A MOVING VEHICLE FIELD EXPERIMENT TO DETERMINE THE EFFECTIVENESS OF CIRCULAR BRACKETING SIGHTS ON THE M16A1 RIFLE

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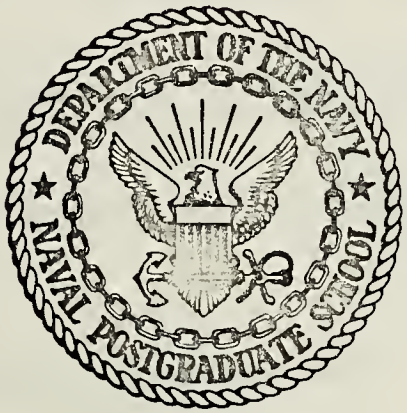

THESIS

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by

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A Moving Vehicle Field Experiment to Determine the Effectiveness of Circular Bracketing Sights on the M16A1 Rifle

by

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Major, United States Army
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Submitted in partial fulfillment of the
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ABSTRACT

A field experiment was conducted to determine whether a circular bracketing sight, framing the front sight on a standard rifle, could enhance the effectiveness of the rifle system in short range, stationary target engagements from a moving vehicle (5-10 mph). Two bracket sights (1.32 and 2.64 inches in diameter) were mounted on M16A1 rifles. "Type E" personnel targets, at ranges of 25 and 50 yards, were exposed individually in random sequence for 4.5 seconds. Ten enlisted subjects each fired 20 (3-round) bursts at the targets using each bracket sight and an unmodified control sight. Results showed that there was no significant difference between sights nor were there any significant interactions. Hit probability per burst was low (20.3%) due to vehicle bounce.

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ACKNOWLEDGEMENT

The author wishes to express his appreciation to Mr. Paul Sparks, Human Engineering Laboratory, Naval Postgraduate School, for assistance in preparing instrumentation; Mr. Kenneth Mothersill, Mechanical Engineering Laboratory, Naval Postgraduate School, for fabrication of the sights; the U. S. Army Combat Developments Command Experimentation Command, and the 6th U. S. Army Marksmanship Training Unit, Fort Ord, California, for generous and outstanding support throughout the experiment.

I. BRIEF

A. PROBLEM

The problem studied was to improve the effectiveness (hit capability) of the infantry rifleman in mounted, short-range, quick-reaction engagements as are expected to occur with the employment of the Mechanized Infantry Combat Vehicle (MICV).

B. PROCEDURE

Ten infantry soldiers (subjects) were trained in firing from a moving vehicle, simulated MICV, using standard sights and two, circular, bracketing sights differing only in size. Each of the bracketing sights was mounted on the front sight post of an M16A1 rifle.

Testing was conducted using a ¼T truck, M151, as the moving vehicle test bed, modified by adding a mock-up of a possible MICV configuration. The firing took place under daylight conditions that varied from overcast with drizzle to bright sunlight.

The range was a flat, open, manmade plateau with all vegetation removed. The nature of the range permitted passes to be made laterally from both left-to-right (L-to-R) and right-to-left (R-to-L). Four silhouette targets were emplaced with two at ranges of 25 yards and two at 50 yards from the firing track. Testing consisted of determining the capability of an individual subject (S) to hit the target while mounted in the simulated MICV and moving laterally across in front of the targets. Targets were exposed in a random manner to prevent the S from anticipating a target's appearance. Traverse speed of the simulated MICV was between 5 and 10 mph with emphasis on maintaining the upper

limit. The target was exposed for 4.5 seconds for a three-round burst engagement on each pass.

Three methods of fire were utilized: standard aimed fire, bracket-aided aiming with a circular sight 1.32 inches in diameter (hereafter called 'small "O"'), and bracket-aided aiming with a circular sight 2.64 inches in diameter (hereafter called 'large "O"'). All firing was done through a firing port while seated in the simulated MICV. Each S fired a total of 60 three-round bursts for record.

The performance of the Ss was analyzed to determine significant differences in hit capability between sight configurations, ranges, movement directions, and bank of targets. In addition, post-test questioning of the Ss was analyzed to determine subject characteristics, trends among characteristics, comments concerning the experiment, and preferences among the three sight configurations.

C. FINDINGS

The small "O" sight obtained the highest hit percentage of 24.5%, followed by the standard and large "O" sights with 22% and 14.5%, respectively. Over ranges, a 33.7% hit percentage was obtained at 25 yards but dropped significantly to 7% at 50 yards for an overall hit percentage of 20.3%. Thus the small "O" showed an 11% increase in hits over the standard sights while the large "O" showed a degradation of 34%.

The Ss confirmed these results with their preferences since they also preferred the small "O" slightly more than the standard sights and found the large "O" to be a hindrance rather than an aid.

Reasons for the low hit percentages are centered around the simulated MICV. First, the suspension of a $\frac{1}{4}$T truck does not provide

the more stable platform that is found in an appreciably heavier vehicle, thus the firer suffered a greater jolting (bouncing) effect. Second, due to the weather conditions, the firing track deteriorated as firing proceeded making any manner of fire extremely difficult. Again, a heavier vehicle with more surface contact, such as a MICV, would have dampened this effect. Last, the firing port was emplaced as if a vision block was positioned above it. This resulted in the firing port, and in this case the observation system, being low and though firing was as it would be in a firing port/observation device system, the observation or target acquisition also called for the cramped firing position. The three factors cited above resulted in a lower hit percentage than pretesting had indicated.

D. UTILIZATION OF FINDINGS

The findings indicate that standard, aimed-fire techniques, with slight modification to permit target acquisition, appear to be adequate for use from a moving vehicle in short-range situations. However, it is essential that the firing platform be as stable, under all conditions, as possible since the ability to bring aimed fire to bear is highly dependent on stability. The firer can dampen some sway and bounce by the manner in which he supports the weapon; however, he cannot compensate for heavy jolts.

II. BACKGROUND

A. CONCEPT DEVELOPMENT

The necessity of engaging fleeting targets with highly accurate fires from moving vehicles has been brought home forcefully as a result of experiences in the Republic of Viet Nam. This need has resulted in the development, as a temporary measure, of the M113 modification called the Armored Cavalry Assault Vehicle (ACAV). A more long-term solution is the development of the MICV concept that fits into current combat doctrine of the U. S. Army's mechanized infantry.

From 22 June to 10 July 1970, the Small Arms Advisory Committee Summer Conference sponsored by the Advanced Research Projects Agency, Office of the Secretary of Defense, was held at Stanford Research Institute. A purpose of the conference was to identify areas that required development or improvement in small arms systems. One such area so identified was the requirement for a short-range, rapid-reaction, battle sight. This resulted in the development of a large aperture, front sight with a rear post. It was thought that this sight configuration could be adapted to the MICV concept resulting in a relatively simple, yet effective, system.

B. PREVIOUS RESEARCH

Kemple and McKinney [1] proposed a combat battle sight which employed the unmodified rear sight of the M16A1 rifle as a post and a circular bracketing sight framing the normal front sight of the rifle. After fabricating bracketing sights with apertures of 1.32 and 2.64 in. diameters and mounting them on M16A1 rifles, test firing was conducted

against stationary targets exposed for 1.6 seconds at ranges of 25 and 50 yards. The small circular sight resulted in a 23% increase in hits (51.5% single-shot hit probability) over the standard quick-fire (42% single-shot hit probability) and the large circular sight (41.5% single-shot hit probability).

This testing was followed by tests conducted by Fisher and McLeskey [2]. This second series of tests had infantry soldiers engage moving targets at ranges of 25 and 50 yards. The target moved laterally in front of the Ss at 6 mph and was exposed for a period of 2.5 seconds. The use of the small and large circular sights resulted in 149% (63.3% single-shot hit probability) and 159% (65.8% single-shot hit probability) increases in hits, respectively, over the standard quick-fire techniques (25.4% single-shot hit probability).

C. CURRENT RESEARCH EFFORT

Although operations in the Republic of Viet Nam have shown a need for the ability to engage targets from a moving vehicle, and current U. S. Army combined-arms doctrine calls for mounted operations insofar as possible, no Army program now exists in either basic or advanced marksmanship programs for this sort of training. Additionally, the quick-fire training programs are being eliminated, while at the same time, development of the MICV is being accelerated. The research mentioned in the previous paragraphs suggested that use of the proposed battle sight in a moving vehicle might prove to be fruitful. The ability of the rifleman to take and hold a reasonable sight picture from a moving vehicle, utilizing standard sights and sighting techniques, was considered highly questionable. At the same time; however, it appeared the circular bracketing sight would enable the

rifleman to lay and remain on target by providing an area of aim rather than a point of aim, and thus would be less sensitive to vehicular movement effects. As a result, the current research was undertaken to examine the utility of this concept.

III. PROCEDURE

A. GENERAL

1. Weapons, Sights, and Ammunition

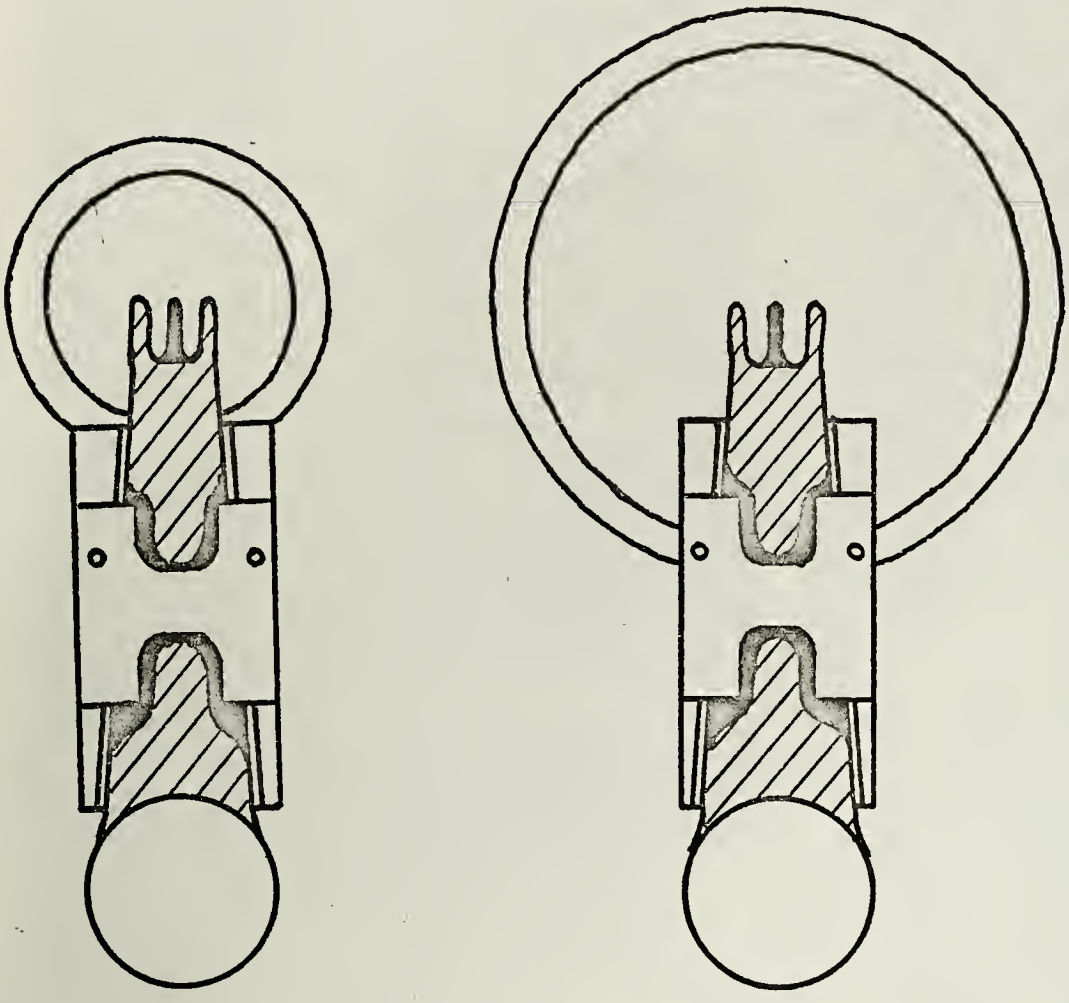
The weapons used were six standard-issue M16A1 rifles. Two rifles each were modified with both the small "0" (1.32 in.) and large "0" (2.64 in.) sight configurations and the remaining two rifles left unmodified (standard sights). Figure 1 depicts the circular bracketing sights and Figures 2, 3, and 4 show them as they appeared when in use. The sizes for the bracketing sights were based on the bracketing of the breadth of three and six average men at 25 yards for the small "0" and large "0" bracketing sights respectively. The duplicity of sight configurations was to allow for rapid changeover of weapons in case of a malfunction. All weapons were found to be in average issue condition.

The ammunition used was 5.56 mm ball and required 864 rounds for the familiarization firing of 12 subjects and 1800 rounds for the record firing of 10 subjects.

2. Simulated MICV

A MICV was simulated by using an M151, $\frac{1}{4}$T truck, and adding plywood mock-ups of a seat and sidewalls in place of the organic rear seat and top. The configuration used was that found in Kehoe [6], less the observation device, and complied as closely as possible with the speed ranges and other requirements stated in the Materiel Need [5] and HEL Report [13].

The overall height of the sidewalls was 48 inches which is 1.5 inches lower than the interior height of the current M113 Armored Personnel Carrier (APC) and 1 inch lower than that of the proposed MICV.



SMALL "0" SIGHT
1.32 in. diameter

LARGE "0" SIGHT
2.64 in. diameter

Figure 1. Experimental Bracketing Sights.

