucked, glued, and taped. Custom straps (side and vertical) are attached and taped. Arctic adapter is attached and binocular assembly connected.

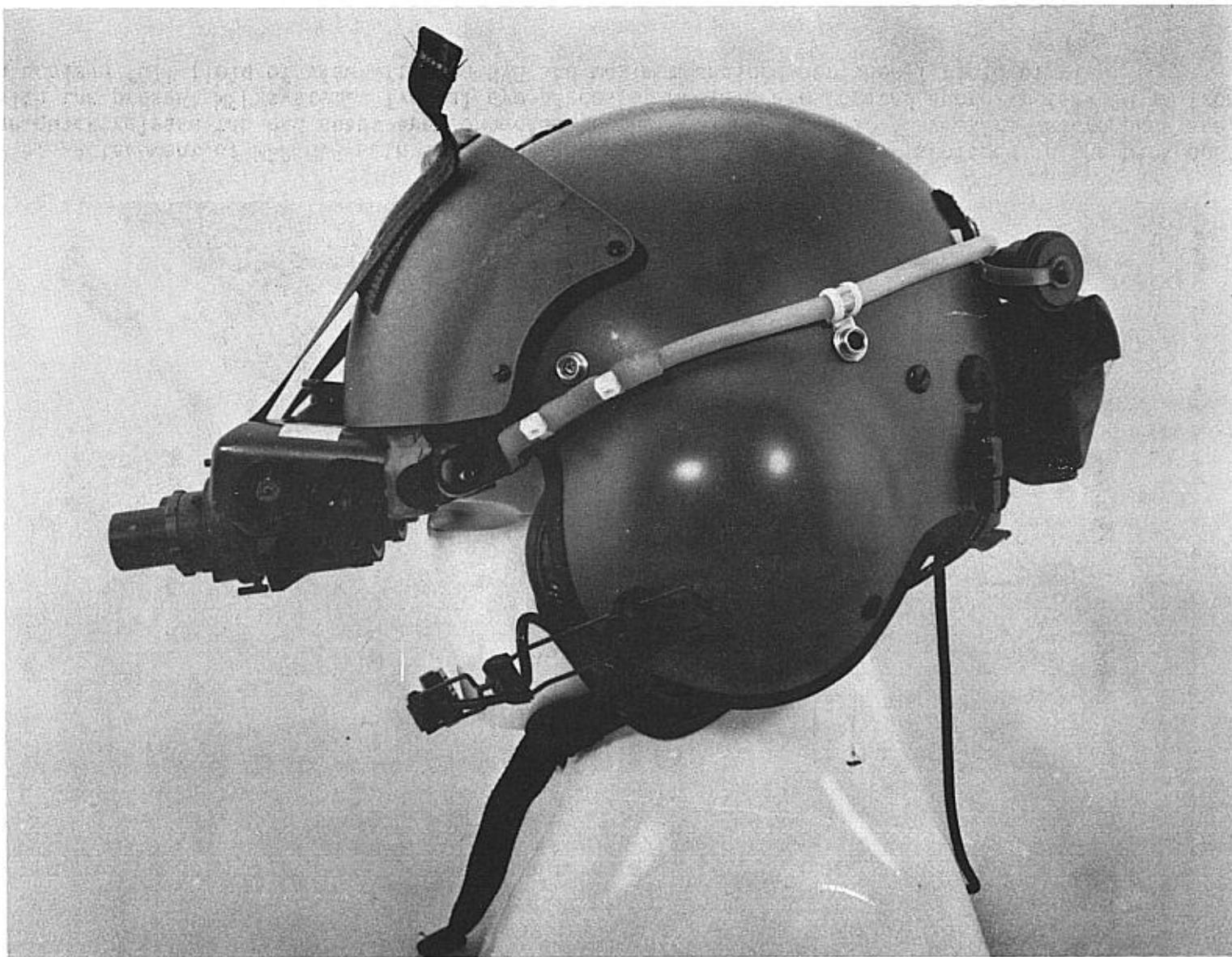


FIGURE 5. Attachment of MFP NVG with surgical tubing on the sides. Upper rear lip of MFP is positioned between helmet shell and visor cover; NVG is secured vertically with Velcro straps. Surgical tubing is connected to side straps of MFP. Counterbalance weight is used as required.



FIGURE 6. Attachment of MFP NVG with standard side straps. A helmet snap is placed in the back position and the quick release tab end snaps are connected to the MFP side straps. The extra Velcro pads are not used with the present MFP system. Typical eye pieces of MFP NVG are located approximately 20 mm from the eye to achieve full field of view with the NVG and maximum unaided peripheral field of view.



FIGURE 7. Standard AN/PVS-5 NVG limited the field of view to 40 degrees through the goggles with no unaided vision possible.

EVALUATION PROCEDURES

The MFP NVG evaluation was conducted in three steps. The initial evaluation was by MOI NVG instructor pilots at Lowe Field, Fort Rucker, with UH-1 aircraft. The second evaluation was by NVG instructor pilots at Hanchey Field, Fort Rucker, with OH-58 aircraft; and the third phase was conducted by NVG qualified aviators in the Directorate of Evaluation and Standardization (DES) with UH-1, OH-58, AH-1, and UH-60 aircraft. As improvements in the goggle design, mounting/dismounting procedures, briefing and flight familiarization contents were identified, they were incorporated into the evaluation. The participants were briefed about the project, mounting and dismounting procedures, helmet modifications and proper NVG adjustment (Appendix D), and they were provided with questionnaires (Appendix E). Initially, the questionnaires were completed each night during the first 20 hours of use of the MFP. Additional questionnaires were completed as requested. An electrical or mechanical NVG failure was to be reported immediately. As personnel changed during the evaluation, new instructor pilots were briefed by the unit and included in the study.

The instructor pilots used the questionnaires to subjectively evaluate various parameters and to give an overall opinion of the MFP NVG. Opinion ratings were numerical:

- 1 - superior to standard NVG
- 2 - slightly better than standard NVG
- 3 - equal or same as standard NVG
- 4 - slightly worse than standard NVG
- 5 - inferior to standard NVG

Subjects used the questionnaire to list perceived advantages and disadvantages, to recommend modifications, to give suggestions, to evaluate the time it took to become comfortable with the MFP NVG, and to evaluate the visual perceptual problems.

RESULTS

UH-1 STUDY (LOWE)

On the first night of use, 22 June 1982, three out of seven MFP NVGs had electrical failures (two on the ground and one in flight). The problem was identified as a poor electrical ground connection through a screw to the battery case. All seven MFP NVGs were taken back to USAARL and the ground contact changed. The metal ground tab was bent in a 90° angle and positioned against the battery case flange.

The following results have been obtained with the 13 participating UH-1 instructor pilots during a three month period:

1. The average prior NVG experience per instructor pilot was 227 hours; range, 10 to 600 hours.

2. The average number of flight hours per instructor pilot with the MFP was 25; range, 3 to 50.

3. On initial use with the electrically corrected MFP NVG, the average overall opinion score was 2.2, with a range from 1 to 4. On the last recorded flight the overall opinion score was 1.17, with a range of 1 to 2. In a word, all 13 instructor pilots preferred the MFP to the standard NVG after initial adjustments.

4. Median time to adapt to the MFP goggles was 15 minutes; range 1 to 150 minutes. All 13 instructor pilots adapted within the initial night of MFP flight.

5. Average flight time for the seven MFP goggles was 46.7 hours; range 20 to 71 hours.

6. The greatest reported difficulty with the MFP was mounting and dismounting. This problem decreased with experience and the addition of quick release tabs.

Some of the advantages and disadvantages identified by questionnaire for the MFP NVG are listed below. The number in parentheses indicates the number of UH-1 instructor pilots reporting this as an advantage or disadvantage.

<u>Advantage</u>	<u>Disadvantages</u>
Better aircraft detection (5)	Harder to mount and dismount (7)
Increased peripheral vision (9)	Difficulty switching batteries (3)
Look-under capability for maps, radios, and instruments (10)	Front V-strap too short (1)
Less weight (3)	Side straps difficult to adjust (2)
Can wear glasses with the NVG (3)	Not as stable (2)
Reduced fogging (8)	Rotary switch difficult to operate (2)
More comfortable/less fatiguing (8)	Counterbalance required (1)
	Peripheral vision distracting initially (2)

OH-58 STUDY (HANCHEY)

The following results have been obtained with the 14 participating OH-58 instructor pilots during a 2½ month period:

1. The average NVG experience per instructor pilot was 276 hours; range, 60 to 600 hours.
2. The average number of flight hours per instructor pilot with the MFP was 29.1; range, 3.0 to 60.
3. On initial use of the MFP NVG, the average overall opinion score was 3.0, with a range of 1 to 5. A value of 3 indicates that the MFP is rated equal to the standard NVG while a value greater than 3 indicates that the MFP is rated lower than the standard NVG. On the last recorded flight the overall opinion score averaged 2.14. Nine instructor pilots preferred the MFP, two rated the MFP equal to the standard, and three preferred the standard NVG. These data include the scores of three participants who requested not to participate after their initial flight and rated the MFP a 5.
4. Median time to adapt to the MFP goggles was 38 minutes; three instructor pilots reported that they could not adapt to the MFP NVG.
5. Average flight time for the seven MFP goggles was 65 hours; range 40 to 90 hours.
6. The greatest reported difficulty with the MFP was mounting and dismounting.

Some of the advantages and disadvantages identified by the first nine participants for the MFP NVG are listed below. The number in parentheses indicates the number of OH-58 instructor pilots reporting this as an advantage or disadvantage. (The last five participants reported only initial and final rating and total time on MFP.)

<u>Advantage</u>	<u>Disadvantage</u>
Increased peripheral vision (4)	Mount and dismount (7)
More comfortable/less fatiguing (3)	Difficulty switching batteries (5)
Less weight (2)	Tubes too far away (4)
Can wear glasses with the NVG (1)	Alignment of goggles (4)
Better aircraft detection (1)	No safety strap (2)
	Rotary switch difficult to operate (2)
	Eye discomfort (2)

Peripheral vision distracting (2)

Increased weight forward (1)

V-straps too short (1)

DIRECTORATE OF EVALUATION AND STANDARDIZATION (DES) STUDY

Before the MFP NVG could be recommended for worldwide use, a larger sample of aviator opinions, various aircraft and flight profiles including weapons fire was desirable. Five pairs of MFP NVG were issued to DES. Two previous studies identified improvements in goggle design and in the briefing. These improvements were incorporated into this evaluation.

The following abbreviated results were obtained with 20 participants flying in UH-1, OH-58, AH-1, and UH-60 aircraft over a two-month period.

1. The average number of flight hours per aviator with the MFP was 6.9; range 1.0 to 25.0, median 3.5.
2. On initial use of the MFP NVG, the average overall opinion score was 1.20, with a range of 1 to 2. All 20 NVG qualified aviators preferred the MFP NVG over the standard NVG.
3. Median time to adapt to the MFP goggles was 15 minutes.
4. The greatest reported difficulty with the MFP was mounting and dismounting.

Some of the advantages of the MFP not listed in the previous studies were (1) no need to focus with blue cockpit lights, (2) superior operations with weapons fire, and (3) ability to see copilot (UH-1, OH-58, UH-60). A disadvantage reported was difficulty in using daylight filters.

SUMMARY RESULTS OF THE THREE STUDIES

1. A total of 47 NVG qualified aviators participated in the study using 20 individual MFP NVG in UH-1, OH-58, AH-1, and UH-60 aircraft.
2. Average number of hours per participant was 18, range 1 to 60.
3. Total sum of recorded flight hours with MFP NVG as of 1 October 1982 was 871 hours, 43.5 hours average per goggle, range 12 to 90 hours.
4. In two incidents the center terminal wire to the battery case broke at the contact point after approximately 15 hours and 30 hours of use, respectively. These wires were reconnected and secured to minimize possible recurrence of the breakage. Also, one V-strap snap pulled out after 3.7 hours.

5. The average final overall opinion rating of the MFP NVG for all 47 participants was 1.46 on a 1 to 5 scale where 1 is the highest rating. Forty-two rated the MFP higher, 2 the same, and 3 lower.

6. For the 27 participants with five or more hours of use with the MFP NVG, the overall opinion rating was 1.15, where 25 preferred the MFP, 2 rated the MFP equal to the standard goggle, and none preferred the standard goggle.

7. Median time to adjust to the MFP NVG was estimated at less than 30 minutes. However, three instructor pilots reported they could not adapt to the MFP NVG.

8. Most frequent listed advantages of the MFP NVG over the standard NVG:

- a. Increased peripheral vision
- b. Look-under capability for maps, radios, and instruments
- c. More comfortable and less fatiguing
- d. Reduced lens fogging
- e. Better aircraft detection
- f. Ability to judge color of lights and distance with unaided vision
- g. Ability to wear glasses with NVG

9. Most frequent or significant listed disadvantages of the MFP NVG:

- a. Difficult to mount and dismount
- b. Difficult to use day filters
- c. Difficult to switch batteries
- d. Counterbalance usually required for goggle stability
- e. Eye pieces further away than standard NVG

DISCUSSION

It is difficult to understand why the initial overall opinion of the MFP was so different between the UH-1 (Lowe Field) and DES aviators, on the one hand, and the OH-58 (Hanchey Field) aviators, on the other hand. The following possible reasons are speculative but should be considered.