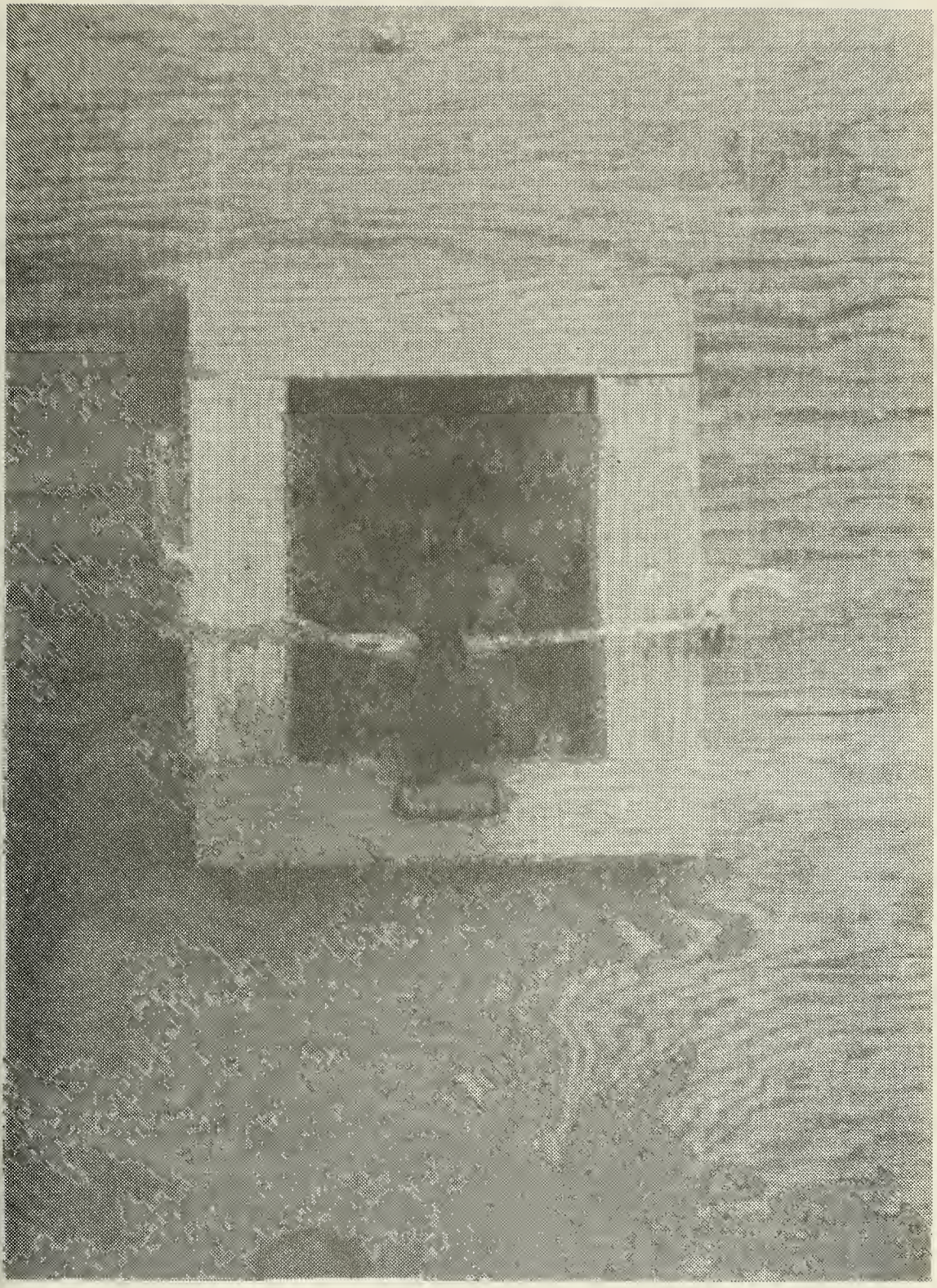


Figure 2. Standard Sight.

Figure 3. Small "0" Bracketing Sight.

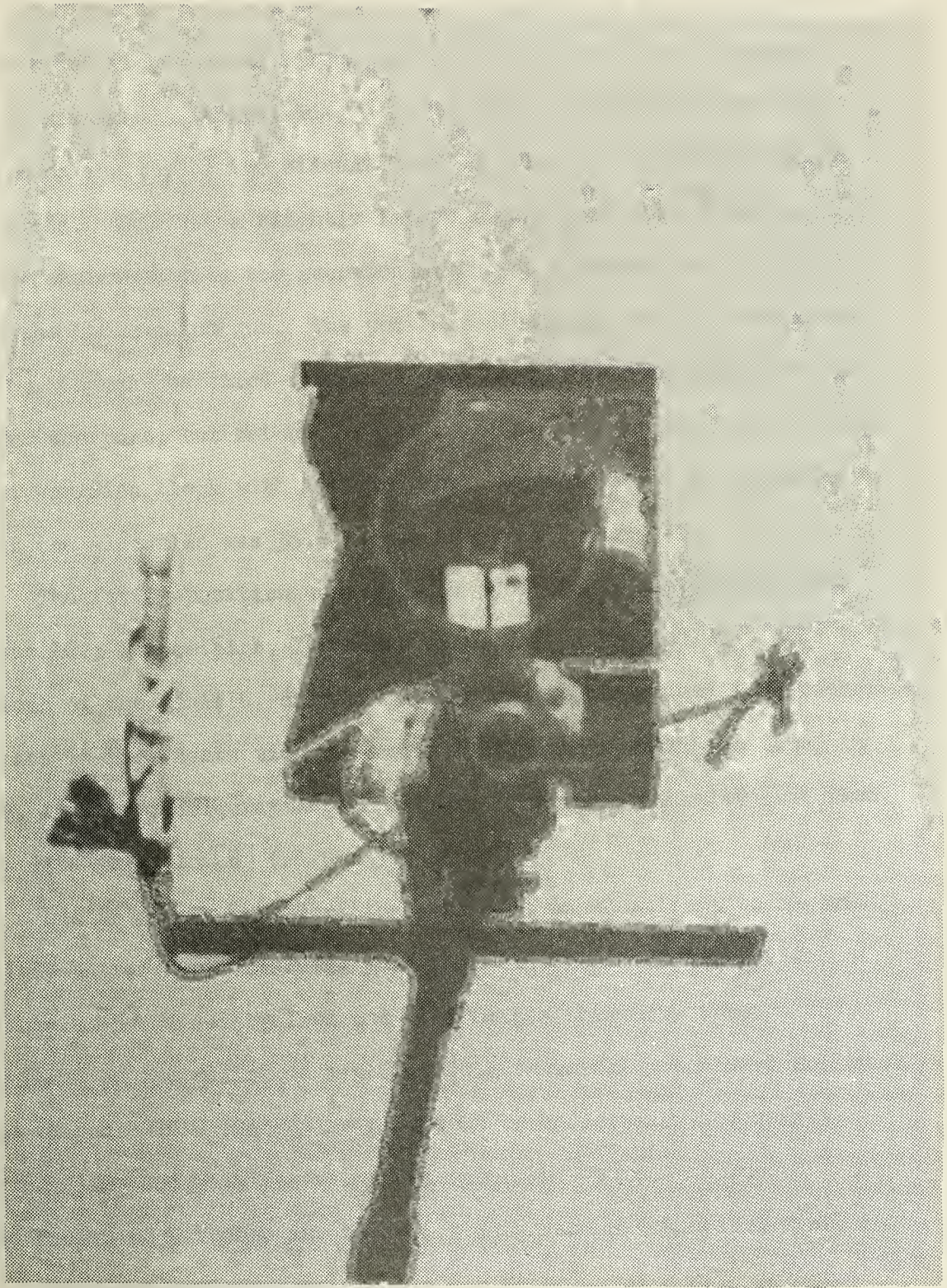


Figure 4. Large "0" Bracketing Sight.

The firing port was centered in the sidewalls to provide for both left and right handed firers and for both directions of movement. The port measured 5 inches wide, 6 inches high and was centered 14.5 inches from the top of the sidewall and 33.5 inches from the floor of the vehicle. This was a slightly larger firing port than found in [6], but was consistent with the recommendation for a larger port to accommodate the M60 machine gun. The port's positioning was also consistent with [6], though the cited reference gave no specific distance from the roof for the port, but rather a distance of 8.5 inches down to the center line of a vision block with a firing port beneath that. The distance between the sidewalls was 55.5 inches (Figures 5 thru 8).

The firing position was provided by a single centerboard seat that was 12.5 inches high, 14 inches wide, and 36 inches long. Due to the width of the vehicle, only the single seat could be utilized rather than back-to-back seats with backrests that would normally be found in an APC, in this configuration, or a MICV. The seat generally conformed to the data given in [6] (Figure 9).

Due to safety considerations, as well as an attempt to restrict the rifle barrel from extending more than 2-5 inches from the sides of the vehicle [5], a safety line was tied across the port, through the front sight of the rifle, to restrict both forward and backward motion of the weapon. This precaution proved to be unnecessary for safety; however, since the retainer was nylon rope, the weapon protrusion varied from 6 to 9 inches due to rope stretch and slackness of ties.

An additional feature, purely for safety, was a mesh screen immediately behind the driver to protect him from the hot, ejected brass.

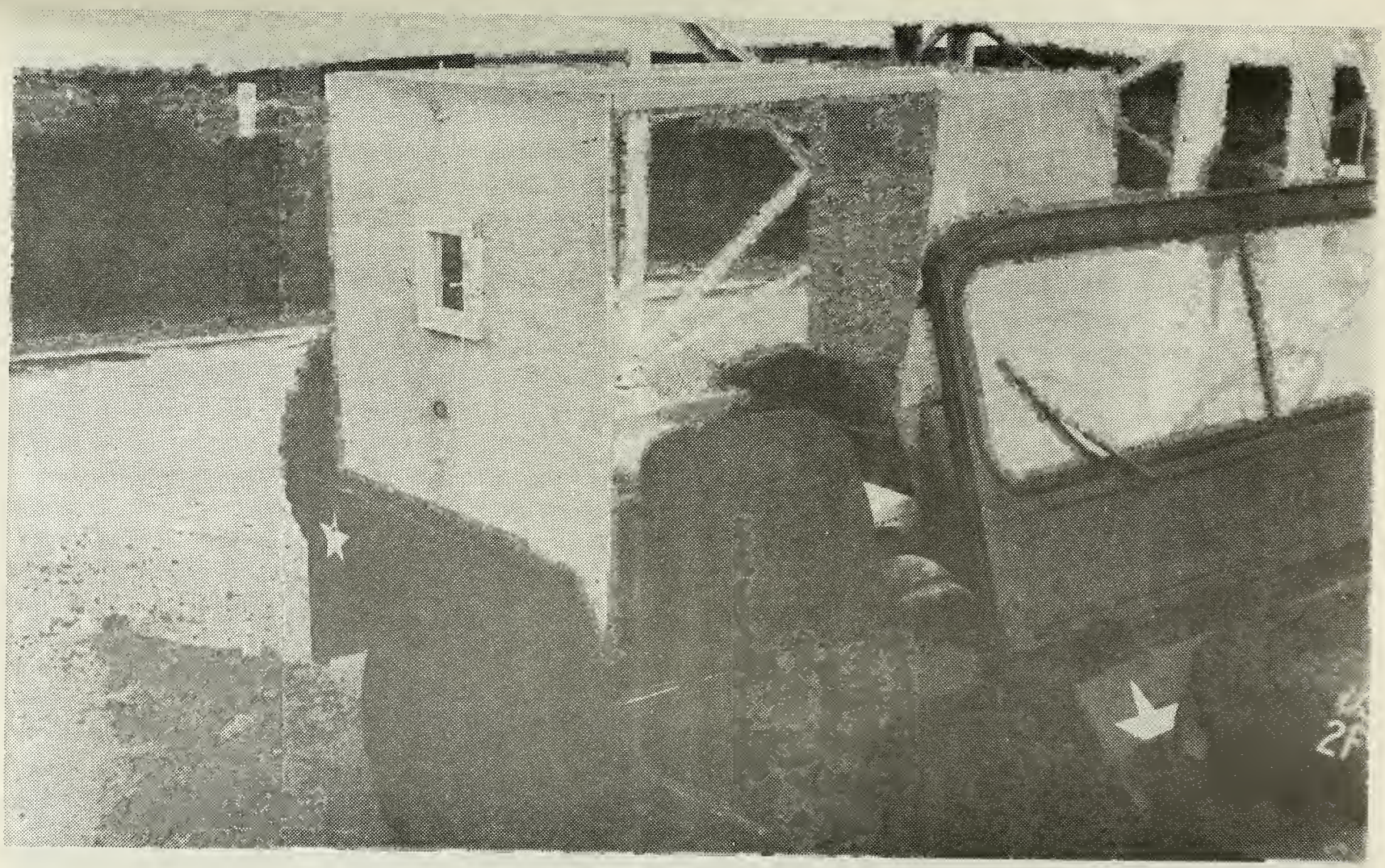


Figure 5. View of MICV Mock-up from Right Front.

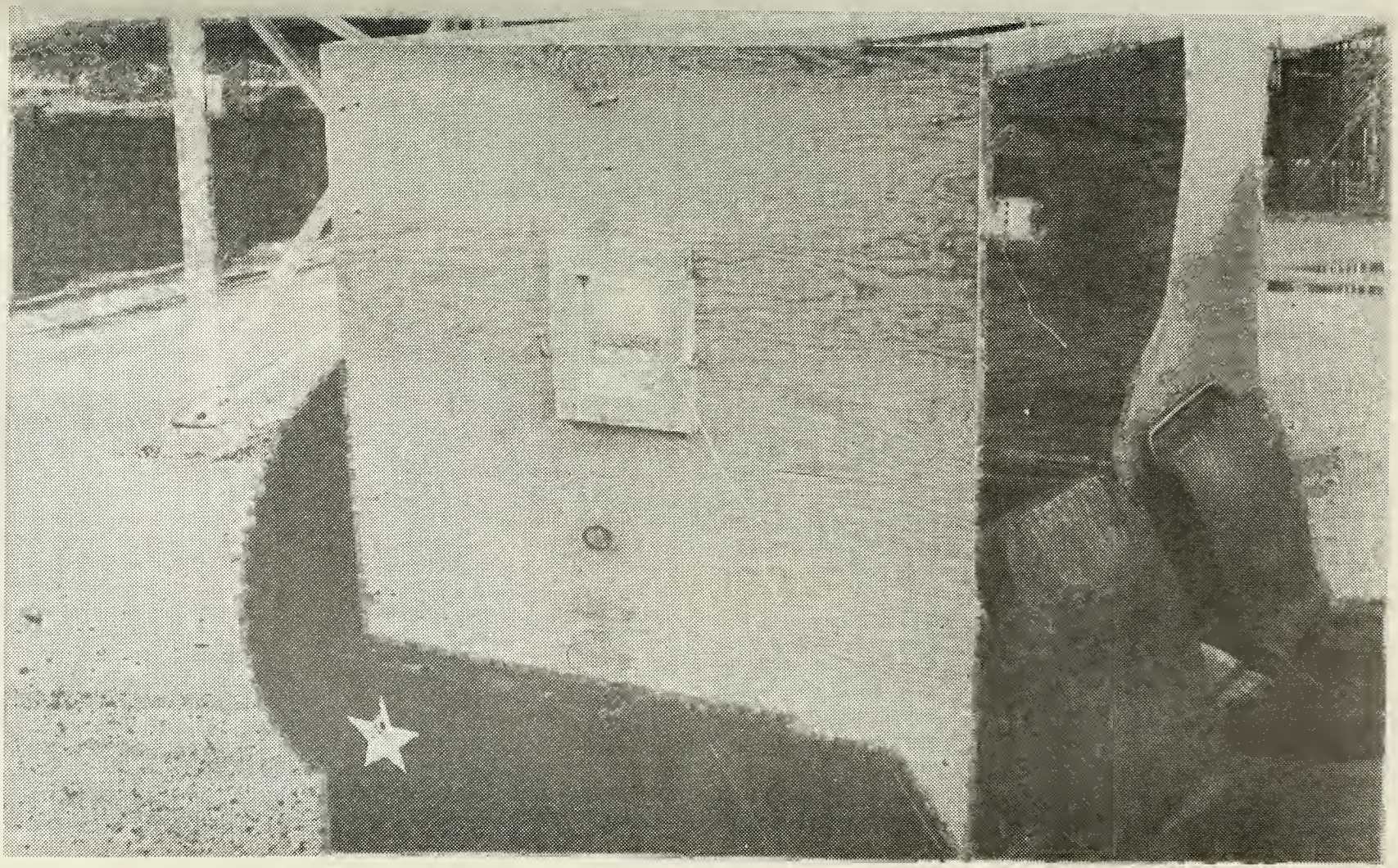


Figure 6. View of MICV Mock-up from Right Side.