1. The OH-58 instructor pilots at Hanchey may have felt that acceptance of the MFP NVG would affect the introduction or priority of issue of ANVIS, although they were briefed to the contrary.
2. The flight commanders at Lowe and DES liked the MFP goggles, while the flight commanders at Hanchey stated they were not impressed with the MFP goggles.
3. The instructor pilots at Lowe had the MFP goggles longer than the Hanchey instructor pilots both before and during flight evaluations. Some of the Hanchey instructor pilots had not made the necessary helmet modifications.
4. The students in the MOI NVG course at Lowe are hightime pilots whereas the students at Hanchey are lowtime pilots. Getting used to a new system and teaching new pilots at the same time may be too demanding.
5. The Lowe instructor pilots had a chance to use the simulator with the MFP goggles before flight evaluations. The Hanchey instructor pilots did not. The present standards for current NVG pilots to qualify with ANVIS NVG are 10 hours of academic instruction and at least 1 hour of familiarization flight. The briefing covering the MFP NVG and evaluation procedures was approximately 30 minutes and a familiarization flight was recommended but not required or utilized by Lowe or Hanchey. However, a familiarization flight was required in the DES study.

Most of the disadvantages of the MFP NVG listed by the instructor pilots have been corrected or improved.

DISADVANTAGES

Following is a discussion of specific disadvantages listed by the pilots on the questionnaire. The actions taken to correct or improve the complaint are discussed.

Mounting

The major problem with mounting the MFP goggles is with connecting the snaps on the MFP side straps to the standard NVG side straps or the surgical tubing snaps. The short MFP side straps eliminate the side stress encountered if snaps are attached directly to the rear side of the MFP, but they increase

the attachment difficulty. When snaps were attached directly to the side of an earlier MFP, cracks developed around the snap where the surrounding support was weakened by the cutaway process. Fiberglass around the side snap to reinforce the MFP (1 pair) and allow direct side snap attachment increased the MFP thickness around and above the side snap. This reinforcement increased the difficulty in mounting between the helmet shell and visor cover, and the quick release tabs blocked part of the side cutout portion of the MFP. The snap on the MFP side strap is positioned behind the faceplate, and the tension on the surgical tubing is usually not adequate unless the tubing is adjusted. With practice, all NVG pilots found mounting the goggles less difficult. The briefing for initial users of the MFP will require the user to mount and dismount the goggles 10 times.

If the standard side straps are used, snaps on the helmet should be in the rearward position to aid in adjusting the tension. Also, the metal quick release tabs should be attached to the MFP side straps to move the excess adjusting strap from blocking the side vision.

Dismounting

If the upper V-straps are removed first on the MFP goggles, the eye pieces will hit the wearer in the face. The participants were briefed and warned of this problem, but this event occurred frequently on initial use. The replacement V-straps on the MFP were made too short for proper attachment and removal from the Velcro pads on the helmet visor cover. To correct this problem, the V-straps and Velcro were lengthened to accommodate variations in the location of the visor Velcro pads. Quick release tabs are being added to the surgical tubing snaps to improve speed and ease of disconnecting the goggles.

Battery Container (Arctic Adapter) Inconvenient

If the arctic adapter is not used with the MFP NVG, the battery would be very difficult to change in flight. Placing the battery container of the arctic adapter on the back of the helmet with a Velcro loop instead of tape used in the initial evaluation would allow easy attachment, detachment, and battery exchange. Also, a sudden battery failure with the standard NVG could be disastrous, whereas the MFP allows unaided vision until the battery is changed. When the double battery pack becomes available, battery failure in flight will not pose a serious safety hazard.

Tubes Too Far Away

Rearward movement of the binocular assembly is limited by the placement of the rotary switch. Substituting a different switch would not be expedient and would defeat the timely fielding of a MFP NVG. Variations in the anatomical location of the eyes and of helmet fit and size can result in less than a full field of view through the goggles for a few individuals. Minimal field reductions can be compensated for with experience, but beyond a certain range, greater

distance between the eyes and eyepieces can produce optical distortion as well as field loss for which experience cannot compensate. For the few aviators experiencing difficulty with excessive eye relief with the MFP NVG, standard NVG should be available.

Alignment of Goggles

Since the MFP NVG are mounted to the helmet, lateral alignment of the goggles for each individual depends on the V-strap and side strap attachments. The method of changing lateral positioning of the goggles will be included and stressed in the initial briefing. Vertical alignment can be achieved with the tilt knob or slight helmet rotation.

No Safety Cord

The first prototype MFP NVG had safety cords, but they proved to be more of a nuisance by tangling with the straps, communications and arctic adapter cords, detaching counterweights and dual battery packs. A cloth NVG bag as installed on some AH-1 Cobras would provide safe storage of the goggles when they are not in use in the aircraft. By placing a Velcro pad on the top of the helmet the goggles can be stored and secured on the visor cover during flight when not in use. Safety cords can be added at the discretion of the individual flight commanders.

IR Switch (AN/PVS-5 and 5A) Difficult To Use

The occasional difficulty in operating the top-mounted rotary switch decreased with experience. Instead of using the goggle-mounted IR source, using IR or blue pen lights/flashlights for inside-the-cockpit viewing could eliminate the need to use the rotary switch. Such an alternate illumination source might also offer greater versatility with less signature.

Eye Discomfort

With the eyepiece of the MFP NVG located slightly further from the eyes than the standard NVG, interpupillary alignment and focusing are more critical, and, when incorrectly adjusted, could cause eye discomfort. Also discomfort can be caused with greater eye movement excursions and sudden luminance differences when looking from the goggle image to the unaided peripheral fields. Improved focusing and interpupillary adjustment techniques will be included in MFP NVG orientation briefings and NVG academics. Increased use of the MFP NVG should reduce eye discomfort from eye excursion and luminance changes.

Peripheral Vision Distractions

Receiving visual information from both the NVG and unaided vision could be initially confusing but should be quickly and easily learned to maximize performance. The MFP NVG will prepare the aviator to effectively use his aided and unaided vision when the AN/PVS-6 ANVIS is available.

Increased Weight Forward

The MFP NVG are approximately 4 oz. lighter than the standard NVG. However, since the MFP NVG are mounted between the helmet shell and visor cover, and there is no face pad support, the helmet may have a greater tendency to rotate forward if the helmet is not properly adjusted or a counterbalance is not utilized. Proper helmet adjustment and stability should be evaluated and corrected before flight with the MFP NVG.

V-Strap Too Short

The V-straps have been lengthened by 1½" with a 1" increase in the Velcro area to accommodate variations in the location of the Velcro pads on the visor cover.

ADVANTAGES

Most of the listed advantages of the MFP compared to the standard faceplate are self explanatory. The significance of the larger field of view with the MFP NVG (Figure 6) can be appreciated by considering the limitations of the 40° field of view with the standard AN/PVS-5 NVG (Figure 7). Proper scanning techniques used by NVG pilots can be described as one second fixations separated by horizontal head movements of approximately 30°. To scan 270° around the aircraft with standard NVG (excluding head movement time) would require 9 seconds, and would include only 20° above and 20° below the horizon. Typically, the aviator spends most of his time looking in the direction of the intended flight path, at ground features and hazards, and aircraft instruments. With standard NVGs, this means a very large portion of the available visual field around the aircraft is seldom viewed adequately or frequently enough to avoid a collision threat. The peripheral vision along with sideward and downward viewing capabilities afforded by the MFP greatly enhance the NVG aviator's ability to scan his environment.

During the study, four instructor pilots reported avoiding a possible mid-air situation by detecting an intruding aircraft with their unaided peripheral vision while wearing the MFP NVG. One of these incidents was verified by the investigator, who was riding as a passenger. A description of this incident follows: At a stage field with four parallel runways, NVG training was being conducted in OH-58 aircraft. At approximately 2 hours into the training period, two aircraft on adjacent runways requested permission to take off at about the

same time. The tower operator instructed the two aircraft to hold for spacing, but then corrected himself and responded "clear for take off" without identifying which aircraft. Both aircraft took off, thinking they had been cleared by the tower. Just before reaching traffic pattern altitude, the instructor pilot in the aircraft to the left detected the parallel aircraft to his right and rapidly decelerated to fall into a trailing position with the other aircraft. Within a few seconds the aircraft on the right turned left to enter the crosswind leg. In questioning the instructor pilot who had detected the other aircraft and avoided a midair collision, he stated that he had first detected the red position light of the other aircraft with his side vision which was provided with the MFP NVGs he was wearing.

CONCLUSIONS

1. NVG aviators indicate that the MFP significantly enhances intruder aircraft detection, inside-the-cockpit vision, and comfort. These findings suggest that the MFP NVG will improve flight safety and increase NVG flight capabilities over the standard AN/PVS-5 until the AN/PVS-6 ANVIS are available.

2. Spectacles can be worn with the MFP, and less fogging of the eyepieces occurs.

3. Primary deficiencies with the MFP appear to be initial mounting and dismounting difficulties, goggle alignment problems, battery container inconvenience, perceptual adjustment difficulties, and difficulty in using daylight filters. Most of the reported deficiencies have been corrected with modifications to the mounting apparatus, thorough preflight briefings, and required familiarization flight.

4. Thorough academic and flight familiarization is essential to successful adjustment to the MFP NVG.

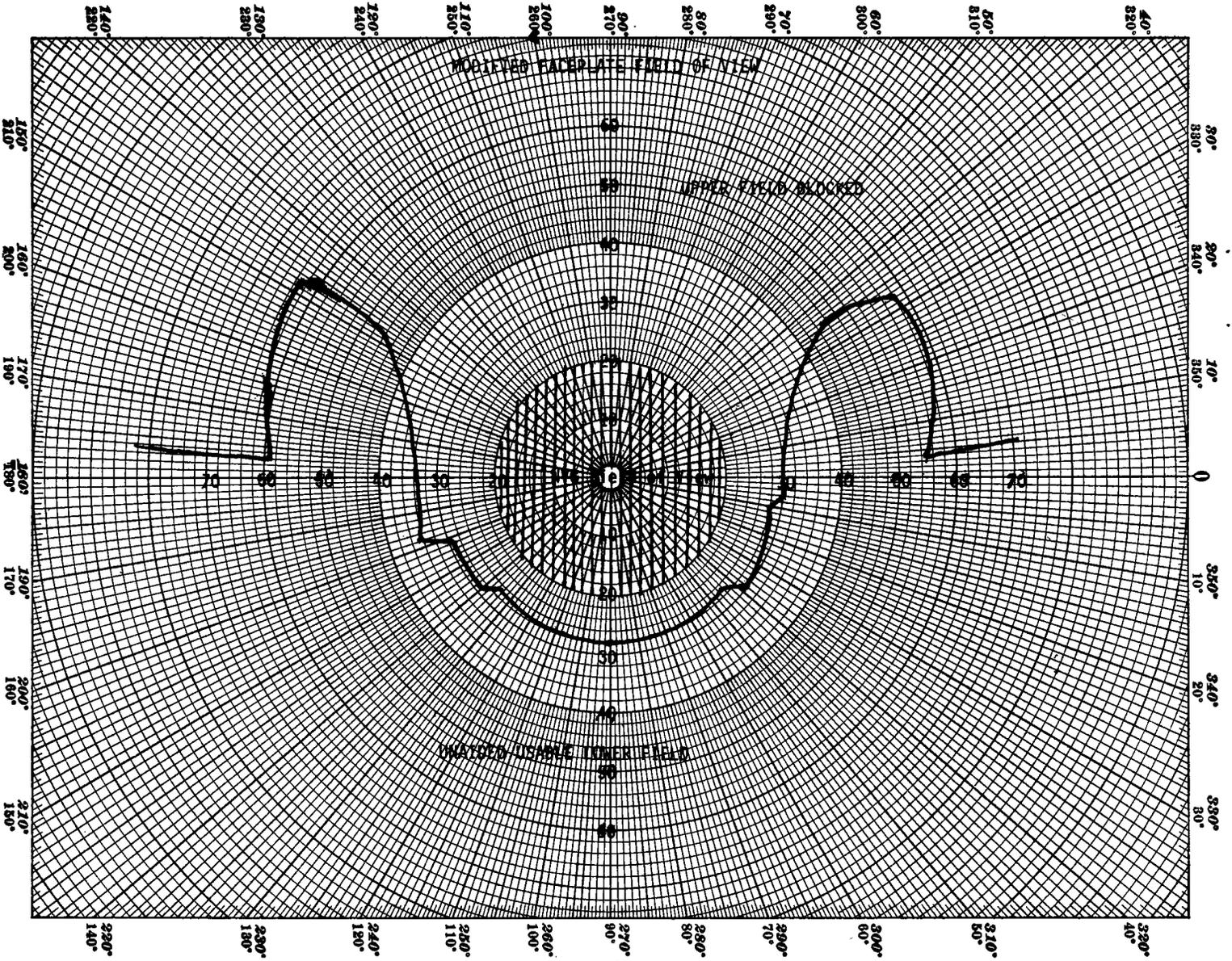
RECOMMENDATIONS

1. These results and conclusions should be considered in efforts to establish a MFP NVG program worldwide for Army aviators.

2. If MFP NVG are adopted for training and/or operations, thorough academic and flight familiarization must be provided to Army aviators.

3. A certain quantity of the standard AN/PVS-5 NVG faceplates should be retained to permit day filter NVG training and to accommodate the few aviators who are not able to effectively use the MFP NVG. The actual number of MFP and standard faceplates should be determined by operational authorities.

APPENDIX A
MODIFIED FACEPLATE FIELD OF VIEW



APPENDIX B

**SUMMARY OF SIGNIFICANT CHRONOLOGICAL
EVENTS IN EVALUATION OF MFP NVG**

SUMMARY OF SIGNIFICANT CHRONOLOGICAL
EVENTS IN EVALUATION OF MFP NVG

1. March 1982 - Initial prototype MFP made at the US Army Aeromedical Research Laboratory (USAARL).

2. May 1982 - Telephonic flight release obtained from US Army Aviation Research and Development Command (AVRADCOM) for MFP feasibility study.

3. June 1982 - Protocol for MFP feasibility study approved; seven MFP NVG issued to Lowe, MOI NVG UH-1 instructor pilots for evaluation. Initial results very favorable.

4. July 1982 - Seven MFP NVG evaluated at Hanchey by NVG OH-58 instructor pilots. Initial results mixed.

5. August 1982 - US Army Aviation Center (USAAVNC), Directorate of Training and Doctrine (DOTD), and USAARL reviewed preliminary findings. Recommendations were to continue and expand the study, incorporate minor modifications and improvements in MFP design, and improve participant's briefing and familiarization. Department of Evaluation and Standardization (DES) was issued five MFP NVG for evaluation in UH-1, OH-58, AH-1, and UH-60 aircraft.

6. September 1982 - Meeting by Directorate of Combat Developments (DCD), Test Board, Directorate of Training Developments (DTD), DOTD, USAARL, and USAAVNC to determine means to implement MFP NVG if evaluation results favorable.

7. October 1982 - MFP study results evaluated and found very favorable. Study included 47 NVG qualified aviators, four types of helicopter aircraft, 20 MFP NVG, and more than 850 hours of MFP use.

APPENDIX C
CONVERSION OF STANDARD FACEPLATE TO
MODIFIED FACEPLATE

CONVERSION OF STANDARD FACEPLATE TO MODIFIED FACEPLATE

No special skills are required to make the conversion; however, a machinist is recommended.

Basic supplies and equipment used: Phillips screwdriver, pliers, small hand drill with metal rotary file, circular stone, and drill bits, clear silicon rubber glue, soldering iron, and high-speed (duct) tape. Straps can be made by the fabric shop.

Initially a couple of discarded or damaged faceplates should be used to develop the skills and techniques to produce a quality cut-out faceplate. Plastic templates help to standardize the battery container and side cut-out patterns.

Faceplates to be used for the conversion should have no damage in the upper plastic portion, and the electrical system should be checked with NVG tube assembly. After the conversion, the cut-out faceplate should be checked again with the NVG tube assembly and mounted on a helmet to check for battery case clearance. The serial number plate is removed from the cut-out faceplate. Serial numbers can be engraved in the plastic cut-out faceplate or the NVG can be inventoried by the numbers on the tubes.

The following photographs show the sequence to convert the standard AN/PVS-5 faceplates to cut-out NVG. Figures C18 and C19 show the template designs, and Figure C20 shows the dimensions and components of the side and vertical straps.

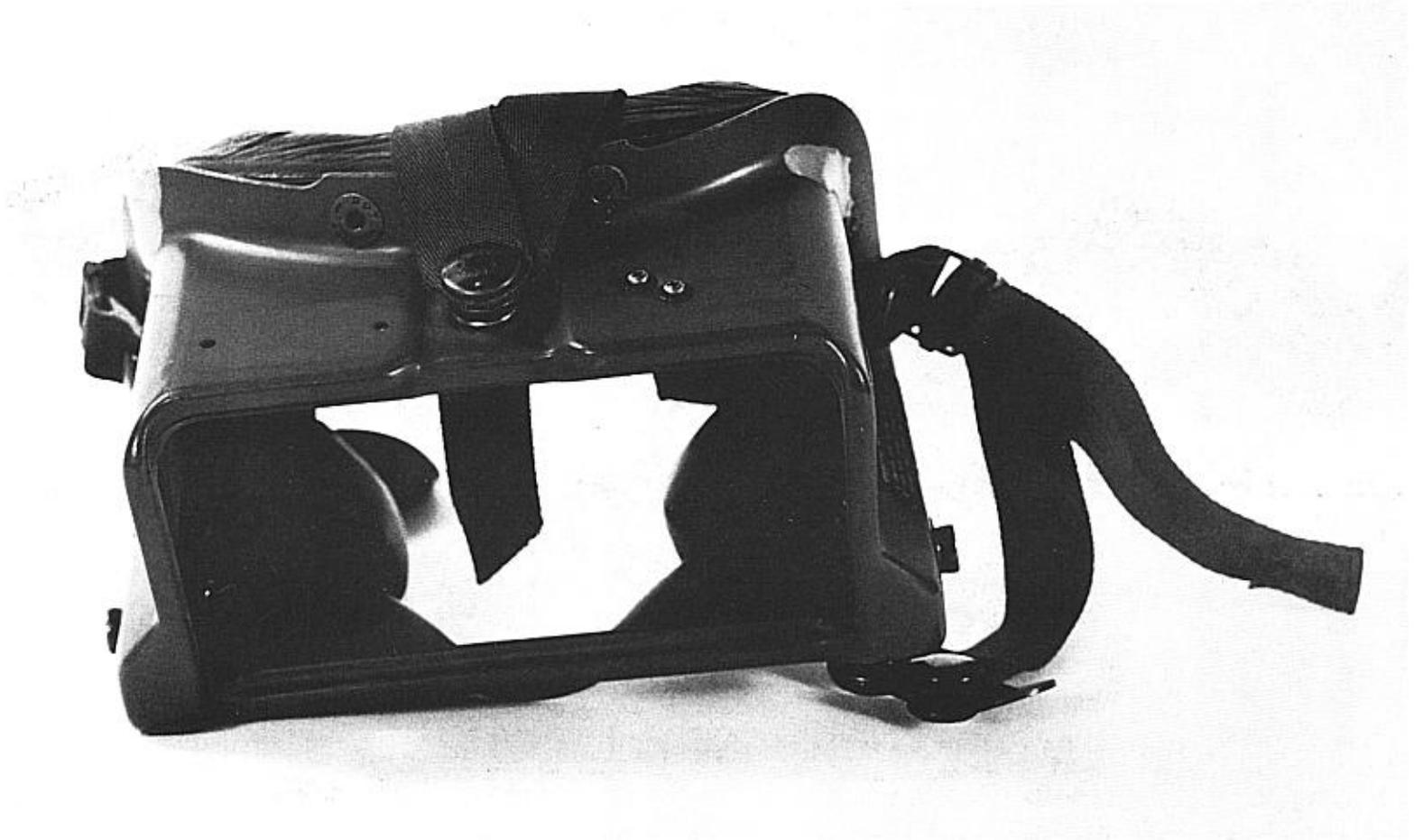


Figure C1. Front view of standard NVG faceplate with face pad and aviator attachment straps.

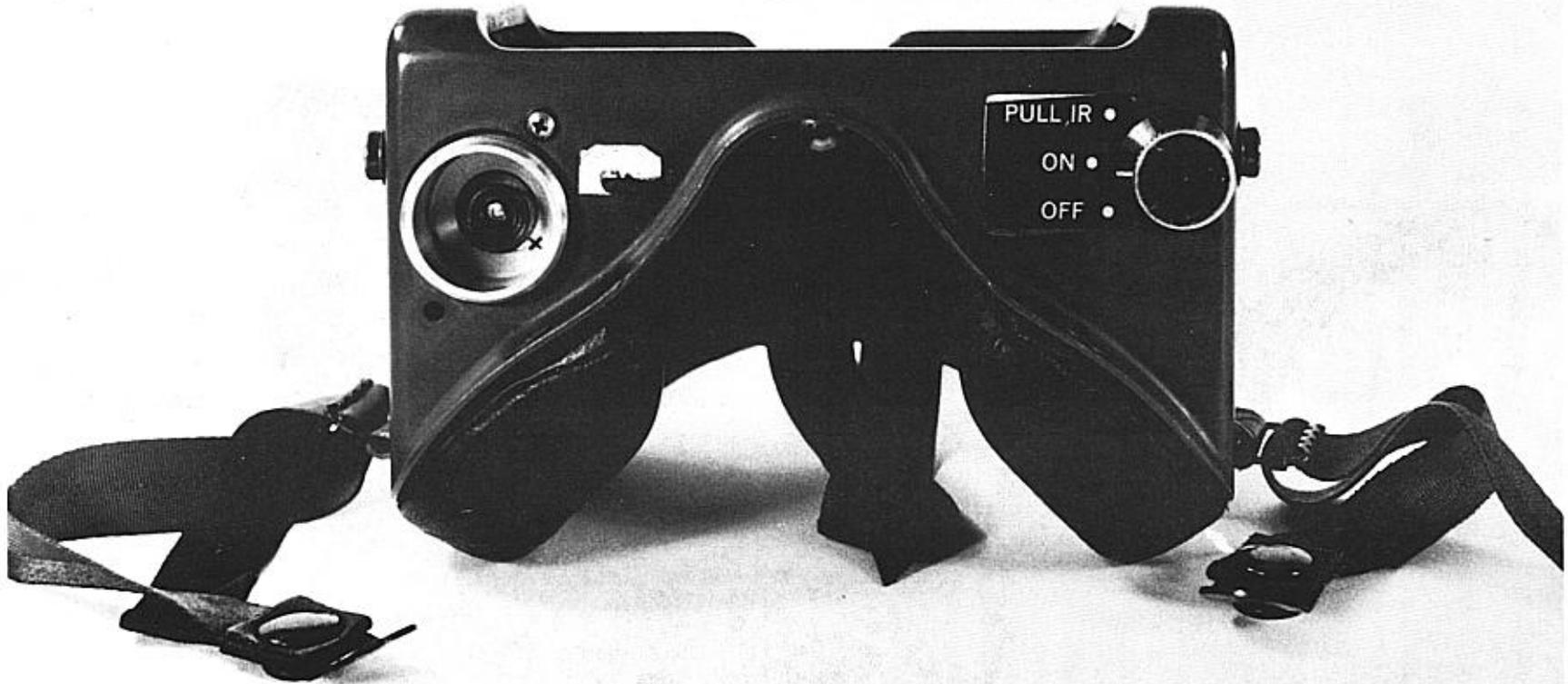


Figure C2. Bottom view of standard AN/PVS-5A faceplate. Note battery case and rotary switch location.

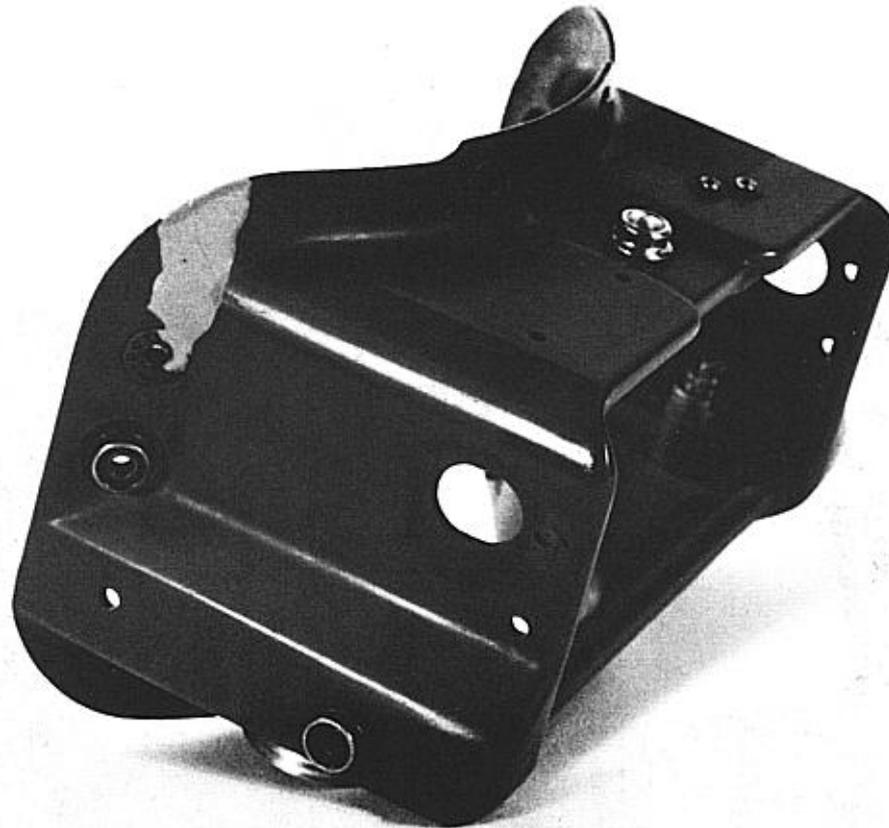


Figure C3. View of standard NVG faceplate without straps or face pad.