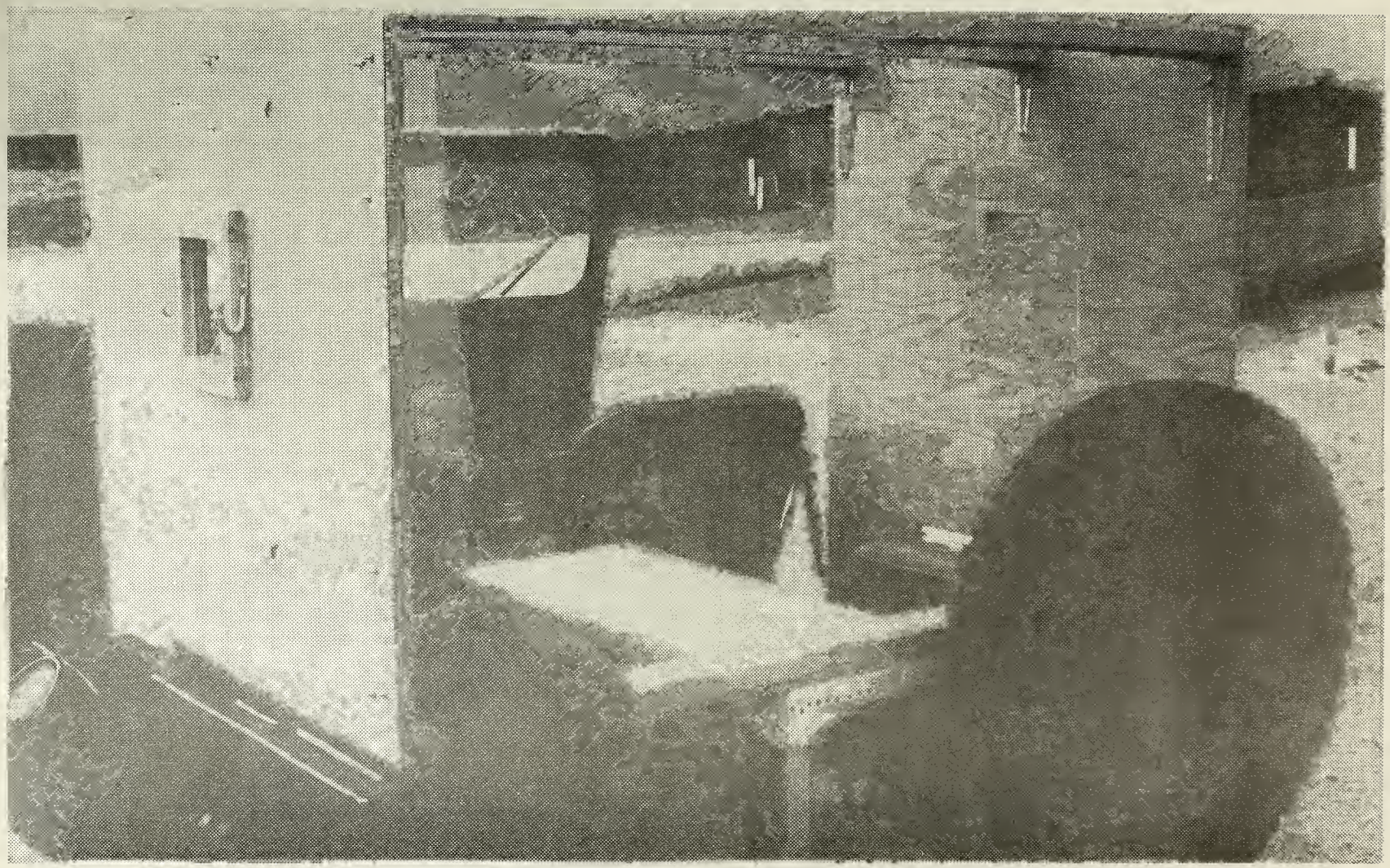


Figure 7. View of MICV Mock-up from Rear.

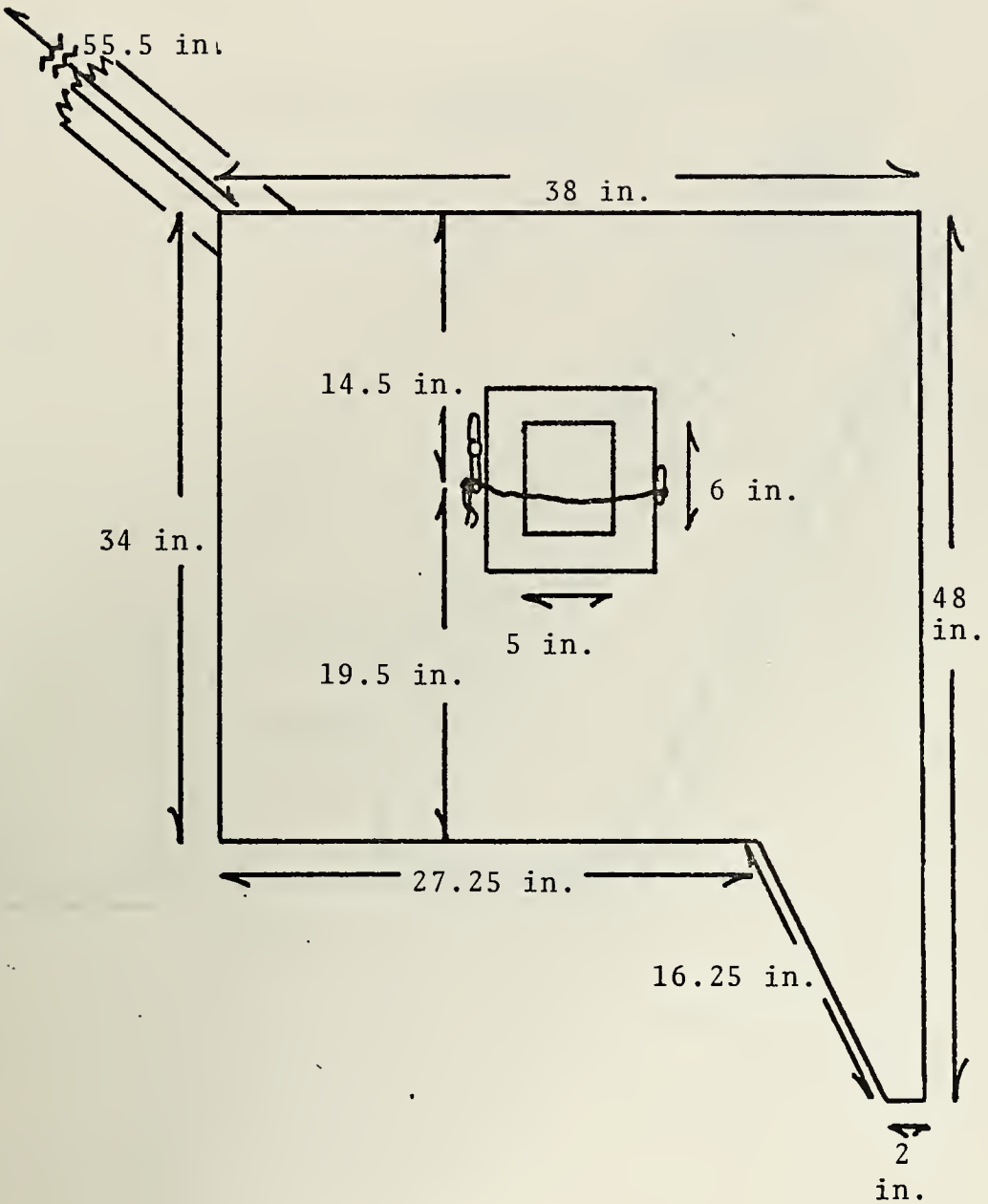


Figure 8. Sidewall to Simulated MICV.

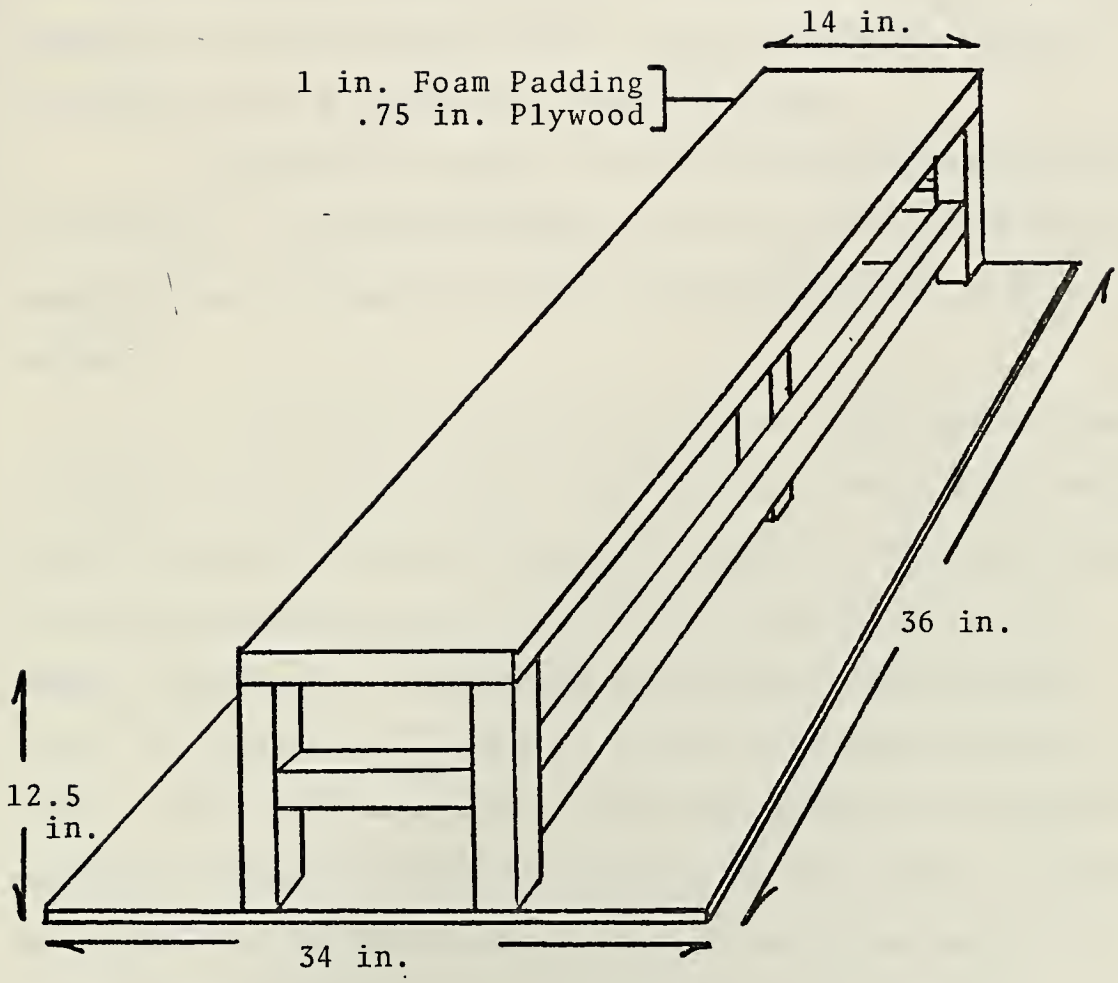


Figure 9. Bench Seat for Simulated MICV.

3. Range

a. General

The range utilized was located at Fort Ord, California, and required modification prior to use. The modifications consisted of establishing a new firing line (track), rewiring existing target pits, and adding two new pits with their essential wiring.

The range was a flat, open, manmade plateau that was free of vegetation. The range was backed by low hills covered with scrub brush that made the targets located at 50 yards difficult, at times, to acquire.

The range had an approximate width of 150 yards thus placing a limitation on the firing track length and speeds that could be safely used. The range was emplaced as shown in Figure 10. Two targets were placed in pre-existing pits 50 yards from the firing track and two targets were placed in newly created pits 25 yards from the firing track. The targets were numbered in a clockwise manner, therefore number 1 was the left-hand target at 25 yards, number 2 was the left-hand target at 50 yards, number 3 was the right-hand target at 50 yards, and number 4 was the right-hand target at 25 yards. The targets were further broken into banks, for analysis reasons, with targets 1 and 2 constituting one bank and targets 3 and 4 the second bank.

The controller/scorer was centrally positioned approximately 15 yards behind the vehicle firing track.

b. Targets

The targets were standard, "E" type, polyethelene, silhouette targets mounted on M31A1 target-holding mechanisms. The amount of target exposed varied with the range due to the use of the

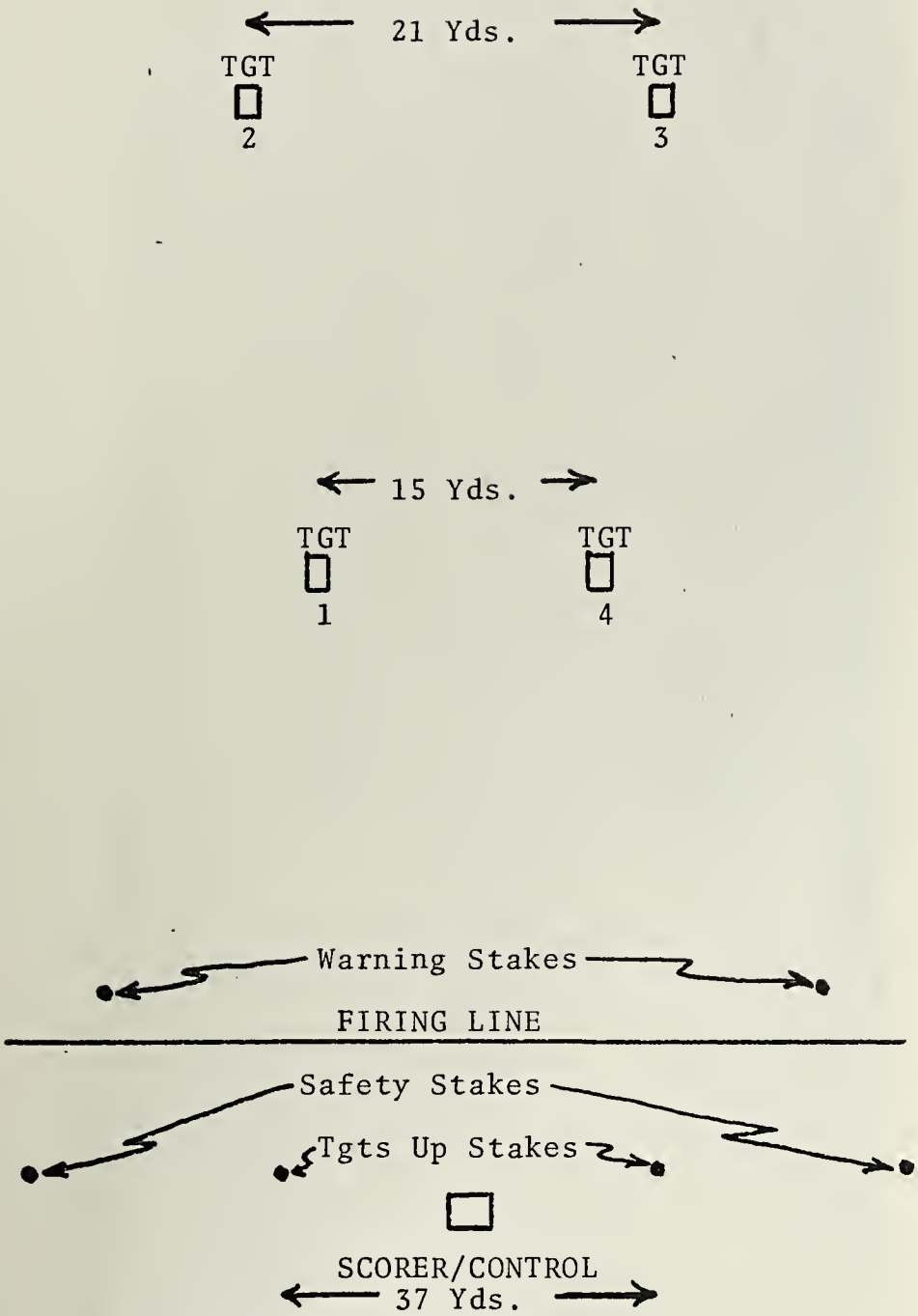


Figure 10. Range Layout (Not to Scale).

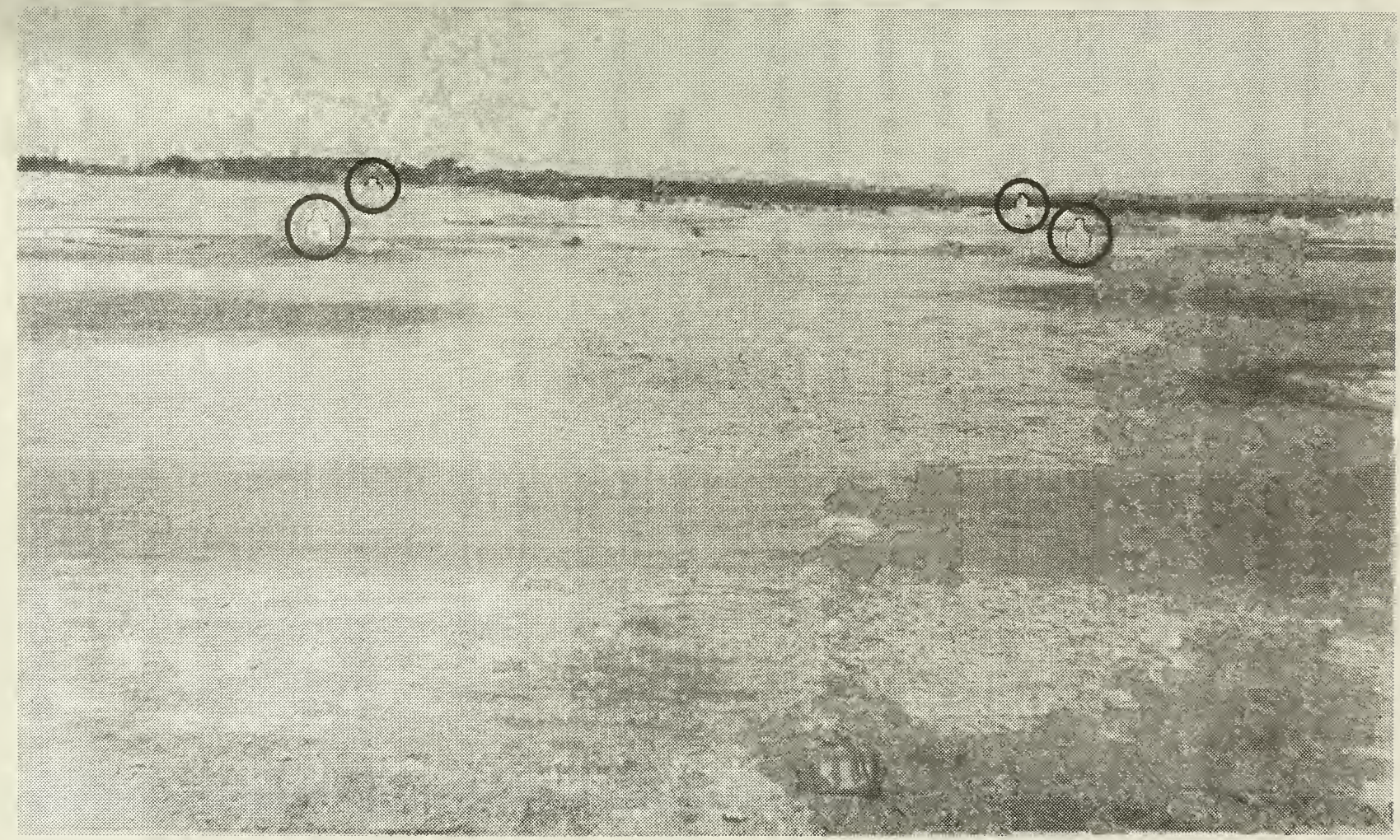


Figure 11. View from Control Position, All Targets Up.

pre-existing target pits at the 50 yard range. All targets were 19.5 inches wide. At 25 yards, however, 26.5 inches in target height was exposed versus only 17.5 inches at 50 yards. Additionally, the targets used at 50 yards had to be modified by cutting the top four inches of the silhouette heads off to fit them into the pits. Thus, targets at 25 yards showed approximately 410 sq. inches of surface area and those at 50 yards, 270 sq. inches.

A Lafayette (Model 5004B) interval timer was used to raise the targets and control their exposure times. A control console, fabricated at the Naval Postgraduate School, was used to select the target for exposure and indicate hits. A hit was indicated by the illumination of two 6v incandescent bulbs placed in parallel, thus if one burned out a back-up was operating. Figure 13 is a schematic diagram of the control system.

The target hit and control mechanism's signals were carried on a four-wire cable, formed from WD-1 telephone wire. One cable was run to each target mechanism. The power for operating the target mechanisms and the timer was 110v A. C. that was carried, from the integral range wiring, by number 10 and number 12 copper wire (Figure 14).

c. Vehicular Movement

The simulated MICV was driven along a marked track approximately 150 yards in length. The firing track was the central 37 yards and was perpendicular to the range center line. Vehicle speed was maintained in a range of 5-10 mph during firing runs for three basic reasons. The first was to make the moving vehicle firing speed compatible with the speed used by Fisher and McLeskey [2] for their moving targets, which was 6 mph. A second reason was the range of 5-10 mph was a common subset of speeds required by the Materiel Need [5] and those used by

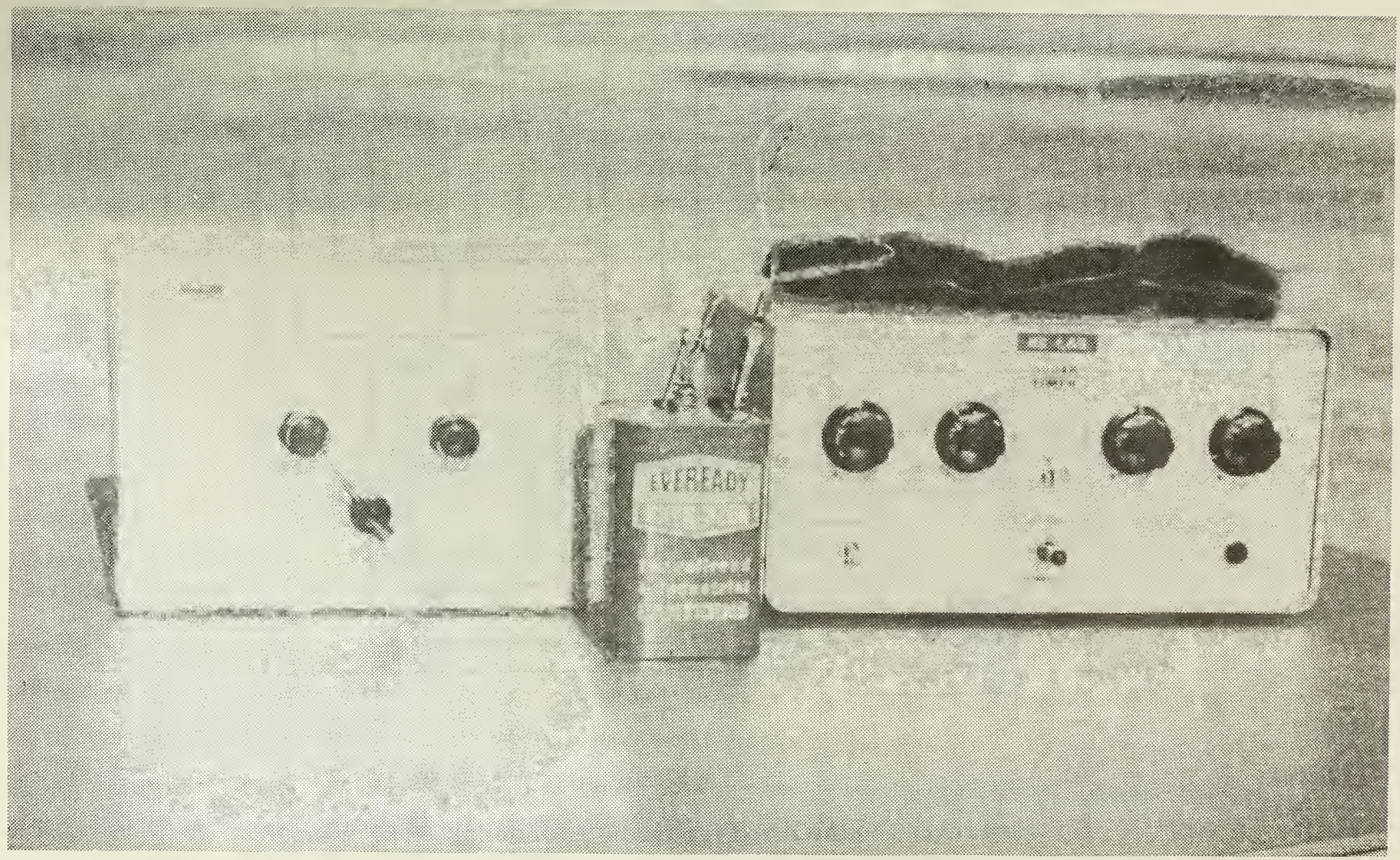


Figure 12. Scoring and Control Instrumentation.

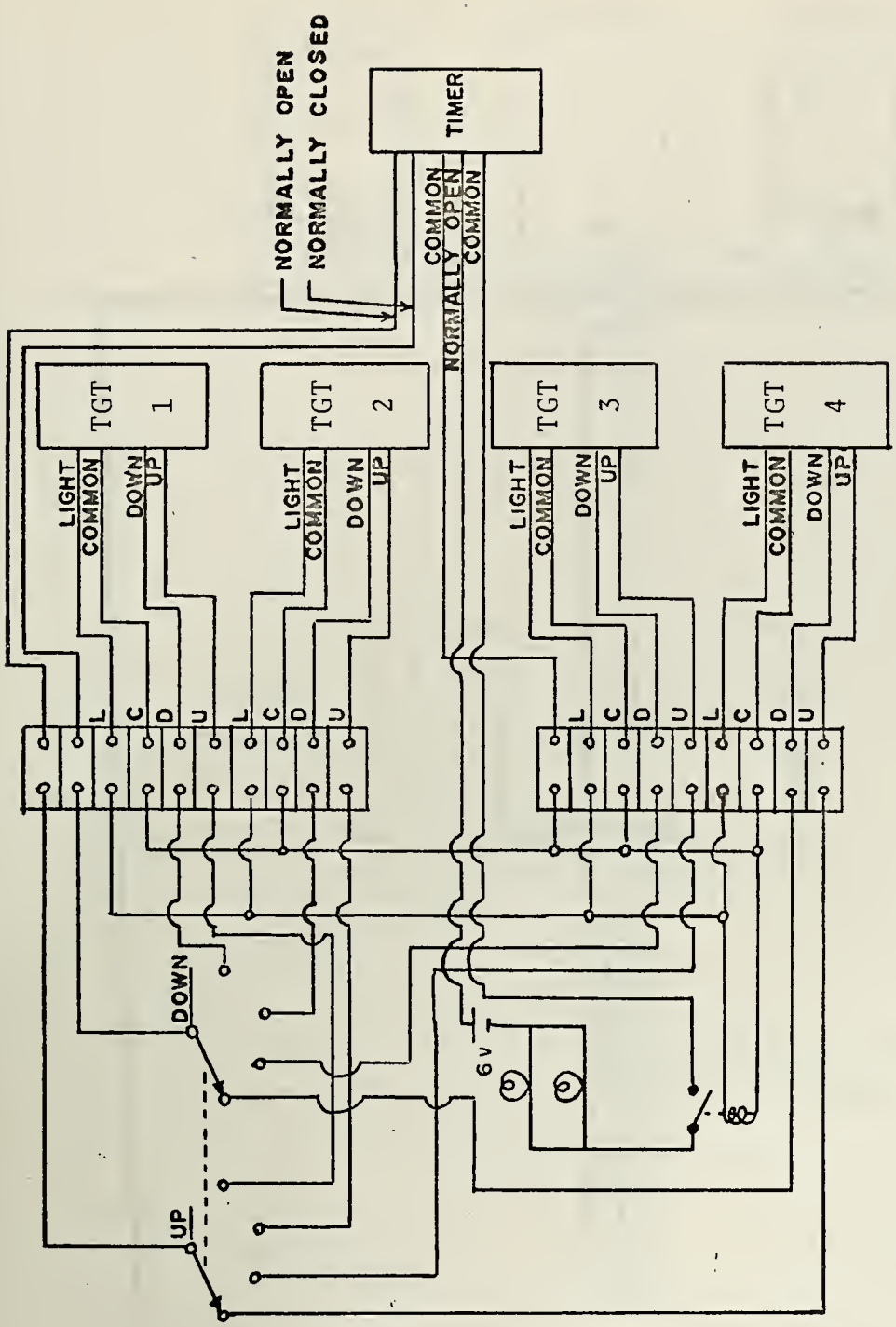


Figure 13. Schematic Diagram for Control System.