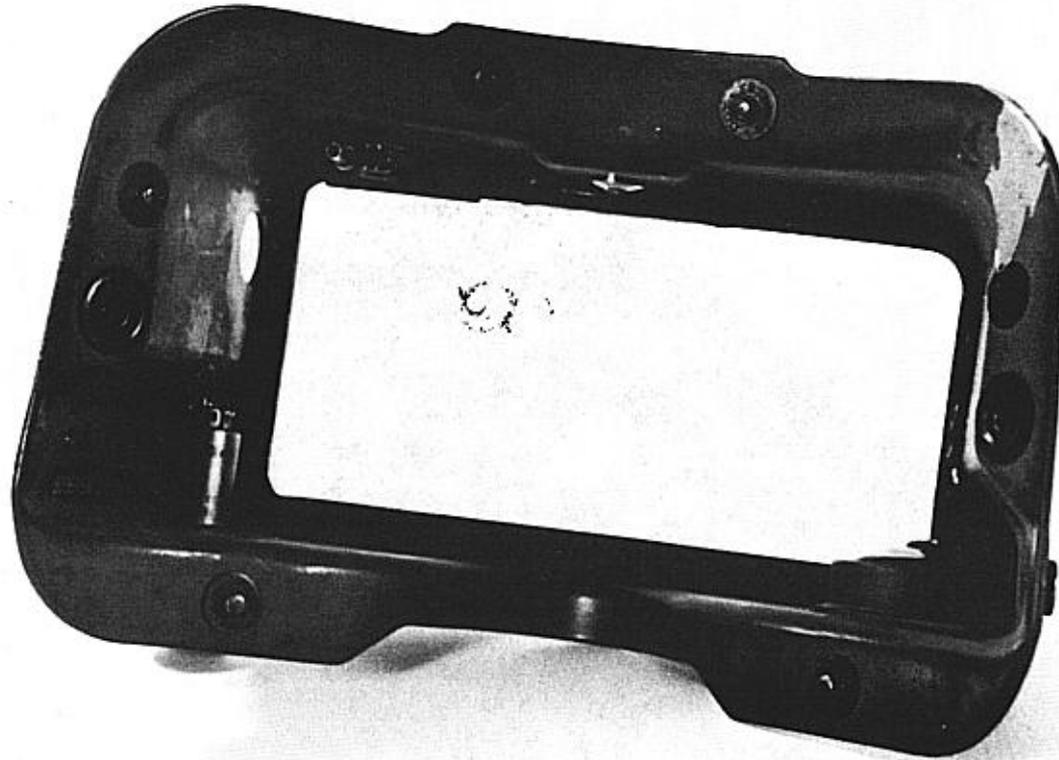


Figure C4. Back view of standard NVG faceplate without pad. Note small upper and side male snaps. These will be used with #16 female snaps to attach the vertical and side straps.

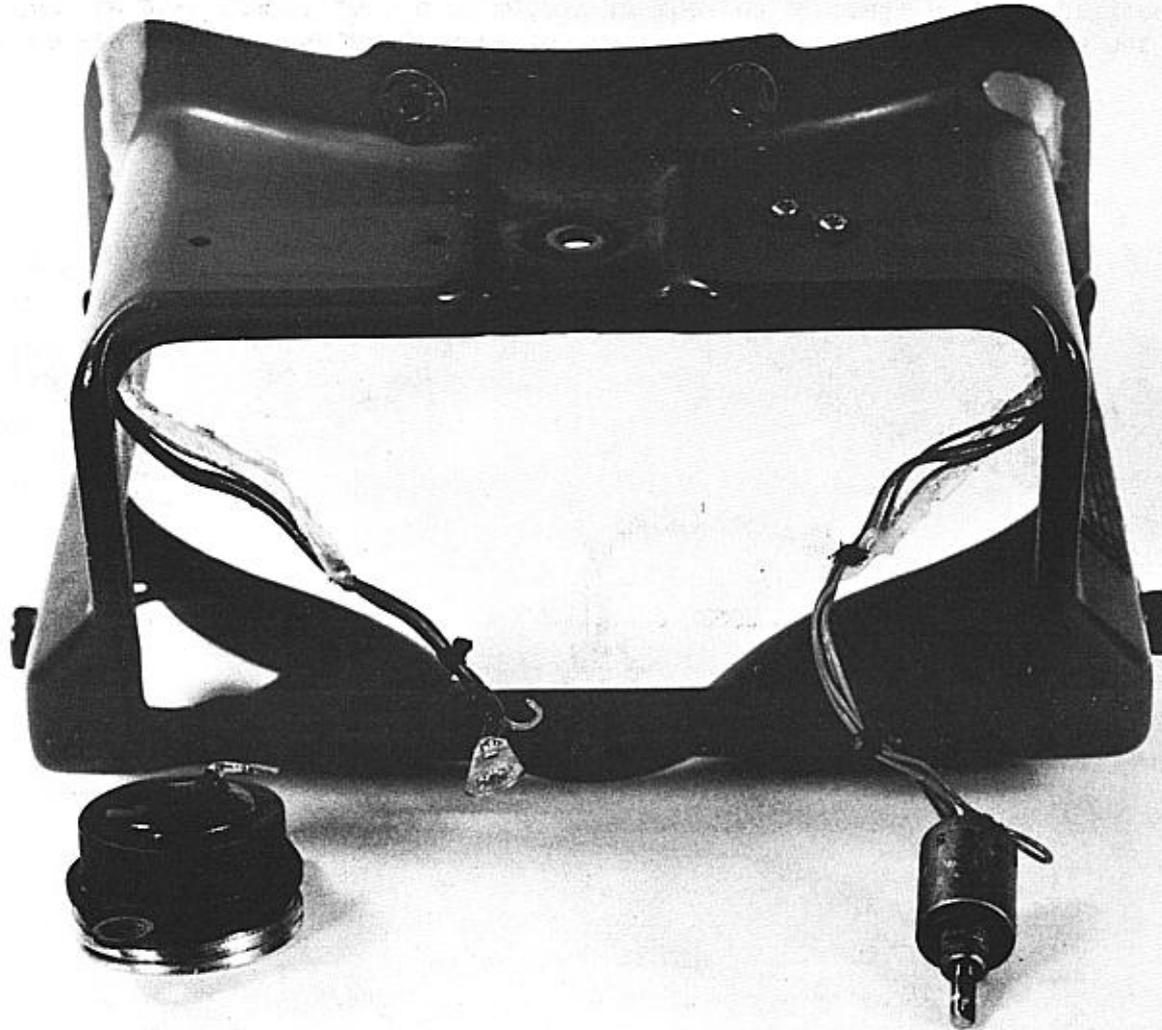


Figure C5. Front view of faceplate. Battery case and switch are disconnected. Wire to center battery case contact is cut. Wires to battery case and rotary switch are pulled from the sides of the faceplate to the upper corners. The black wire ties are usually glued in the grooves of the faceplate and will require small screw driver to break loose. Snap holding V-strap is removed.

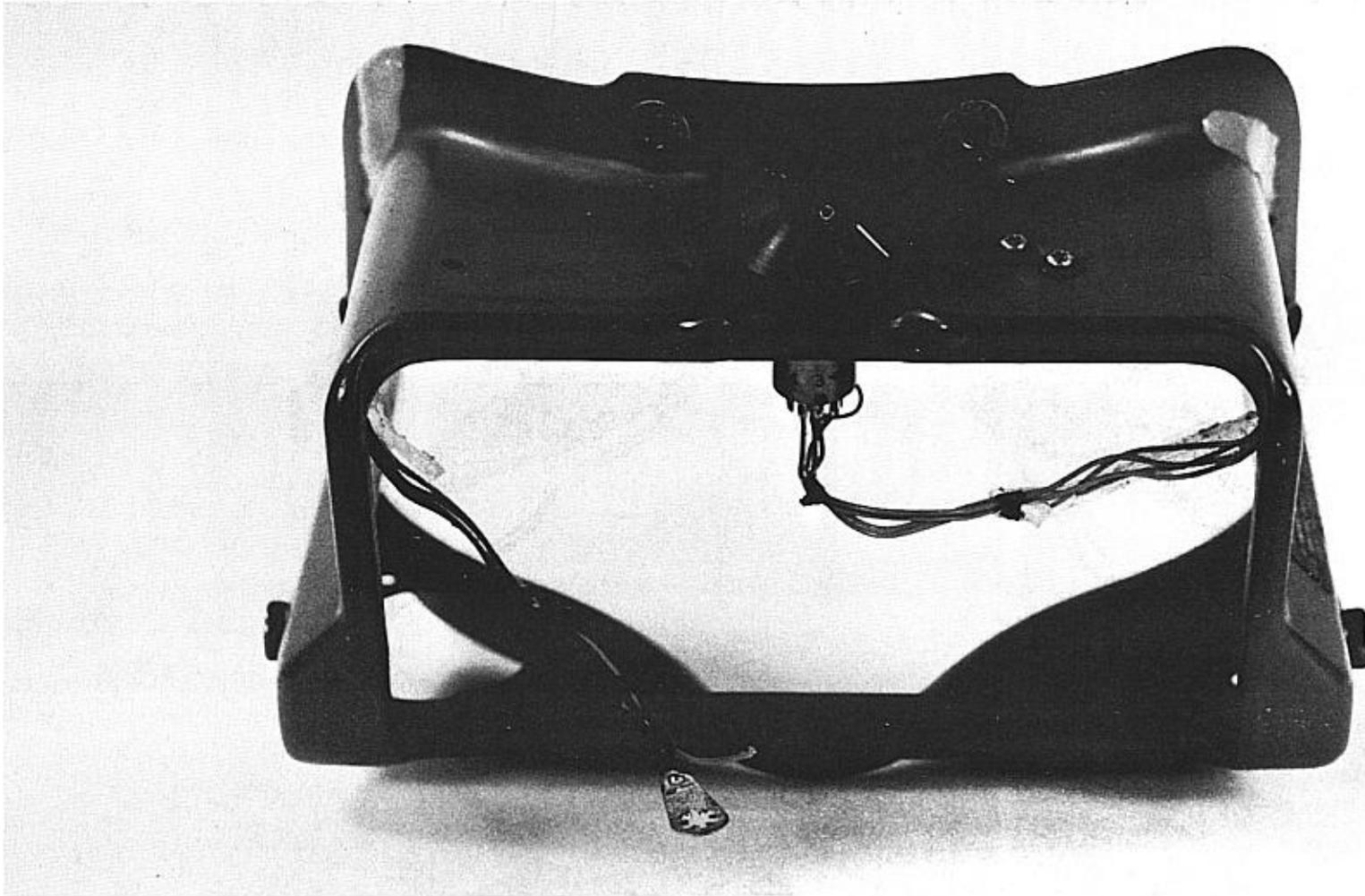


Figure C6. The rotary switch is mounted where the V-strap snap was located. Hole has to be enlarged for the switch and the enlargement should be mainly to the rear. Small hole is drilled next to the V-strap hole for bracket used to prevent base rotation of the switch.

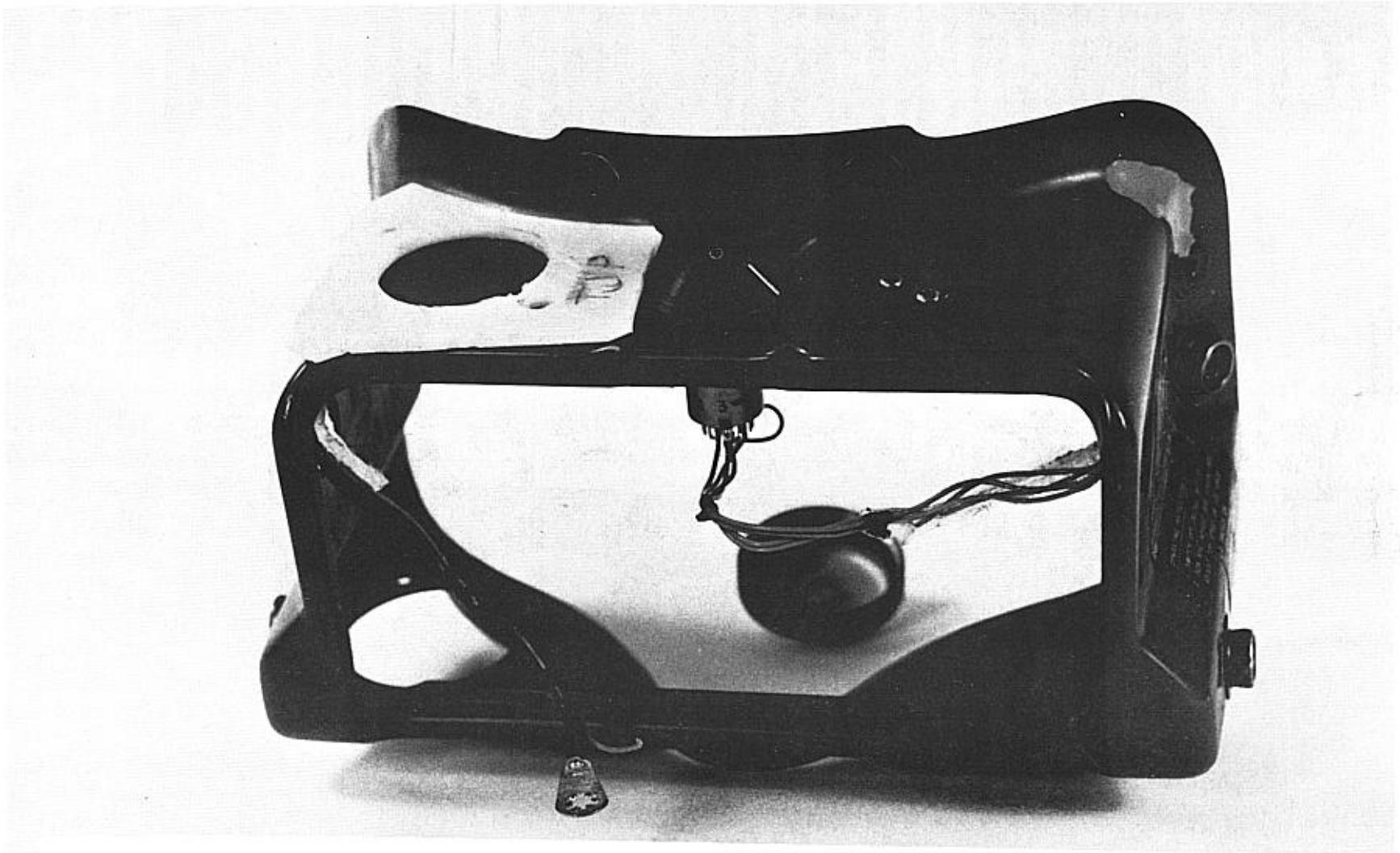


Figure C7. A template is positioned on the upper right part of the faceplate and design drawn for new location of battery case. See Figure C18.