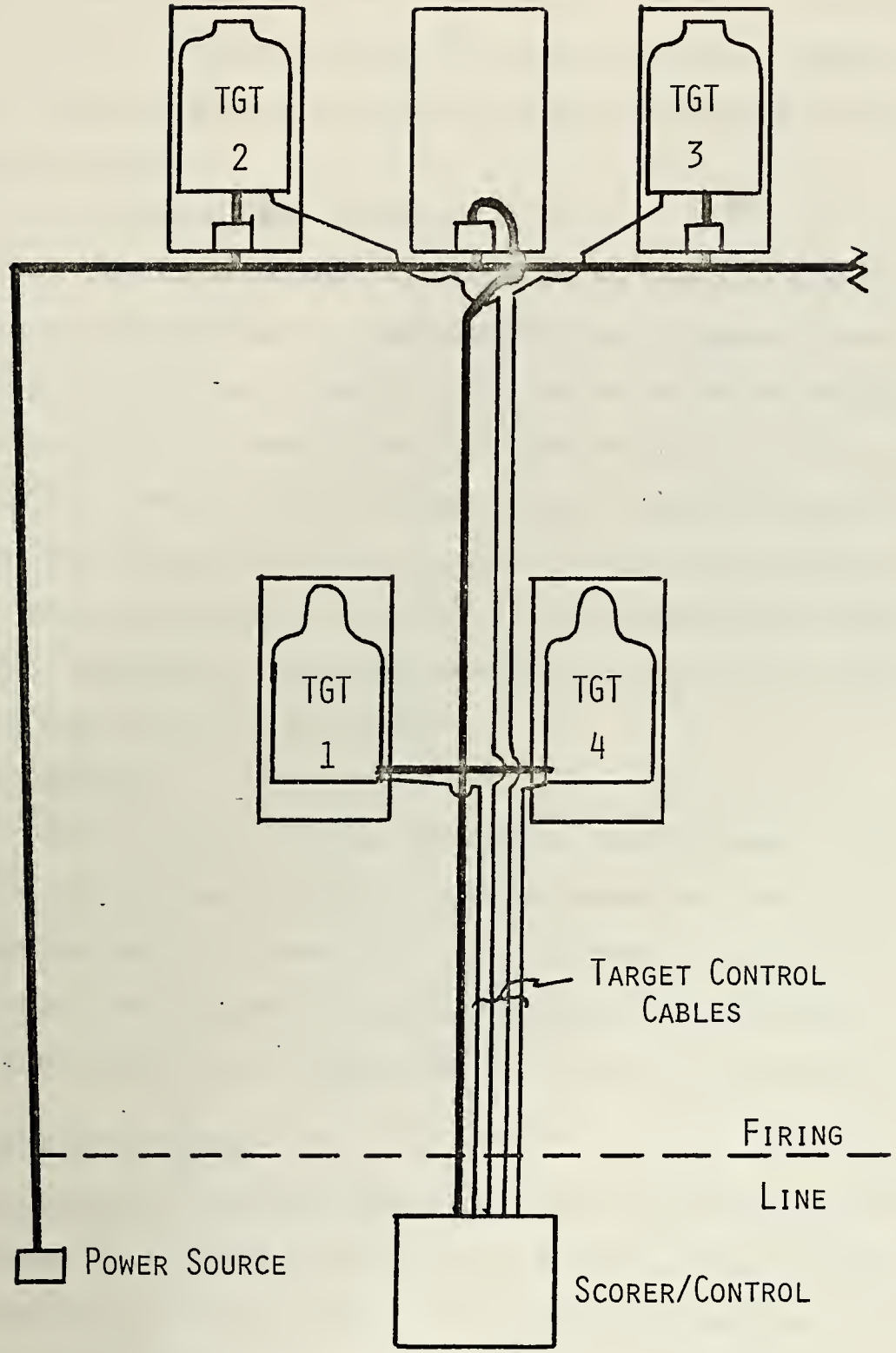


Figure 14. Wiring Diagram of Range (Not to Scale).

Kehoe [6] and Williams [10]. The final reason was safety. In the limited area available, a higher speed for firing runs would have necessitated faster starts and stops thus interfering unduly, and unsafely, with the firer's stability.

d. Additional Instrumentation

Due to the weather conditions, and the resultant deterioration of the firing track, it was decided to get a graphical representation of the various jolts and rocking motions the Ss were subjected to during their firing runs (Figure 15). Power was fed from one of the vehicle's 12v batteries into a Heathkit Invertor (Model MP-14) which stepped the voltage up to 110v. Recording of the jolts was done by a Gould, Brush 220 Recorder on a setting of 25 mm-per-second graph speed and 50 mv sensitivity. The sensors used were CEC, Type 4-102A vibration sensors taken from U. S. Navy aircraft.

4. Subjects

The Ss were 10 U. S. Army enlisted men from "F" Company, 41st Infantry, Experimentation Brigade, U. S. Army Combat Developments Command Experimentation Command, Fort Ord, California. Each S had an infantry Military Occupational Specialty (MOS) and 8 of the 10 were quick-fire trained, 8 were right handed and 4 were Viet Nam veterans.

B. EXPERIMENTAL DESIGN

The independent variables were three sight configurations, two ranges to targets, and two directions of vehicular movement, making a 3x2x2 factorial design. Each S underwent all conditions, firing five, 3-round bursts at each sight, range, and direction of movement combination. Since the order in which the conditions were encountered was randomized (see paragraph III-C-1), the final design was a 3x2x2 randomized block design

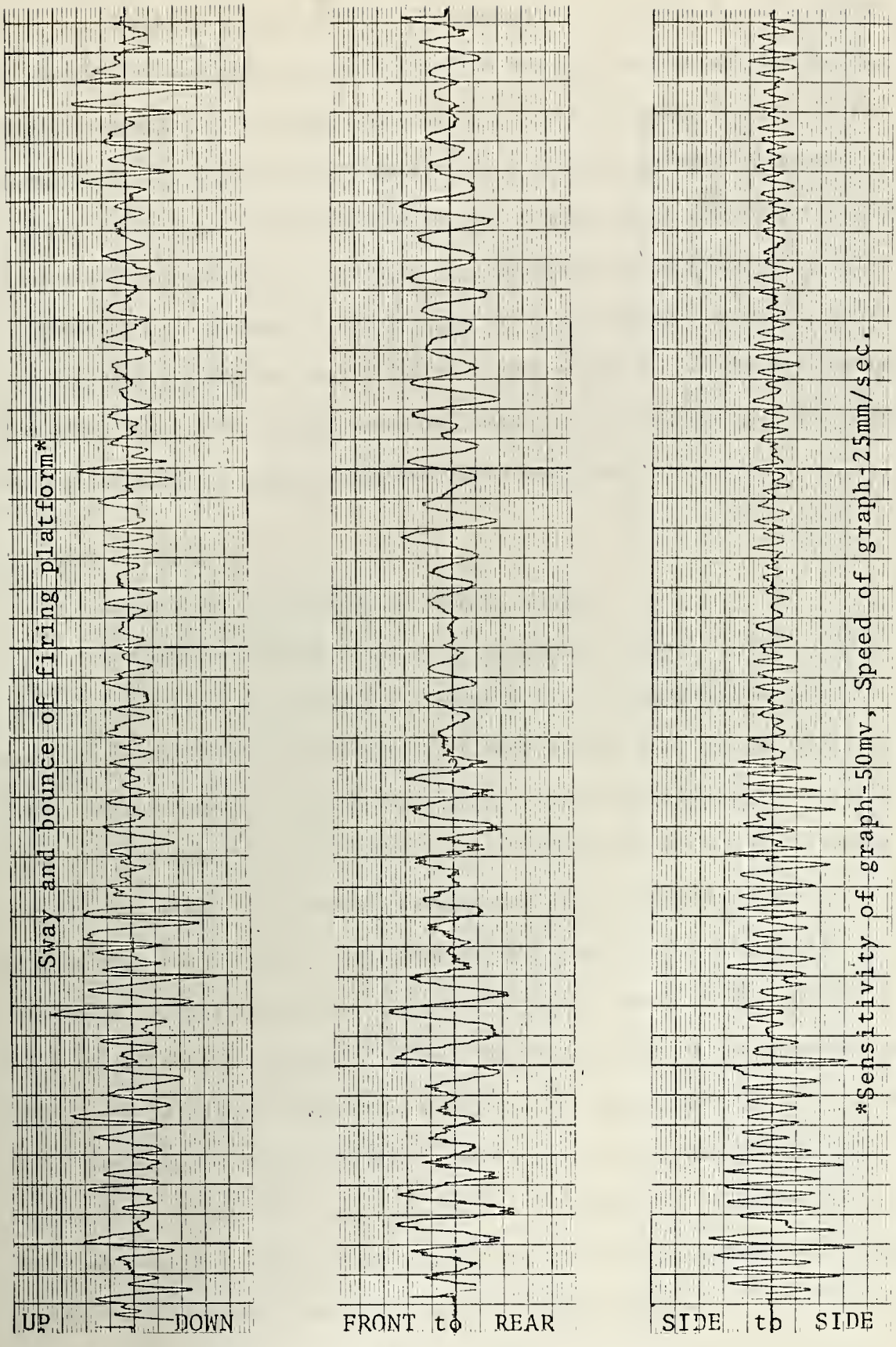


Figure 15. Graphic Representation of Jolts.

with the Ss being the 10 blocks. The dependent variable was the number of targets hit by each S out of the five bursts fired at any one sight, range, direction of movement combination. An additional variable was added after the data had been collected, and that was bank of targets. In this variable a bank consisted of the targets at 25 and 50 yards that were first encountered (near bank) or last encountered (far bank) based on direction of movement. The lateral movement across the range, rather than angular approaches to the targets, was chosen to enable data comparison with the moving target tests of Fisher and McLeskey [2]. The ranges were also based on prior tests to allow comparison.

C. TEST PROCEDURE

1. Assignment of Subjects to Firing Orders

Originally, all Ss were to be randomly assigned to each sight, range, and direction of movement configuration. Under such a design, each firer would have been unaware of when he would be called upon to fire. This, however, proved impractical due to the limited time available and the possibility of the loss of some or all of the Ss to other commitments after only partial firing had been completed. Thus to insure that all Ss fired five, three-round bursts under all conditions, the 12 Ss initially assigned to the experiment were randomly divided into three, four-man groups. It had been determined that groups of this size could be fired through all conditions in approximately three hours. Thus, every three hours complete data would be available on four Ss rather than partial data on 1 to 12 Ss. An additional modification was required when two subjects were lost, due to other requirements, necessitating restructuring group three into a two-man group.

The firing orders as finally used are found in Tab 1, Appendix C. A firing order was defined as two randomly assigned Ss, from the four-man group being tested, assigned to the firing vehicle for a particular random sight, range, and direction of movement combination. The order in which the targets were presented is found in Tab 2, Appendix C. These target presentation sets presented the targets in a random order within the constraint of presenting each target an equal number of times.

2. Data Collection

The data was collected from the control box indicator and recorded using a prepared data sheet (Tab 3, Appendix C). A hit was scored if the S fired and the hit light came on at the control panel; otherwise, a miss was scored.

3. Post-Test Questionnaire

A post-test questionnaire (Appendix A) was administered to all Ss to obtain their sight preferences, impressions of the experiment, and biographical data.

4. Conduct of the Experiment

a. Environmental Conditions

The firing was done under relatively adverse weather conditions (Table I). Light conditions varied from bright sunlight to heavy overcast, with intermittent rain varying from light drizzle to moderately heavy. Temperatures throughout the day remained in the low to mid-thirties with intermittent winds up to 14 knots. The weather did not appear to be a significant factor for the firers, other than occasional difficulty in acquiring the 50 yard targets under reduced light conditions. The weather did result in a severe degradation of the firing track. This resulted in an increased bouncing of the vehicle with its resultant degradation in aiming.

TABLE I. WEATHER CONDITIONS

ORDER	WEATHER	TRACK
1-3	Bright sunlight	Fair
4-12	Light to heavy overcast Intermittent rain	Deteriorating
13-14	Bright sunlight	Poor
15-16	Light overcast	Poor
17-20	Moderate overcast	Poor
21-22	Moderate overcast Light drizzle	Poor
23-24	Bright sunlight	Poor (Tried to repair)
25	Moderate overcast	Poor
26-30	Bright sunlight	Poor

b. Orientation

Upon arrival at the range the Ss were given an orientation briefing (Appendix B, Orientation Briefing). The purpose of the experiment, a review of previous work (without mention of results), range configuration and safety, and techniques of fire were all explained, followed by a brief demonstration.

c. Training

Prior to testing, the Ss were given instruction on the techniques of fire to be used from a moving vehicle. Instruction covered both the use of standard sights and the circular bracketing sights. This was followed by a static demonstration of firing positions and techniques utilizing the mock-up vehicle.

After this initial instruction, the subjects were moved to the firing track and the range operation demonstrated. A demonstration series of firing passes, one per target, was made by the instructors to conclude the formal instruction.

The primary points of the instruction were to: (1) Keep the line of vision clear of all sight systems until the target was acquired, (2) in aiming, lead the approached side of the target by 4 to 6 inches depending on range, (3) aimed fire should be utilized, not quick-fire, when using standard sights and, (4) when using the circular bracketing sights, the firer should center his point of aim in the center of the sight using only one eye.

Following the firing demonstration, each S made four familiarization passes from each direction, with each sight configuration for a total of 24 firing passes. The runs were made at the speed of 5-10 mph, targets exposed for 4.5 seconds and three-round bursts

were fired as would be the case in record firing. Exploratory experimentation had shown this was a sufficient amount of familiarization to dampen out learning effects.

d. Record Firing

Record firing began the morning of the second day. To minimize the experimentation time, two Ss were placed in the simulated MICV, with one designated to fire on L-to-R passes, and the other, on R-to-L passes. Ss engaged one target per pass with a three-round burst. Targets were presented in a random order and remained exposed for 4.5 seconds. The time interval of 4.5 seconds was selected since exploratory experimentation had indicated that target acquisition would no longer be a factor and that a hit probability of approximately .3 would result.

When it came time for Ss to fire, their number, sight configuration, and position in the MICV were announced. Thus, two Ss moved forward and mounted the vehicle. Simultaneously, a loader moved forward, with 20 magazines loaded with three rounds each, and the range OIC and safety NCO mounted the correctly configured M16A1 rifles in the appropriate ports. The vehicle was then positioned, to commence the firing runs, on the left side of the range. The safety NCO, riding in the vehicle, gave the command to load and lock the weapon. When the S was ready, the command was given to unlock the weapon and the driver commenced the run. After firing, the magazine was removed from the weapon, the bolt left back, and the safety put on. At this time, the safety NCO cleared the weapon and the driver turned the vehicle around to make a pass from the right side of the range to the left side with the second S firing.

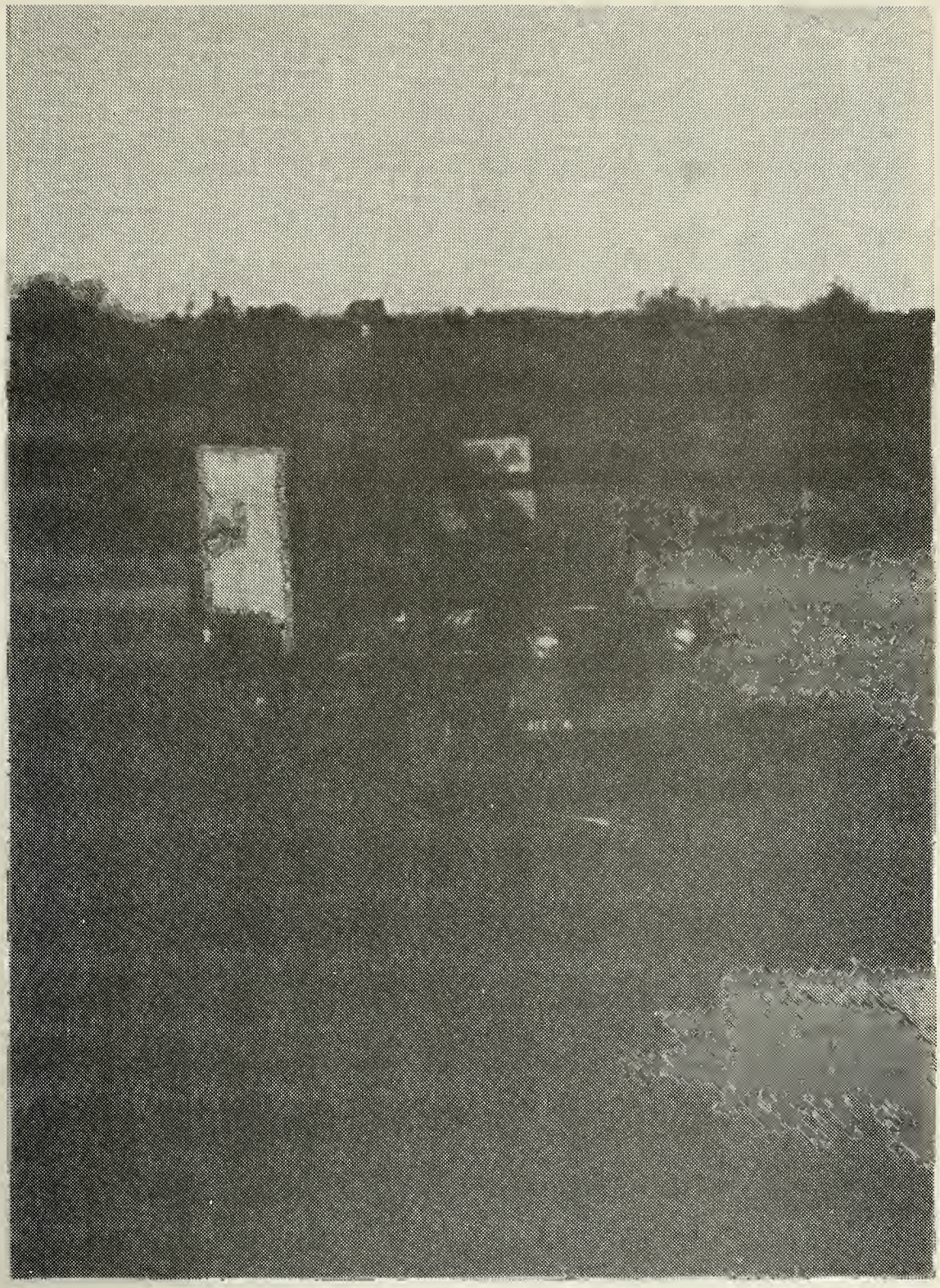


Figure 16. Firing Run- Left to Right.

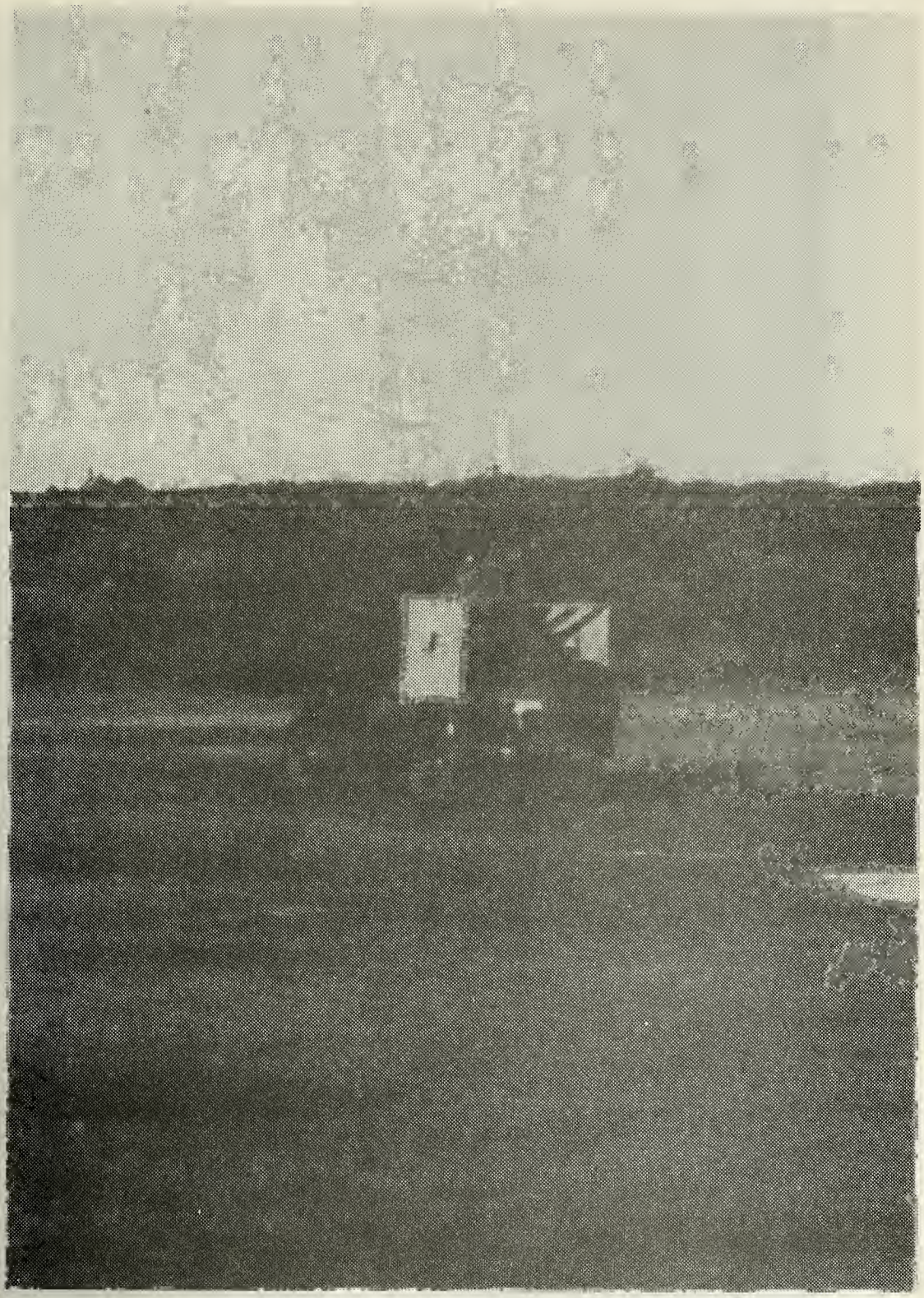


Figure 17. Firing Run-Right to Left.

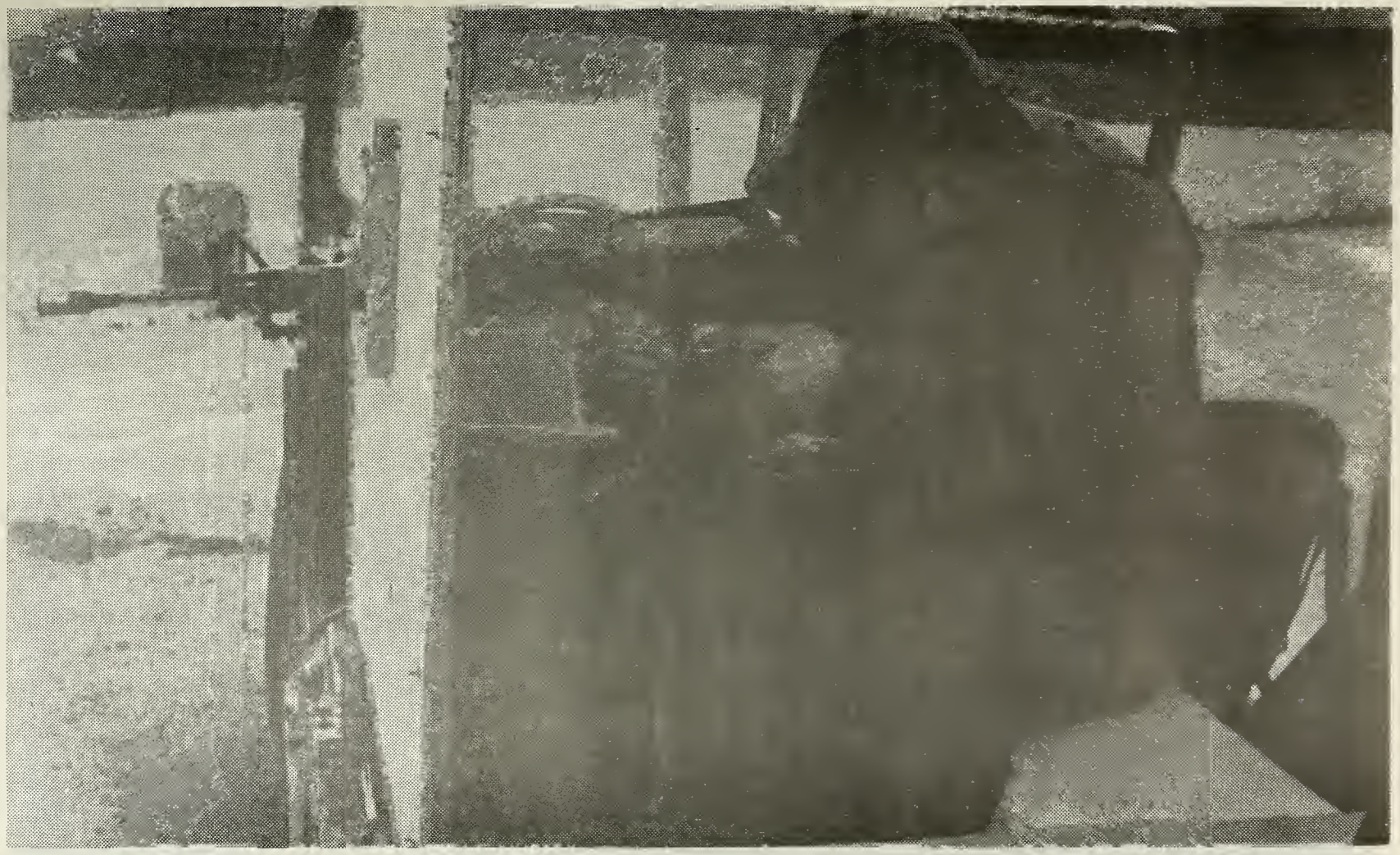


Figure 18. Firing Position-Left to Right (Left Handed Shooter).

Figure 19. Firing Position-Right to Left (Right Handed Shooter).

This procedure continued for a total of 10 firing passes from L-to-R by one S and 10 passes from R-to-L by the other S. At the conclusion of the 20-pass run, the two Ss were given unofficial scores for the run. This procedure was repeated until all Ss, in a four-man group, had made 10 passes from each direction with each sight configuration, a total of 60 passes. After one group was finished, the second group started. Due to more pressing needs, two subjects became unavailable for the record firing, necessitating modification of one four-man grouping into a two-man group.

e. Hit Scoring

A kill was only recorded if the target was killed as it came up or while it stayed up. A target hit as it was going down, at the end of the exposure time, was not recorded as a kill. A hit by any single round of a burst, multiple round hits, or a ricochet was recorded as a kill if the target went down.

IV. FINDINGS

A. GENERAL

The overall results of the experiment are shown in Tables II and III. Table II shows the results by sight, range, and direction of movement and Table III summarizes the results for sight and bank of targets.

For purposes of data analysis, all data obtained on the left-handed firers was converted to right-handed data, thus eliminating handedness as a factor. Additionally, an analysis based on the bank of targets was done as a result of the comments of some firers that they had more difficulty engaging certain targets than others, based on their direction of movement. On this basis, two banks of two targets, consisting of one target at 25 yards and the other target at 50 yards, were created. These banks consisted of targets 1 and 2 and targets 3 and 4, as shown in Figure 10, with the 1,2 bank designated the near bank and the 3,4 bank designated the far bank for L-to-R movement. For R-to-L movement the bank designations were reversed.

Due to the loss of subjects during the experiment, perfect distribution for bursts fired at the near and far banks of targets at the 25-yard range was lost as at the time the experiment was designed bank of targets was not thought to be a factor. Bank of targets only became a factor after studying the questionnaire responses; thus the balance for this range, which was designed over a four-man group, was lost when the third group was cut to a two-man group due to the loss of Ss.