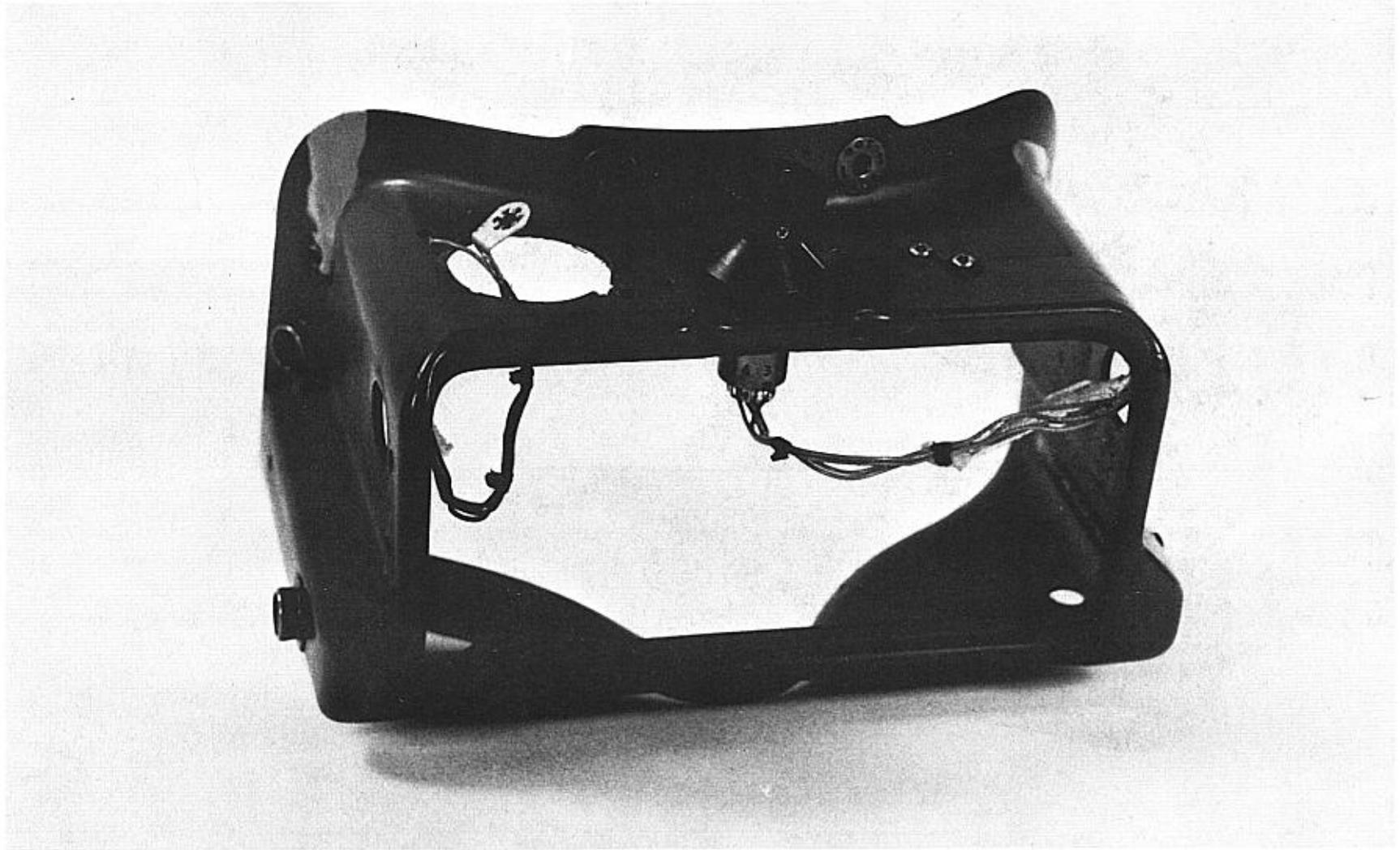


Figure C8. Hole is cut for battery case with notch for ground tab. Ground tab is bent 90° to make contact with battery case.

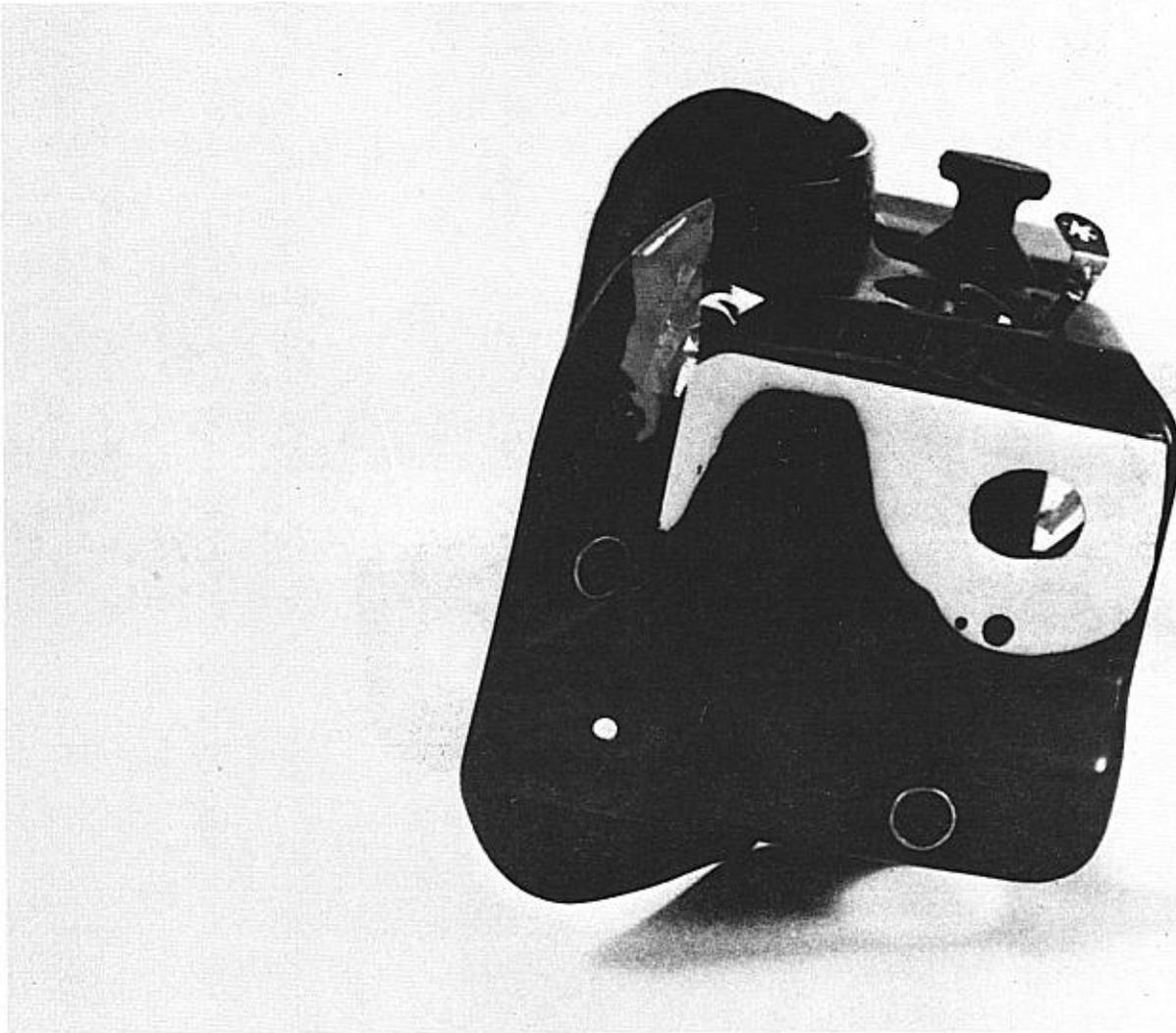


Figure C9. Side template for cutout is positioned and pattern drawn on faceplate. The back edge location of the cutout will vary with the location of the face pad snap location. See Figure C19.

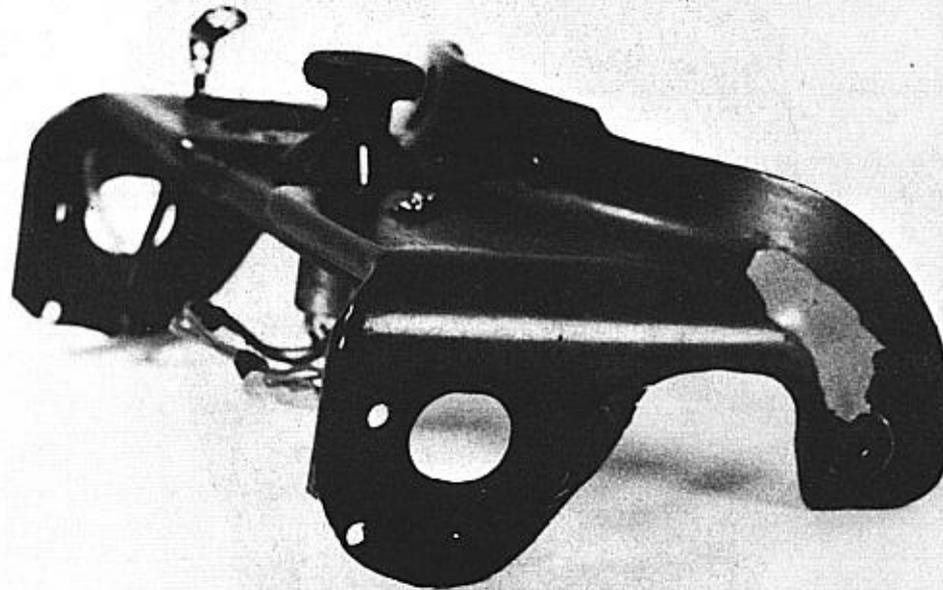


Figure C10. Side pattern is cut out. The back portion of the cutout should be approximately $\frac{3}{8}$ " in front and below the face pad snap with very little rounding of the corner. The clamp knob holes are enlarged $\frac{1}{8}$ " to the rear. Do not drill the two holes pictured in front of the clamp knob hole.

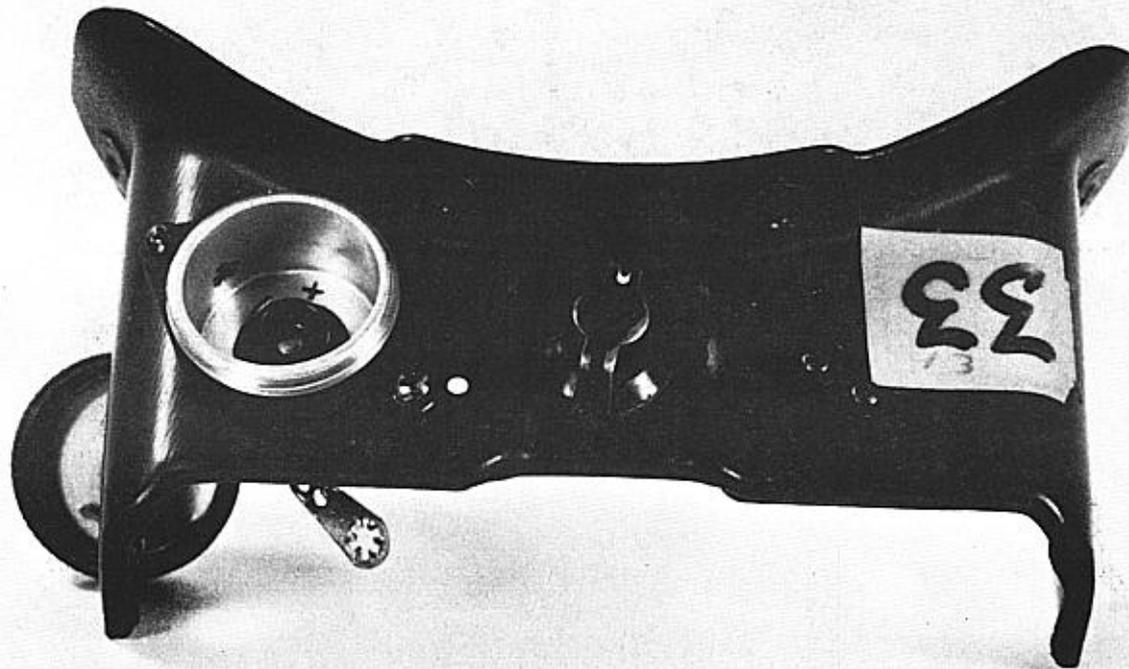


Figure C11. Top view. Note the AN/PVS-5 switch difference from the AN/PVS-5A switch. The ground tab will be bent 90° and placed between the battery case flange and faceplate before the battery case is mounted. (Not shown)