TABLE II. SUMMARY OF HITS BY SIGHTS, DIRECTIONS OF MOVEMENT, AND RANGES

SIGHT AND TOTALS	RANGE			
	25 YDS		50 YDS	
	DIRECTION of MOVEMENT		DIRECTION of MOVEMENT	
	L-to-R	R-to-L	L-to-R	R-to-L
STANDARD	15	20	4	5
SMALL "0"	22	20	4	3
LARGE "0"	9	15	1	4
OVER SIGHTS	46 30.7%	55 36.6%	9 6.0%	12 8.0%
OVER DIRECTIONS (HITS AT RANGE)	101 33.7%		21 7.0%	
OVER RANGES (HITS BY DIRECTION)	Left-to-Right = 46+9 55 18.6%		Right-to-Left = 55+12 67 22.3%	

TABLE III. SUMMARY OF HITS BY SIGHTS, BANKS OF TARGETS, AND RANGES

SIGHT AND TOTALS	RANGE			
	25 YDS		50 YDS	
	BANK of TARGETS		BANK of TARGETS	
	NEAR	FAR	NEAR	FAR
STANDARD	16 of 48	19 of 52	6 of 50	3 of 50
SMALL "0"	22 of 47	20 of 53	4 0f 50	3 of 50
LARGE "0"	11 of 47	13 of 53	4 of 50	1 of 50
OVER SIGHTS	49 of 142 34.5%	52 of 158 32.9%	14 of 150 9.3%	7 of 150 4.7%
OVER RANGES (HITS BY BANK)	Near Bank of Tgts = 49 + 14 63 of 292 21.6%		Far Bank of Tgts = 52 + 7 59 of 308 19.2%	

B. SIGHT DIFFERENCES

There were no statistically significant differences found between the sight configurations (Table VI). Table II shows 22% kills using standard sights, 24.5% kills using the small "O" and 14.5% kills using the large "O" sights. With 200 three-round bursts fired with each sight configuration the small "O" sight showed an 11% improvement and the large "O" sight, a 34% degradation from that obtained by the standard sights.

C. RANGES

The targets located at 25 yards were hit by a significantly larger proportion of the bursts fired than those at 50 yards. The targets at 25 yards were hit by 33.7% of the bursts while only 7% of the bursts fired at the 50 yard targets were hits. Table II contains a breakdown of hits by range and Table V contains a more detailed breakout by target.

These findings indicate an inverse relationship between range and accuracy that is quite severe even at short ranges.

D. DIRECTION OF MOVEMENT

There was no significant difference (at the 0.05 level of significance) between kills obtained when moving from L-to-R compared with moving R-to-L. The difference was significant at the .10 level. The Ss scored 18.6% kills moving L-to-R and 22.3% kills when moving R-to-L (Table II).

These findings, coupled with Ss comments, might indicate some problem for a firer when moving in the direction of his handedness; e.g., a right hander moving L-to-R, if he didn't have the lateral movement, along the bench seat, that was available to the Ss in this experiment.

E. BANK OF TARGETS

There was no significant difference at the .05 level when kills were studied from the viewpoint of which bank of targets was engaged. The difference was significant at the .10 level, however. The Ss scored 21.6% kills on the near targets and 19.2% kills on the far targets (Table III).

F. INTERACTIONS

None of the pairwise interactions were significant, nor were either of the three-way interactions as shown in Figures 20 and 21.

G. HITS

As a result of the system of scoring, i.e., any hit after the target had started down or multiple hits, in the three-round burst, were not recorded, it is interesting to look at the actual hits by target (Table V). Depending on whether the interest is target penetration by any source, by the bullet only, or by any round in a three-round burst, the percentage of hits was 13.9, 11.8, and 20.3%, respectively. The respective percentages by range were 19.1, 15.8, and 33.7% at 25 yards and 8.8, 7.8, and 7% at 50 yards (Table V).

H. PREFERENCES

Results of the S questionnaire (Appendix A) show a preference for either the standard or small "O" sight with the small "O" being the slightly preferred of the two. The small "O" sight was preferred by six Ss, four preferred the standard sight, and none preferred the large "O".

TABLE IV. SUMMARY OF EFFECTIVENESS

VARIABLE	LEVEL	NUMBER HITS	PERCENT HITS	PERCENT INCREASE IN EFFECTIVENESS
	Standard	44	22	
Sight	Small "0"	49	24.5	11% over Standard
	Large "0"	29	14.5	34.1% under Standard
Distance	25 YDS	101	33.7	381% over 50 YDS
	50 YDS	21	7	
Direction of	L-to-R	55	18.3	
Movement	R-to-L	67	22.3	21.8% over L-to-R
Bank of	Near	63 of 292	21.6	12.6% over Far
Targets	Far	59 of 308	19.2	
TOTAL		122	20.3	

Note: A total of 600 (3 round) bursts were fired.

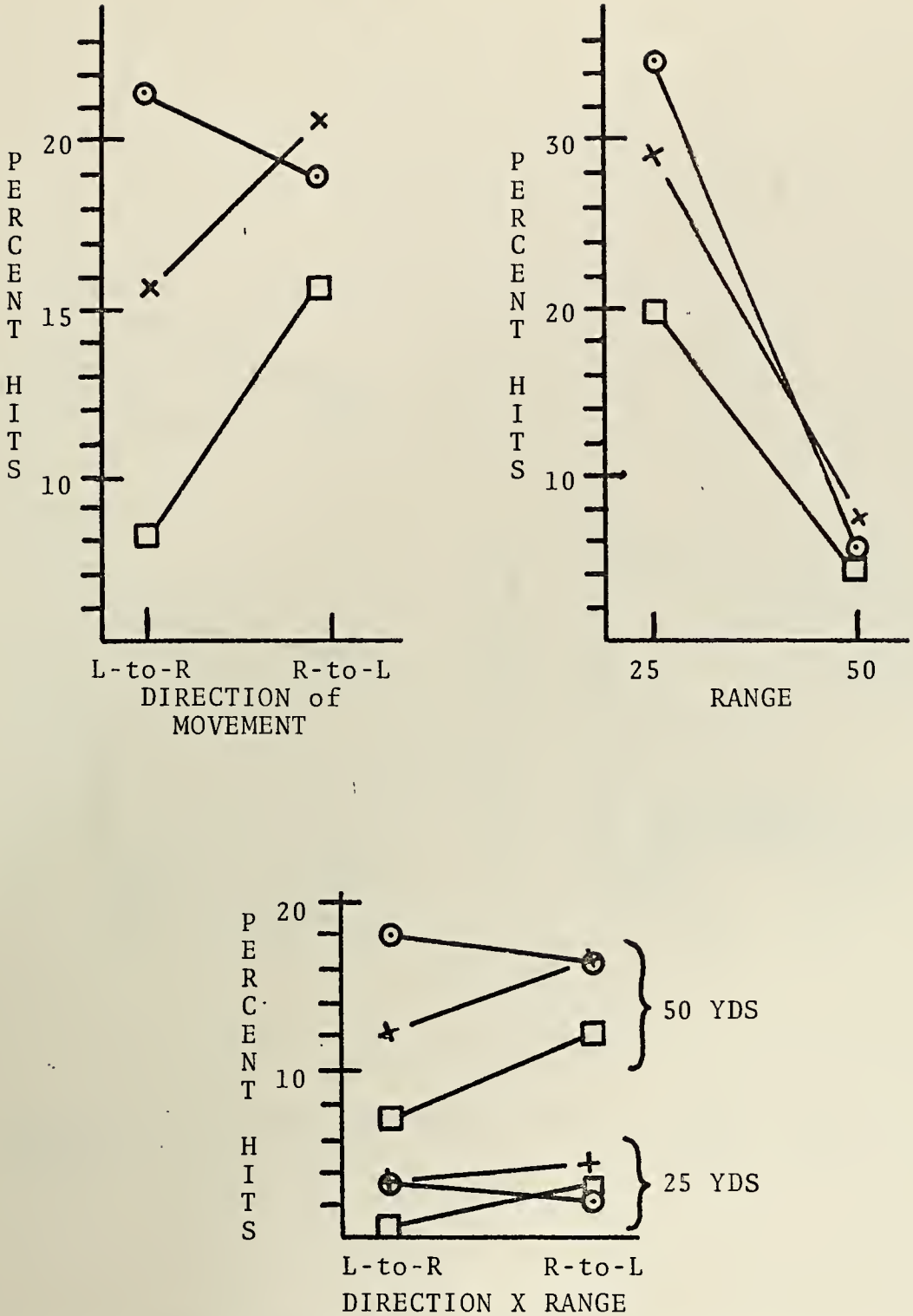
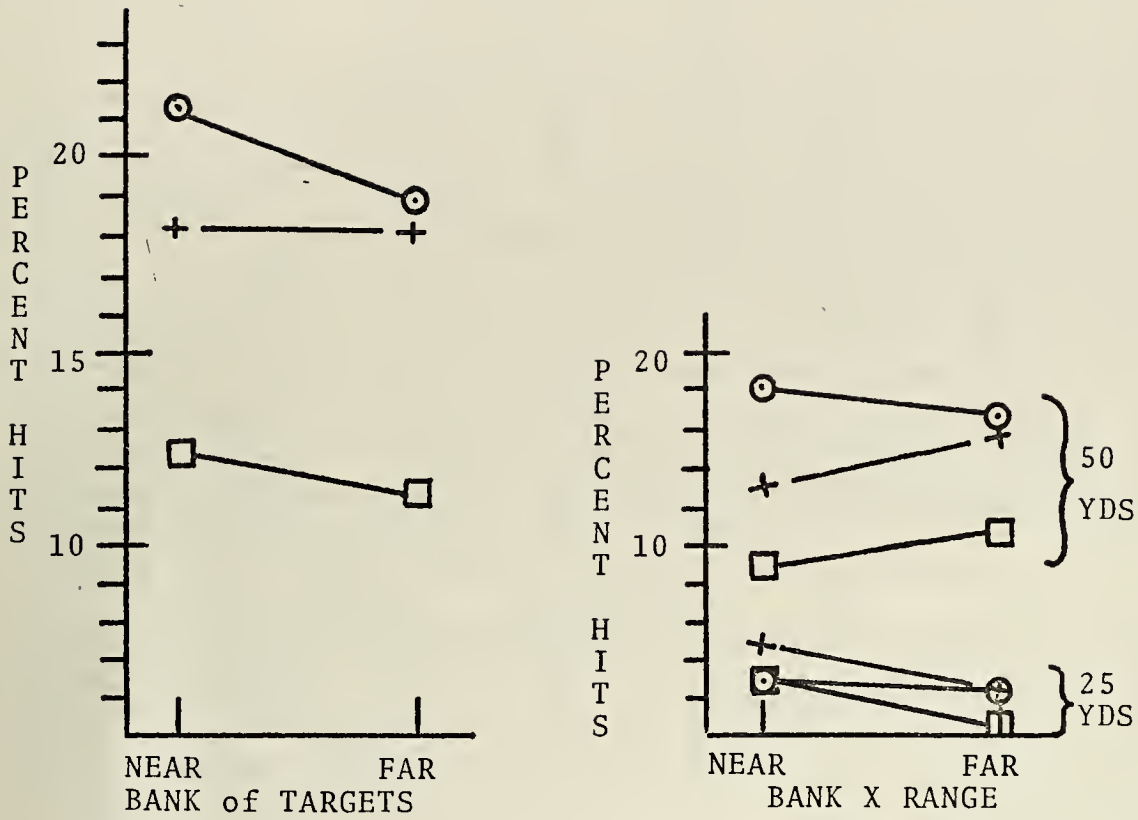


Figure 20. Relationships of Direction of Movement, Range to Target, and Sight Configuration to Percent Hits.



X- Standard Sight, ⊙ - Small "0" Sight, □ - Large "0" Sight

Figure 21. Relationships of Bank of Targets, Range to Target, and Sight Configuration to Percent Hits.

TABLE V. TARGET HITS BY TARGET AND TYPE OF HIT

	TARGET 1*	TARGET 2*	TARGET 3*	TARGET 4*	TOTALS
SCORED HITS	48	9	12	53	122
HOLES IN TARGET, ALL SIZES (ANY TGT. PENETRATION)	100	43	36	72	251
HOLES IN TARGET (BULLET ONLY)	80	39	31	62	212
NUMBER ROUNDS FIRED AT TARGET	450 (150 Brsts)	450 (150 Brsts)	450 (150 Brsts)	450 (150 Brsts)	1800 (600 Brsts)
HOLES IN TGT (ANY SIZE) / SCORED HITS	2.083	4.778	3.000	1.358	2.057
HOLES IN TGT (BULLET ONLY) / SCORED HITS	1.667	4.333	2.583	1.170	1.738
% BURSTS FIRED SCORED HITS	32	6	8	35.3	20.3
% ROUNDS FIRED HIT TARGET (ANY TGT. PENETRATION)	22.2	9.6	8	16	13.9
% ROUNDS FIRED HIT TARGET (BULLET ONLY)	17.8	8.7	6.9	13.8	11.8

* Target arrangement facing down range: 1-left, 25 yds.; 2-left, 50 yds.; 3-right, 50 yds.; 4-right, 25 yds.

V. DISCUSSION

Although the experiment was designed to be a continuation of those performed by Kemple and McKinney [1] and Fisher and McLeskey [2], it differed in one important respect and that was the method of fire using the standard sights. Exploratory firing had shown that quick-fire firing techniques, as used in the earlier experiments, would not produce sufficient hits for the standard sights to permit a comparison with the bracketing sights. Therefore, aimed fire was used for the standard sight trials in this experiment.

A second problem area was obtaining sufficient hits for analysis with any of the sight configurations. It was desired to have a kill probability of .5 for the standard sights over all bursts fired. It was found in exploratory firings under ideal range conditions that this was not possible. The best that could be obtained, with the 4.5 second target exposure time, was a hit probability of .3. Under the test conditions of rain and cold this dropped to .22 for the standard sights.

This degradation was to a large degree due to the instability of the firing platform. This instability was accented as the firing track deteriorated during the course of the experiment.

The resultant low hit probability quite likely masks differences in the sight capabilities. In previous tests, the probability of a hit was a matter of individual skill with the three sights, while in this experiment the condition of the track and the simulated MICV's ride characteristics contributed a great deal to the firer's accuracy.

Target acquisition and rapid engagement, a key factor in evaluating the sights, had to be eliminated to obtain as many hits as possible for analysis. To have used a shorter exposure time for the targets would have required many more runs or subjects to properly evaluate the data due to the lowered hit percentage. Time and manpower constraints precluded this. Another approach would have been to expose the targets until they were first hit, with the time to first hit as the measure of effectiveness. This would have required a longer firing track and would not have been compatible with the previous studies as the measure of effectiveness would have been changed as well as the manner of engagement.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The current experiment, though not showing a significant difference between sights, indicate that for firing from a moving vehicle aimed fire is important and that the smaller the area of aim, the greater the likelihood of achieving hits. The large "0" sight appeared to allow too much wander and thus degraded accuracy. This apparent difference was substantiated by the comments of the firers and their preferences.

The significant difference in hit capability by range indicates that this method of engagement, firing from a moving vehicle, is severely restricted as to ranges where it might be effectively employed. In a more stable platform, it would be expected that this method would be more effective, thus it is necessary to determine what the greatest practical firing range is.