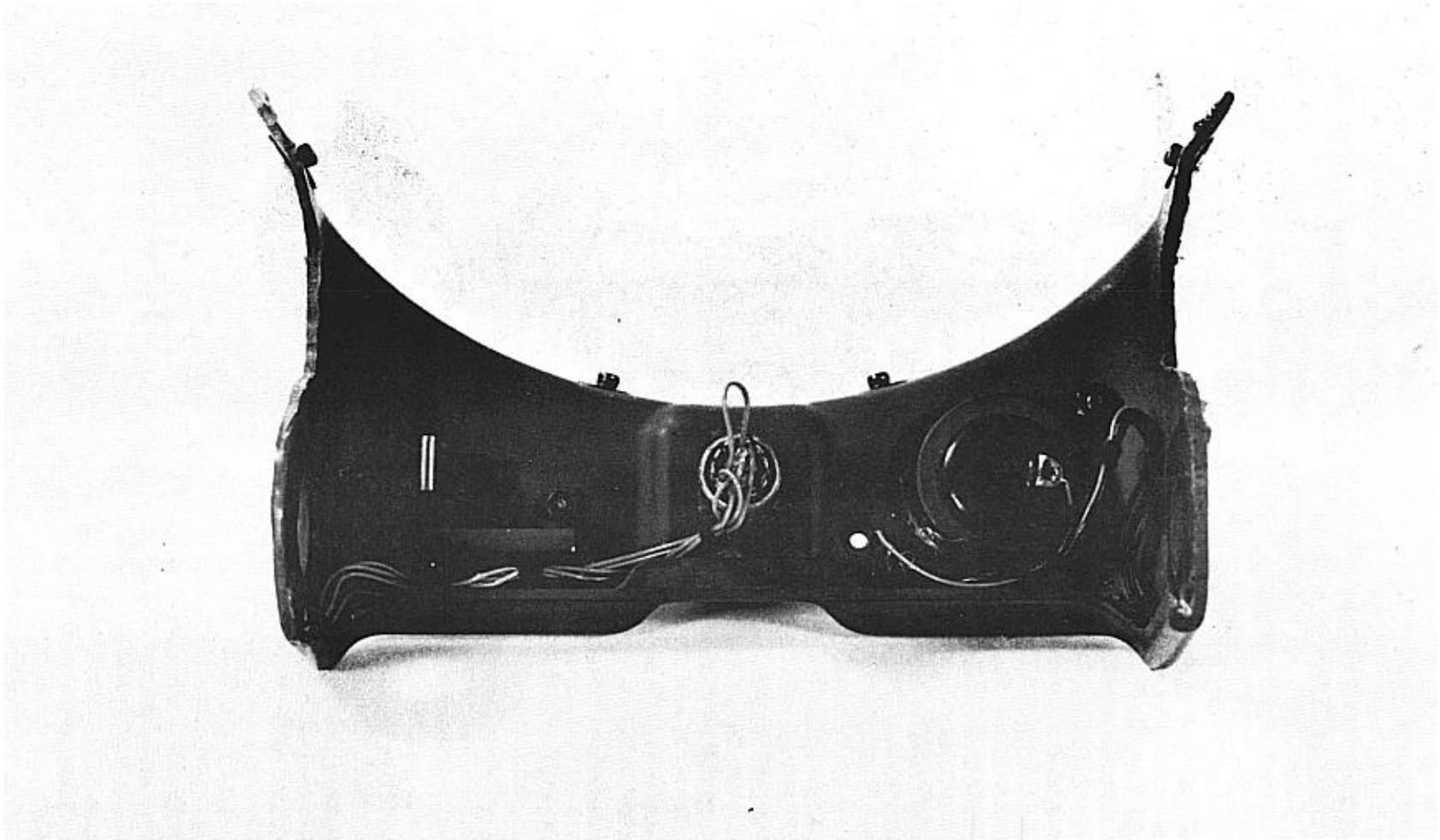


Figure C12. Bottom view. The center battery case electrical contact is positioned to the side of the faceplate and bent towards the case. The center battery case wire will be resoldered. The wires are delicate and recommend using hot wire stripper. Battery case and rotary switch wires are tucked as shown. Use clear silicon rubber cement to glue wires in place and on battery electrical contact point.

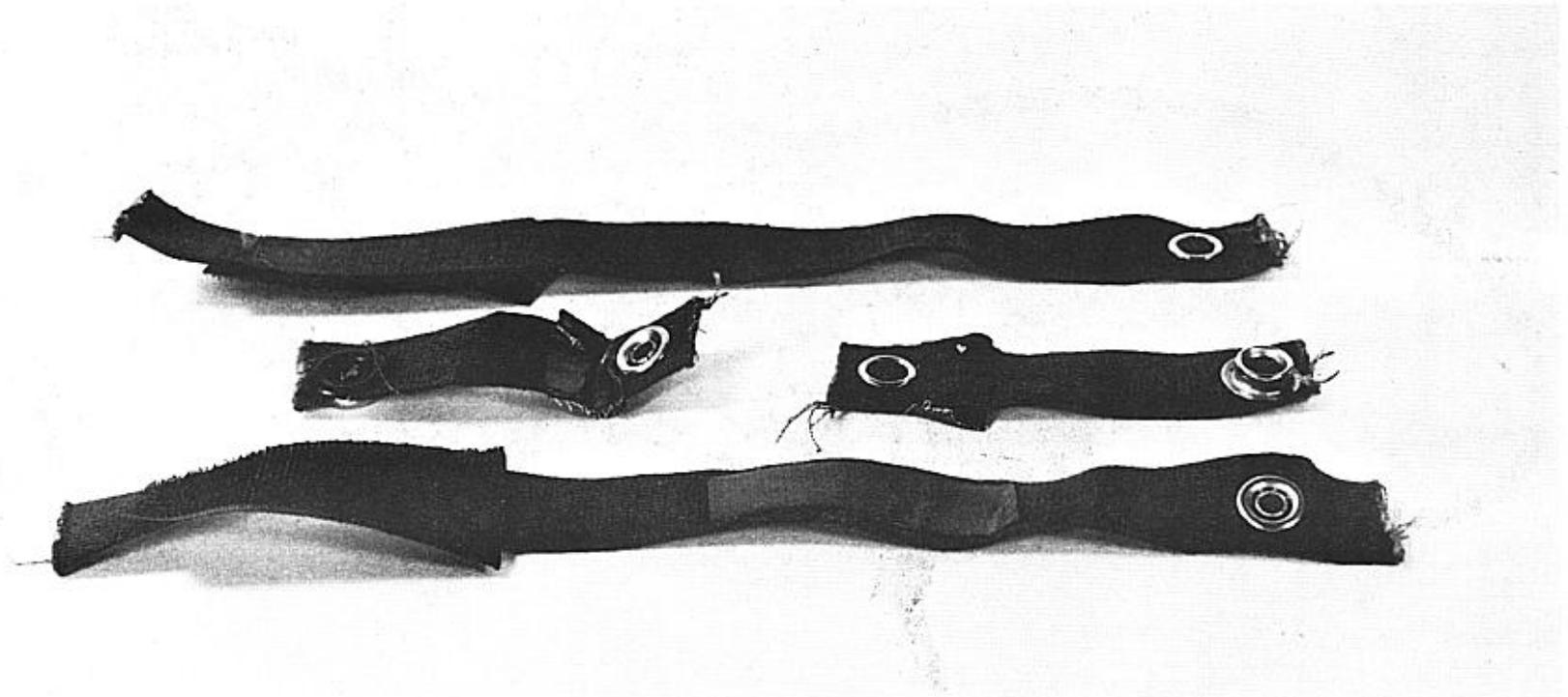


Figure C13. Earlier version of side and vertical straps for cutout goggles. Dimensions and description are shown in Figure C20. The actual vertical straps to be used are made of nylon.

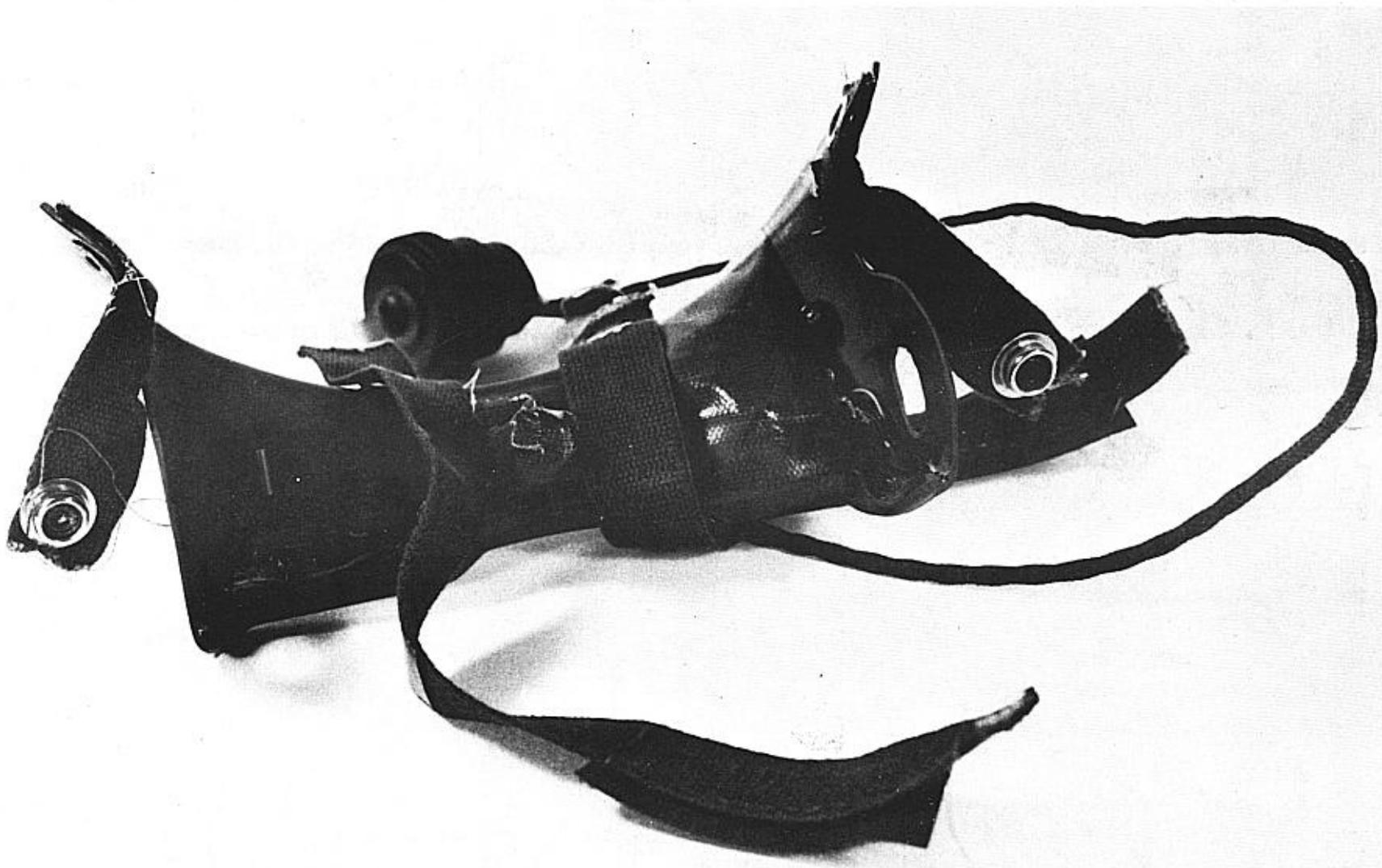


Figure C14. Bottom view. After silicon rubber cement is dry, battery case and switch are taped with high-speed (duct) tape and straps attached at face pad snaps. Note the edges of the cutout have been smoothed and rounded.



Figure C15. Top view. Straps are attached to face pad snaps. Side straps pass through the side cut out from the inside of the faceplate, and bend around the outside. Side straps are taped in place.

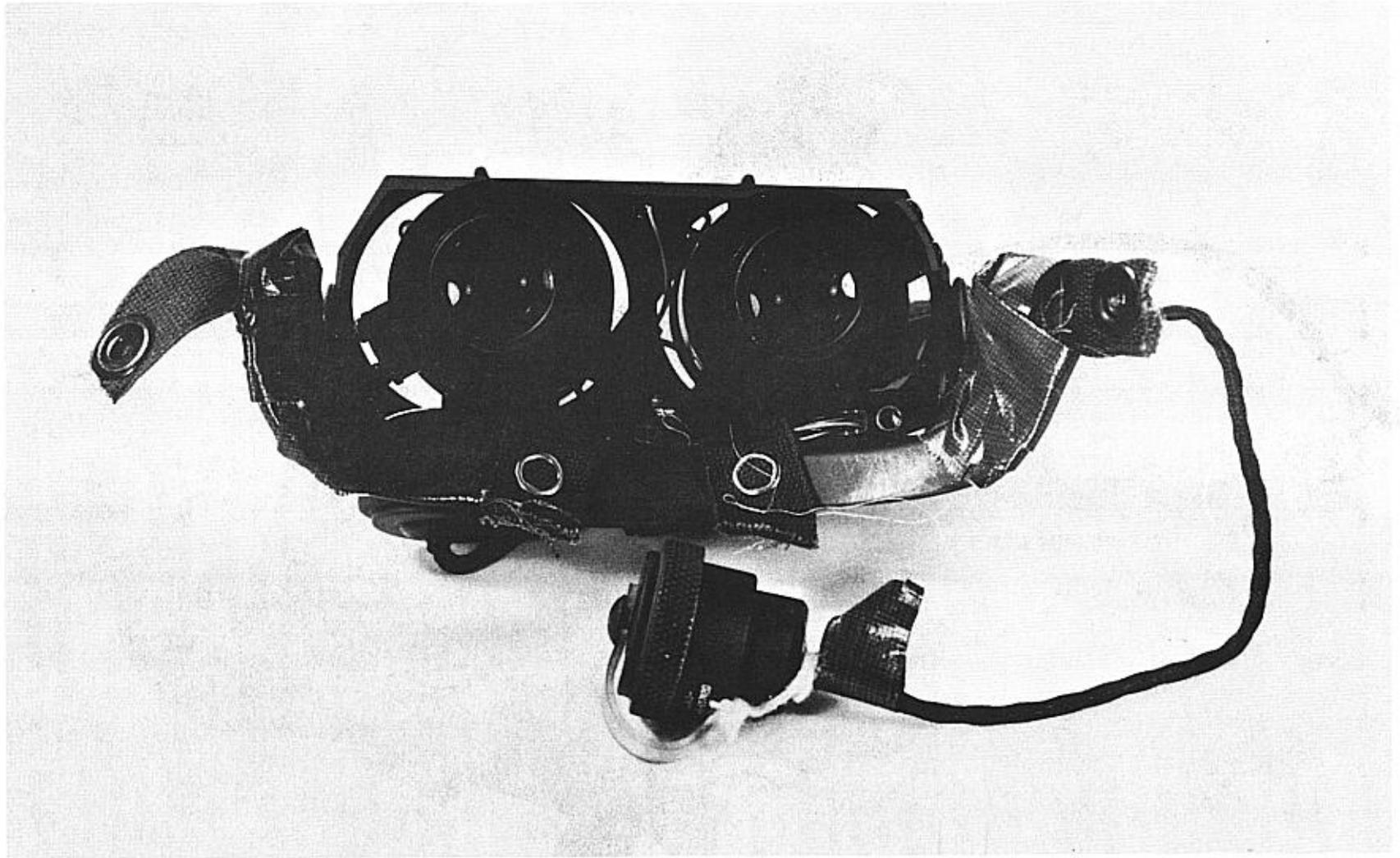


Figure C16. Back view. Electrical connection from the binocular assembly is connected to the faceplate with an allen wrench. Side clamp knobs are replaced. A small cord is fastened to the rubber portion of the battery cap and to the electrical cord of the arctic adapter.

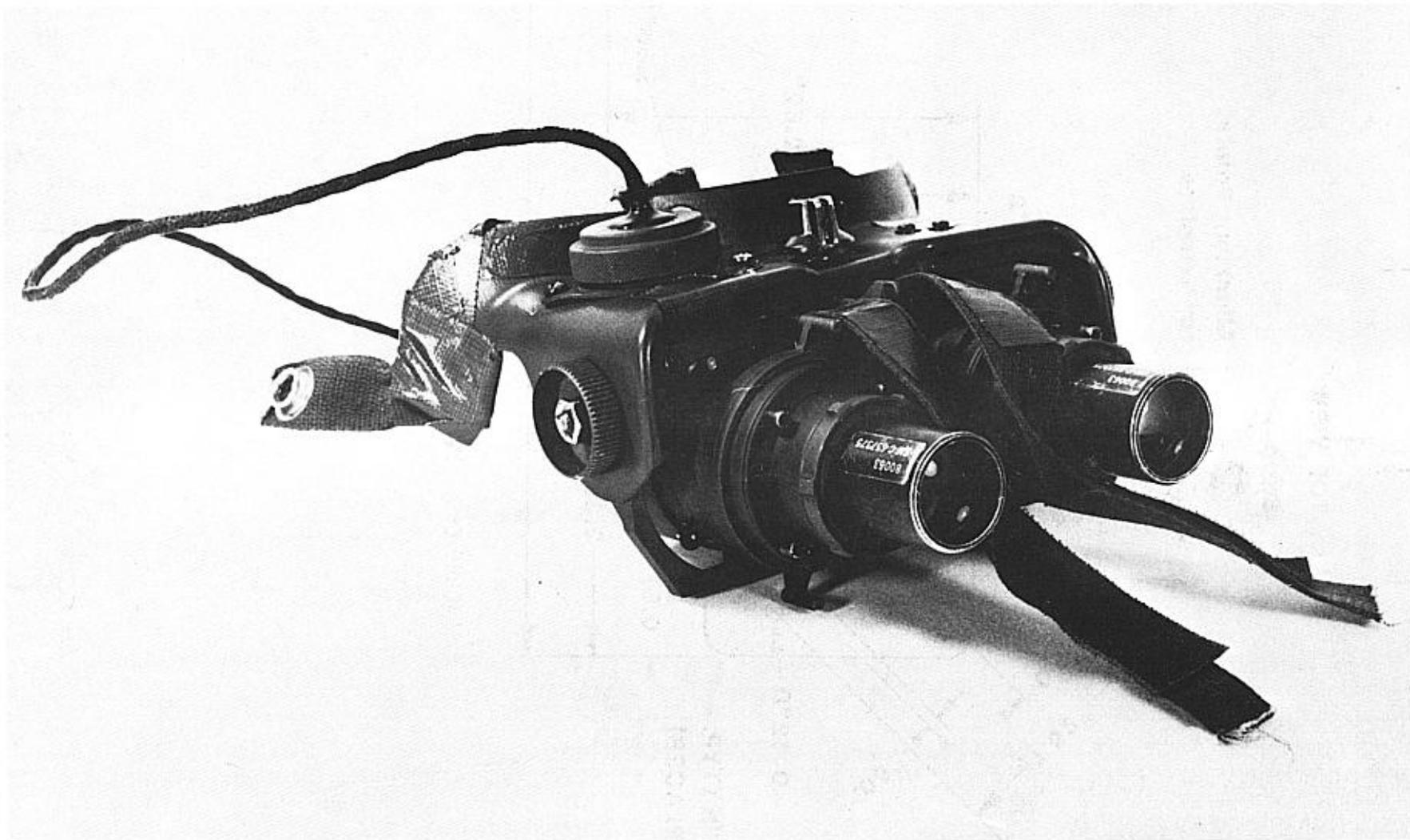


Figure C17. Completed and assembled MFP NVG. Note the vertical straps pass between the binocular assembly and faceplate.

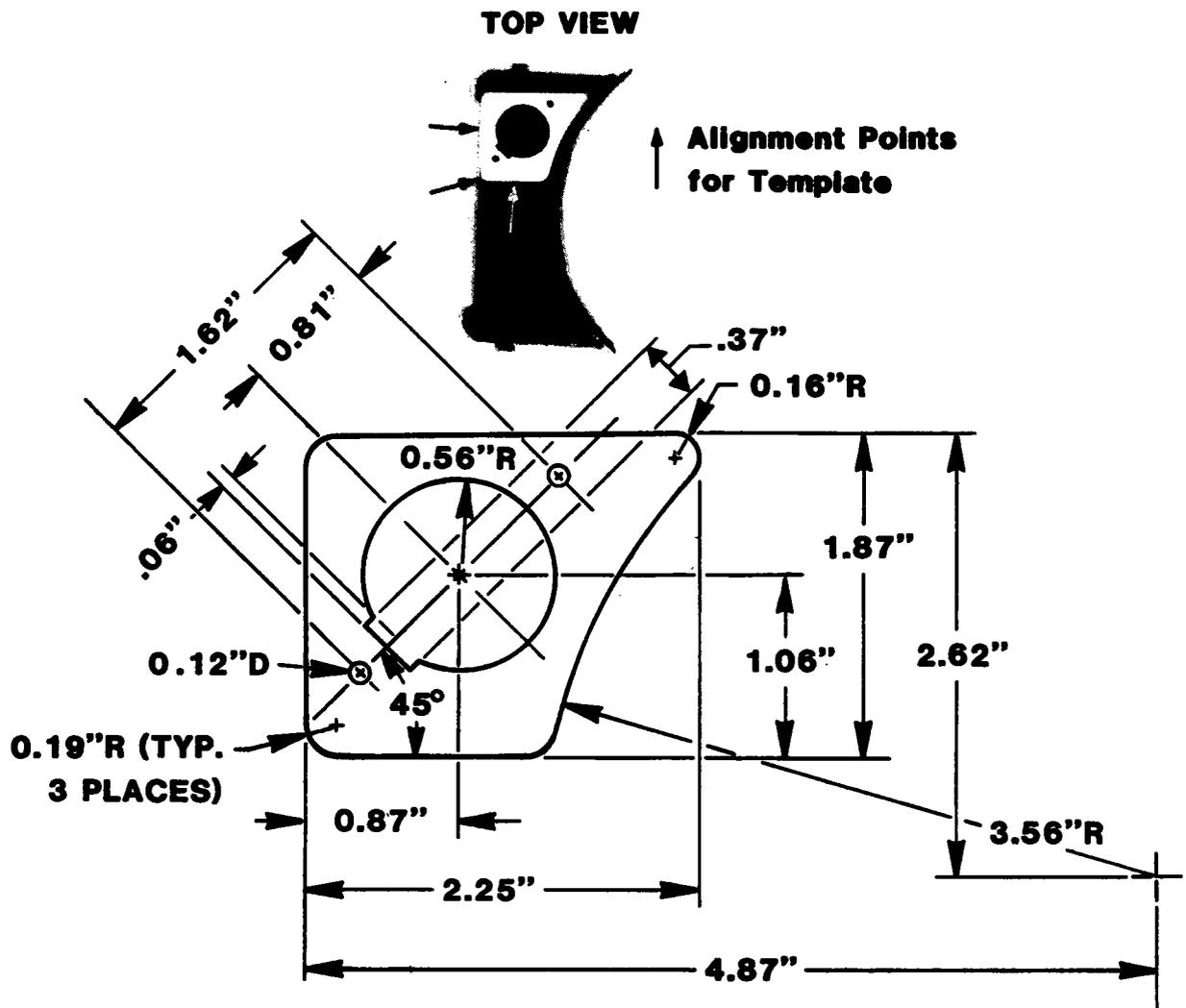


FIGURE C18. Template design.

SIDE VIEW

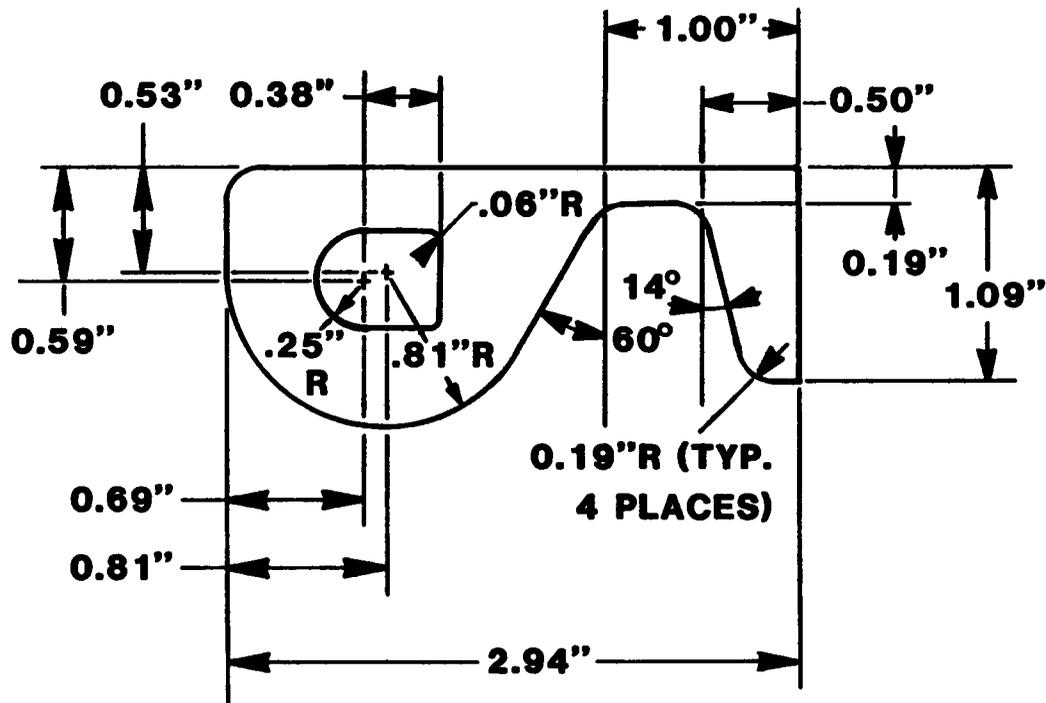
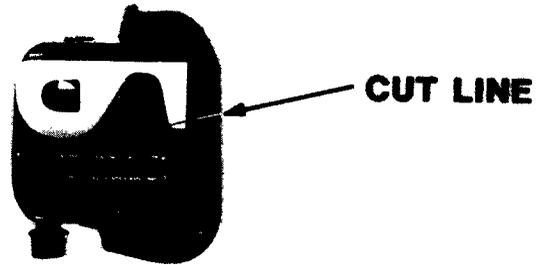


FIGURE C19. Template design.

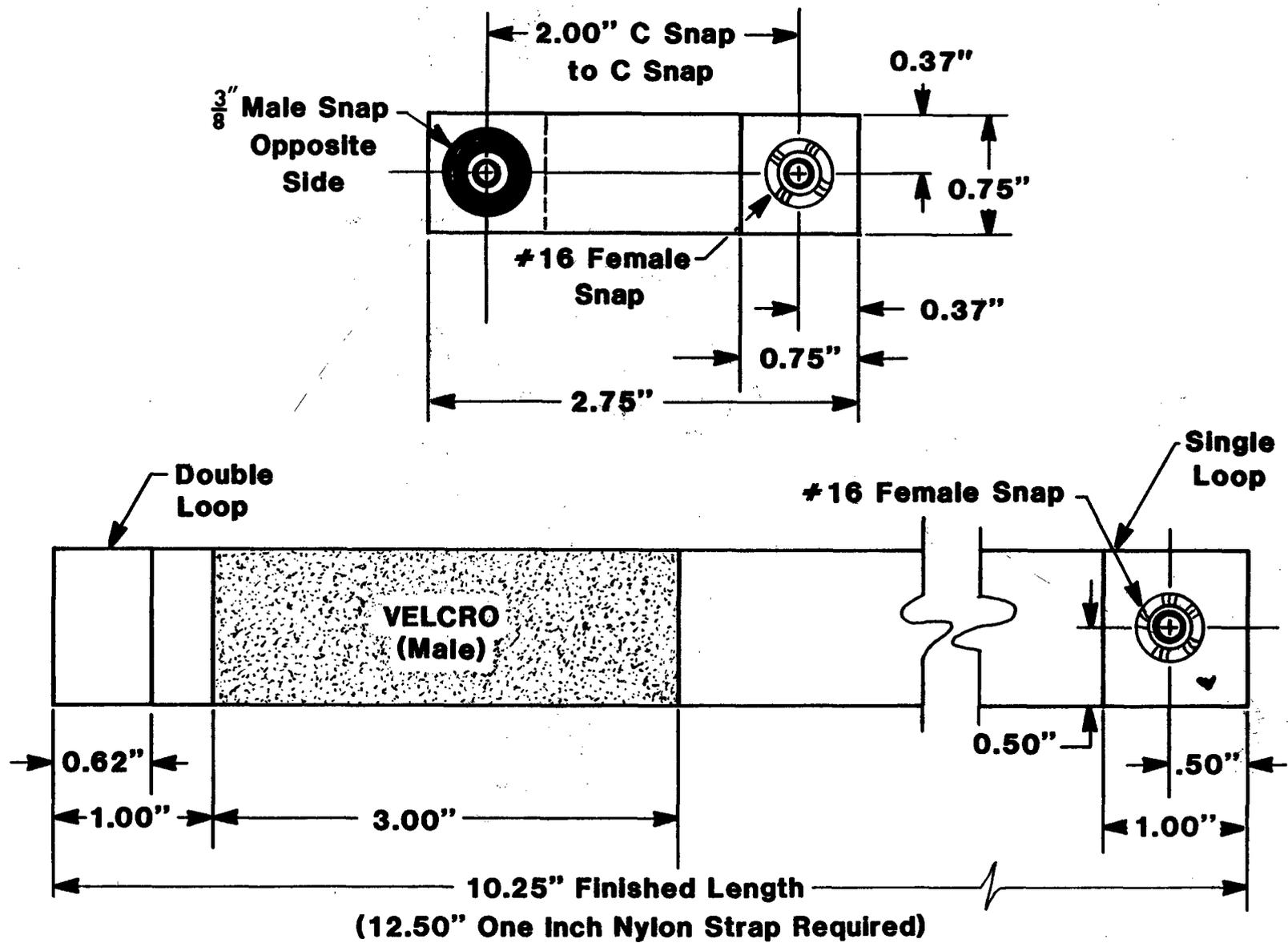


FIGURE C20. Dimensions and components of the side and vertical straps.

APPENDIX D
MODIFIED FACEPLATE (MFP) AN/PVS-5 BRIEFING

MODIFIED FACEPLATE (MFP) AN/PVS-5 BRIEFING

EACH AVIATOR TO HAVE HELMET, GLOVES, AND MODIFIED FACEPLATE GOGGLE

1. Background and History: Originally the AN/PVS-5 night vision goggles (NVG) were designed for ground use by armor, mechanized, and infantry units. The AN/PVS-5 NVG were used as an expedient until a version could be developed specifically for aviation. The Army recognizes that the use of NVGs for night flight compromises certain concepts for standard safe operations. NVG limitations include a reduced visual field (40°), decreased visual resolution (20/50), lack of color discrimination, manual focusing to adjust from far vision to near and back, increased weight on the head and a forward shift of the center of gravity. The midair collision between two OH-58 aircraft at Fort Rucker in December 1981 underscored the limitations of the standard AN/PVS-5 NVG and stimulated positive corrective actions focusing on air traffic procedures and operations, stage field markings, configuration of the standard NVG and its attachment to the helmet, and NVG accessory equipment.

As part of the quick-fix efforts to improve NVG flight safety until the AN/PVS-6 (ANVIS) becomes available, a cutaway faceplate converted from the standard AN/PVS-5 faceplate was developed. After relocating the electrical components, the lower portion of the standard faceplate was cut away, to enable (a) unaided vision for the lateral and lower viewing fields, allowing color discrimination of aircraft and ground lights, map reading, and spectacle wear, (b) reduced weight, (c) less fatigue with improved comfort, and (d) reduced lens fogging. The modified faceplate (MFP) is compatible with the proposed standard counterbalance system, which can provide optimum stability.

The side cutaway portion of the faceplate provides approximately 30° vertical and 20° lateral unaided peripheral vision for each side. The cutouts on the sides are located approximately 45° to the right and left.

The MFP NVG is not a replacement for ANVIS, but an interim measure until ANVIS is available.

2. Inspect helmets for modifications as required including standardized counterbalance system with quick release tabs when available. Standard side-strap helmet snap should be in rearward position if surgical tubing arrangement not present. With standard side straps, the quick release tabs should be connected to the MFP side straps.

3. Switch operation, arctic adapter requirement and location: The rotary switch is located on the top of the faceplate. When viewed from the top, the movement from off to on is clockwise. If the MFP has the AN/PVS-5A switch, the IR position requires the switch to be lifted and turned.

The arctic adapter is required to improve battery changing ability until the double battery pack is available. A male Velcro loop will allow the arctic adapter to be attached to the back of the helmet. Other options are tape or tucking the adapter under the surgical tubing.

4. Mounting and aligning the MFP NVG: The upper lip of the MFP is centered and placed between the visor cover and the helmet shell. With one hand holding the goggle, the vertical straps are attached to the Velcro pads on the visor cover. The side straps are snapped either to the standard side straps on the quick release tab end or the surgical tubing snaps. If the goggle tubes are not centered before the eyes, they can be moved laterally after disconnecting the vertical strap opposite the direction of movement. That is, to move the goggles to the right, disconnect the left vertical strap. When properly aligned, secure the vertical straps and snug the side straps. Minor lateral alignment can be adjusted with the tilt clamp knob by moving one tube closer to the eye.

5. Storing the MFP goggles in flight: By placing a Velcro pad on the top of the helmet and using the surgical tubing for MFP side attachment, the goggle can be placed on the visor cover and secured with one of the vertical straps. A safety cord can be attached if desired, or a NVG cloth bag as used in the AH-1 Cobra is functional.

6. Dismounting the goggle: Remove the side straps first! If the vertical straps are removed first, the goggle will hit you in the face. The quick-disconnect tabs are a must for rapid removal of the goggles. After the side snaps are disconnected, tilt the goggle up and pull forward and up with one motion to complete removal. With a safety cord, you may have to remove the vertical straps individually. To complete the dismount the battery container of the arctic adapter is disconnected from the back of the helmet.

7. Determining if a counterbalance is needed and how much: Before flying with the MFP goggle, adjust your helmet and mount the MFP goggle. Place the microphone against your lips. Tilt your head down about 45° and rotate your head from side to side. If you feel the microphone moving (on your lips) in the opposite direction of head movement, you need a counterweight to stabilize the goggles. Add just enough weight, not to exceed 22 ounces, to prevent movement of the microphone on the lips. Check up and down movement of the head. With excessive weight, rotation of the helmet on the head is exaggerated.

8. Spectacle Wearers: Corrective lenses can be worn with the MFP goggle, but not with the standard goggle. The eye pieces of the goggle could bounce on the spectacle lenses and create an eye hazard, even though the corrective lenses have been hardened. The present recommendation is to order a set of aviator spectacles requesting plastic lenses for flying with NVG. Different lense materials are being investigated to improve the lense strength. If bifocal lenses are used, the segment height should be small to fall outside the eye piece viewing area of the NVG.

9. Adjusting the interpupillary distance of the NVG: The eye pieces of the MFP NVG are usually located further from the eyes than the standard NVG. Therefore, proper optical alignment is more critical and sensitive for optimum visual resolution. Forming a single circle from the images of the two NVG tubes, as previously taught, usually results in the tubes being too close together. Loosen the interpupillary clamp, look at a distant object, and slide the tubes back and forth until the edges of the images are clear. If the outside edges are blurred, the tubes are too close together. If the inside edges are blurred,

the tubes are too far apart. When the edges are clear, the two circles may not appear to perfectly coincide. If the top or bottom edges are blurred, the goggles need to be tilted with the clamp knob.

10. Flight techniques to maximize MFP use:

a. Limitations of unaided dark adaptation with MFP NVG: The intensity of light from the NVG will keep the eyes from fully dark adapting. Therefore, the information obtained from the side and lower unaided visual fields will be less than the fully dark adapted eye.

b. Scanning between the aided and unaided vision: Primary source of detailed information will be obtained through the goggles. Illuminated sources when viewed through the goggles may not be accurately interpreted as to their intensity, distance away, or color. The unaided vision can provide this additional information. Practice and experience with the MFP are needed to obtain maximum information from both aided and unaided vision. Initially, unaided peripheral vision may be distracting until you can utilize this additional information.

c. Illumination considerations: The brighter the ambient light, the more difficulty will be experienced in seeing and detecting dim lights such as chemical sticks with unaided vision. The increase in the goggle gain will produce more of the brown or pink afterimage vision which can slightly alter the apparent color of lights or objects.

d. Map reading: With the MFP goggle standard maps can be read with unaided vision. Using a blue-green filter over the flash light, only slight alterations of the map colors occur without shutting down the goggles. A common filter used is the green position light lens from an OH-58 aircraft.

e. Blue light cockpit illumination: Blue cockpit lighting in aircraft allows the instruments to be viewed with unaided vision without having to focus the goggles, thereby decreasing the time required for instrument monitoring.

11. Check-out procedure for MFP NVG: At the end of the briefing, the aviator will mount and dismount the MFP NVG ten times, and change batteries five times while wearing gloves. Approximately 1.0 hour familiarization flight with a qualified NVG pilot is required to include:

- a. Take off to a hover
- b. Hovering turns
- c. Landing from a hover
- d. Normal take off
- e. Traffic pattern flight
- f. Normal approach
- g. Low-level autorotation
- h. Hovering autorotation
- i. Slopes
- j. Emergency procedure for simulated goggle failure

APPENDIX E
EVALUATION OF MODIFIED FACEPLATE
FOR AN/PVS-5 NIGHT VISION GOGGLE
QUESTIONNAIRE

EVALUATION OF MODIFIED FACE PLATE
FOR AN/PVS-5 NIGHT VISION GOGGLE

QUESTIONNAIRE

Coded Identification _____ MFP Goggle # _____ Date _____

Moon Rise _____ Moon Set _____ % Illumination _____

1. How many hours have you flown with the Modified Face Plate (MFP) NVG? _____

2. What type cockpit illumination used?

cockpit illumination _____ Blue-Green lights _____

3. On the following maneuvers (if flown), rate the modified face plate NVG with the standard NVG (AN/PVS-5) using the following scale:

1- superior to standard NVG

2- slightly better than standard NVG

3- equal or same as standard NVG

4- slightly worse than standard NVG

5- inferior to standard NVG

+ difficult with initial attempt

++ dangerous with initial attempt

EXAMPLE: 3+ running landing - this means "same as standard NVG" after initial adjustment.

Maneuvers: Write in maneuvers if not listed

_____ T/O	_____ mask & unmask	_____ slopes
_____ 3 ft. hover	_____ weapons fire	_____ navigation
_____ normal landing	_____ reading instruments	_____ tuning radios
_____ running landing	_____ 3 ft autorotation	_____ confined areas
_____ low level autorotation	_____ traffic pattern	_____ out of ground effect hover
_____ NOE flight	_____ contour flight	_____ deceleration
_____ mounting to helmet	_____ dismounting from helmet	

4. _____ Overall opinion of this type MFP NVG on this flight. (Mark for each night)

5. How long did it take you to become comfortable with this type modified face plate (MFP) NVG?

_____ minutes _____ couldn't adjust to this type

6. Any mechanical or electrical failures?

If yes, describe.

7. The MFP NVG tubes are usually located higher and farther from the eyes.

Did this cause any perceptual problems or eye discomfort? ____yes ____no.

If yes, please explain.

8. Did you detect any objects with your unaided peripheral vision while

looking through the tubes with the MFP NVG? ____yes ____no

If yes, estimate how often per hour. (____ times/hour) and list a few examples:

9. List the advantages and disadvantages you found with the MFP NVG compared to the standard NVG.

ADVANTAGES

DISADVANTAGES

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

10. What recommendations would you make to improve the design without increasing complexity or cost significantly? Any major modifications will delay field use.

11. Comments, suggestions, etc.

12. The following 4 questions are required only for your initial evaluation of a MFP NVG. On subsequent flights, these questions can be omitted.

- a. Estimate your total hours of rotor wing flight. _____ hours
- b. Estimate your total hours of Night Hawk RW flight. _____ hours
- c. Estimate number of hours of AN/PVS-5 NVG time. _____ hours
- d. What type aircraft are you using for testing the MFP NVG and number of hours in this type aircraft? _____ aircraft _____ hours