B. RECOMMENDATIONS

Tests similar to the current experiment should be run using targets at greater ranges and firing from a platform that more nearly approximates the MICV. The ranges used were realistic for defense against ambush [7 and 9] and quite possibly certain assaults; however, they did not approach the ranges specified in the Materiel Need [5]. There is a definite need to determine the effective target acquisition ranges from a MICV as this will determine engagement ranges, not the enemy weapon's ranges as is currently used.

There are several concepts that have been considered for the firing capability to be used with the MICV. To determine which is best, this

experimental system should be retested with an observation device above the firing port to provide the firer a more comfortable position for initial target acquisition. Other testing should be done to test the circular bracketing sights, small "O" in particular, against a fixed mount weapon which uses a burst on target method of engagement.

The size of the circular bracketing sight should be tested to determine an optimum size. The results of this experiment indicate the size should be smaller than that of the small "O" (i.e., a diameter of less than 1.32 inches).

VII. DETAILED RESULTS

A. DATA

The data was originally collected in the 120 cells found in Tab 4, Appendix C. Each cell in this table described the number of kills achieved by each S with each sight configuration, direction of movement, and at each range. In Tab 6, Appendix C, the data was reorganized into 120 new cells that substituted bank of targets for direction of movement as a factor to be analyzed.

The number of engagements per trial, five three-round bursts, was small for the original analysis (and small, as well as unequal, in the second analysis), and the statistical analysis techniques required data that was normally distributed. In order to accomplish this, the cell values were transformed (see [12]) by letting

$$C_{ijk} = 2\arcsin\sqrt{P_{ijk}}$$

where P_{ijk} is the proportion of hits from cell (i,j,k).

Tabs 4 and 6, Appendix C, list the data by cells with Tab 4 providing data for analyzing direction of movement and Tab 6, data for bank of targets. The number at the top of each cell is the total number of kills for the given S, direction of movement (or bank of targets), range, and sight combination. That value divided by five provides the proportion used in the arcsin transform. The bottom figure in each cell is the resulting normalized value and is the one used for analysis.

B. INITIAL HYPOTHESIS

Eleven null hypothesis were tested using a three-factorial randomized block design where the 10 Ss constituted the blocks. The basic statistical model used was:

$$X_{ijkm}=u+B_i+R_j+D_k+S_m+BR_{ij}+BD_{ik}+BS_{im}+RD_{jk}+RS_{jm}+DS_{km}+BRD_{ijk}+BRS_{ijm}+BDS_{ikm}+RDS_{jkm}+BRDS^*_{ijkm}$$

where X_{ijkm}=the cell value,

u =the mean value,

B_i =the Sight level,

R_j =the Range level,

D_k =the Direction of Movement level,

and S_m =the Subject block. In this case the model is mixed with factor S_m random and factors B_i, R_j, and D_k fixed.

Since each S underwent all conditions, and it was assumed they would interact with the factors, the BS, RS, DS, BRS, BDS, RDS, and BRDS interactions were broken out as components of the model rather than combined into one large error term. This breakout allowed for the testing of differences in the various factor levels or of simple interactions by using the mean square of the factor or interaction, to be tested, compounded with the block mean square. No test of hypothesis was done for S differences since it was assumed there was a difference between subjects.

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*Since there were no replications, the true error term could not be separated from the $BRDS_{ijkm}$ term.

TABLE VI. TESTS OF HYPOTHESIS FOR FIRING DATA

TEST		TEST STATISTIC*	STATISTIC VALUE	DIST. UNDER H_o	$F^n_d(.05)$ [$F^n_d(.10)$]**	RESULT
1	H_o: $B_i=0$ H_A: $B_i\neq 0$	MS_B/MS_{BxS}	2.3954	F(2,18)	3.55 [2.61]	FAIL# [FAIL]
2	H_o: $R_j=0$ H_A: $R_j\neq 0$	MS_R/MS_{RxS}	49.5160	F(1,9)	5.12	REJECT
3	H_o: $D_k=0$ H_A: $D_k\neq 0$	MS_D/MS_{DxS}	3.7718	F(1,9)	5.12 [3.36]	FAIL [REJECT]
4	H_o: $BR_{ij}=0$ H_A: $BR_{ij}\neq 0$	MS_{BxR}/MS_{BxRxS}	1.6809	F(2,18)	3.55	FAIL
5	H_o: $BD_{ik}=0$ H_A: $BD_{ik}\neq 0$	MS_{BxD}/MS_{BxDxS}	2.3100	F(2,18)	3.55	FAIL
6	H_o: $RD_{jk}=0$ H_A: $RD_{jk}\neq 0$	MS_{RxD}/MS_{RxDxS}	0.0247	F(1,9)	5.12	FAIL
7	H_o: $BRD_{ijk}=0$ H_A: $BRD_{ijk}\neq 0$	$MS_{BxRxD}/MS_{BxRxDxS}$	0.1528	F(2,18)	3.55	FAIL
8	H_o: $T_k=0$ H_A: $T_k\neq 0$	MS_T/MS_{TxS}	4.5198	F(1,9)	5.12 [3.36]	FAIL [REJECT]

TABLE VI. TESTS OF HYPOTHESIS FOR FIRING DATA (Cont.)

TEST		TEST STATISTIC*	STATISTIC VALUE	DIST. UNDER H_o	$F_d^n(.05)$ [$F_d^n(.10)$]	RESULT
9	H_o: $BT_{ik}=0$ H_A: $BT_{ik}\neq 0$	MS_{BxT}/MS_{BxTxS}	0.2111	F(2,18)	3.55	FAIL
10	H_o: $RT_{jk}=0$ H_A: $RT_{jk}\neq 0$	MS_{RxT}/MS_{RxTxS}	0.6804	F(1,9)	5.12	FAIL
11	H_o: $BRT_{ijk}=0$ H_A: $BRT_{ijk}\neq 0$	$MS_{BxRxT}/MS_{BxRxTxS}$	0.4490	F(2,18)	3.55	FAIL

*Subscripts: B=Sights, R=Ranges, D=Directions of Movement, T=Bank of Targets, S=Subjects
**Used when needed
#FAIL means FAIL TO REJECT

The first seven hypothesis tested (see Table VI) were those involved with the model given above and utilized the data found in Tabs 4 and 5 of Appendix C. At a level of significance (L.O.S.) of .05, only the hypothesis that there was no Range effect was rejected. The hypothesis that there was no Direction of Movement effect was rejected at a L.O.S. of .10.

Due to S comments and study of the above data, it was decided to modify the given model by replacing Direction of Movement with Bank of Targets (T_k). The modified data to support this model is found in Tabs 6 and 7 of Appendix C. The modified data was used in the last four tests of hypothesis (see Table VI) and resulted in the rejection of the hypothesis that there was no Bank of Targets effect at a L.O.S. of .10.

C. SUBSEQUENT HYPOTHESIS

Analysis of variance calculations, and F tests, only serve to demonstrate that there is a statistically significant difference between the levels of a factor. In this case, no significant differences were found for the only factor with more than two levels, that is the sights, thus no further testing was necessary to determine which level, or levels, were significantly different.

D. POST-EXPERIMENT TESTING

In order to determine if the Ss had a statistically significant preference ordering for the different sight configurations, their preference ordering responses from the questionnaires were analyzed using the Kendall Coefficient of Concordance Test [11,12]. Two of the 10 Ss did not indicate a second or third choice, thus an average entry of 2.5 is made for both these subjects in Table VII.

The H_o tested was:

There is no agreement in the Ss preferences for sight configurations.

The H_A was:

There is agreement.

The H_o was rejected at the α=.05 level since χ^2_W=11.35 > χ^2(.05,2)= 5.99. The data, calculations and results of the Kendall test are given in Table VII.

TABLE VII. SUBJECT SIGHT PREFERENCE AND KENDALL'S COEFFICIENT OF CONCORDANCE

N=3 K=10		(N) SIGHT RANKINGS (1, 2, or 3) STANDARD	SMALL "0"	LARGE "0"	
S	1	2	1	3	
U	2	1	2	3	
B	3	2.5	1	2.5	
J	4	2	1	3	
E	5	1	2	3	
C	6	2	1	3	
T	7	2	1	3	
S	8	1	2.5	2.5	
(K)	9	2	1	3	
	10	1	2	3	
	R_i	16.5	14.5	29	$\Sigma R_i=60$
$R_i-\Sigma R_i/N$		-3.5	-5.5	9	
$A=(R_i-\Sigma R_i/N)^2$		12.25	30.25	81	$\Sigma A=123.5$

$$W=\Sigma A/\frac{1}{12}K^2(N^3-N) = \frac{123.5}{\frac{1}{12}(100)(24)} = \frac{123.5}{200} = .617$$

H_o: There is no preference among subjects.

R_i^2	262.25	210.25	841	$\Sigma R_i^2=1313.5$

$\chi_W^2=(12/KN(N+1))(\Sigma R_i^2)-3K(N+1)=11.35$

Critical Value $\chi^2_{.05,2}=5.99$

SIGNIFICANT DIFFERENCE. Reject H_o.

APPENDIX A. POST EXPERIMENT QUESTIONNAIRE

QUESTIONNAIRE ON MOVING VEHICLE EXPERIMENT

This questionnaire is designed to obtain information about each person performing in the moving vehicle experiment. Some questions are specific and should be answered as accurately as possible. Other questions ask for personal views of the firer on aspects of the experiment.

In filling out the questionnaire, try to be accurate and express YOUR views as best you can. There are no "right" answers. Each person's views are equally important. Take your time and write or print clearly in the spaces provided. If some questions don't apply, put an N/A in the blank space.

1. NAME Summary of Responses

2. RANK 3-E2's, 2-E3's, 3-E4's, 1-E5, 1-E6

3. Your subject number for the experiment was _____

4. UNIT F Company, 41st Infantry

5. MOS 8 - 11B (Light Weapons Infantryman), 2 - 11C (Infantry Indirect Fire Crewman)

6. AGE at last birthday Ave 21.2 Range 19-25 HEIGHT Ave 71.05 in Range 67.5-76 in
WEIGHT Ave 176.6 lbs., Range 155-200 lbs

7. Number of years on active duty Ave 2.26 yrs., Range .67-4 yrs.
Volunteer or Draftee 7 Volunteers, 3 Draftees

8. Are you right or left handed? 8 right handed, 2 left handed

9. Do you wear glasses ? 3 - yes, 7 - no

10. Are you Quick-Fire trained? 8 - yes, 2 - no
If YES, state date and place various posts throughout country

11. Do you now have or have you ever had a physical profile? 3-yes, 7-no
If YES, please describe only 1 currently in effect and concerned leg.

No effect on this experiment.

12. Have you been stationed in Viet Nam? 4 - yes, 6 - no

If YES, complete the following:

Dates of assignment 1969 to 1972
*Unit(s) assigned to 1-9th Inf Div, 1-11th ACR, 3-101st ABN Div, 1-MACV, 1-1st LOG CMD
*General area of Viet Nam 4-I CORPS, 1-III CORPS, 1-IV CORPS
Type terrain Principal - mountains, jungles
Length of tour(s) 8.6 months average
Principal duty performed there 1-security guard, 3-infantry
Did you ever use Quick-Fire Techniques in combat? 2 NO 1 SOME 1 OFTEN
Where you ever in an ambushed convoy? 1 - yes, 3 - no
Did you ever engage targets (enemy) from a moving ground vehicle? 1 - yes, 3 - no

* Total more than 4 due to transfers and multiple tours.

13. How do you feel about firing weapons either militarily or as a sport in civilian life?

___Dislike all firing
___Dislike military firing but like to shoot or hunt off duty or in civilian life
2 Don't care one way or another
___Like military firing but don't shoot or hunt off duty or in civilian life
8 Like to fire both militarily and off duty or in civilian life
___Other _____

14. Non-military shooting experience: Member of the NRA? 1-yes, 9-no

a. Have you hunted?

2 Never 2 Once or twice ___3-5 times ___6-10 times
6 Over ten times

b. If you hunt, is your weapon:

___Shotgun only
___Rifle only
3 Some shotgun, mostly rifle
5 Some rifle, mostly shotgun
___Other _____

If use rifle, type sights 1 - bead, 3 - notch (only answers)

15. Do you own a weapon? 7 - yes, 3 - no

If YES, what type and purpose? 6 rifles, various calibers, hunting and target shooting; 1 pistol, 22 cal, target; 5 shotguns, .410 through 12 gauge, hunting

16. Were you raised in an urban or rural community? 3-urban, 7-rural

17. Comments on the moving vehicle experiment:

a. Do you feel Quick-Fire Techniques should be retained in Basic or Advanced Individual Training? 9-yes, 1-no
Explain: Of yes replies, 6 had no preference for when taught, remaining 3 preferred AIT

b. Do you feel the idea of bracketing targets with the special sights is a legitimate or valid concept? 9-yes, 1-no

Explain: 2 subjects answered yes but thought they fired best with standard sights. Other comments: speeds, acquisition and aim, applicable to area fire.

c. Do you feel that use of the special sights from a moving vehicle, or in a firing port configuration, is a legitimate or valid concept? 8-yes, 1-no, 1-no answer

Explain: Aids in laying on and staying on target

d. Do you think the way the test was run will help tell which sight is best? 9-yes, 1-no

Explain: Comments about rough track and how it made aiming difficult

e. Was the target exposure time:

1 Too short
__ Too long
9 Correct
__ Other (Comments) _____

f. Do you feel the target ranges were appropriate for engagements from moving vehicles? 10 - yes, 0 - no

If NO, what ranges do you feel would be appropriate? N/A

Why? _____

g. Was the orientation (instruction) prior to the experiment helpful in understanding what the experiment was all about (and how you should perform)? 9 - yes, 1 - no

Comments: The no comment dealt with the concept and techniques not being developed enough for instruction

h. Was the practice given prior to the test sufficient? 9-yes, 1-no

Explain: General concensus was they were used to firing conditions prior to record firing.

i. Was any part of the firing particularly difficult for you? 6 - yes, 4 - no

Explain: Difficulties were: 1 subject felt port was terrible; 2 subjects had difficulty firing when moving from left-to-right; 1 subject found 50 yard targets first encountered difficult; and 2 subjects had problems with the weather and bumps.

j. Which part of the experiment were you most confident in performing? Mark one block in each column:

10 25 Yd	5 Moving left to right	4 Standard sight
50 YD	5 Moving right to left	6 Small O
		Large O

k. Do you feel you scored significantly better with one particular sight? 9-yes, 1-no

If YES, which one 3-standard, 6-small O

l. Do you feel you would have scored significantly better with one of the sights if target exposure time had been longer? 2-yes, 8-no

If YES, which sight and explain 1-standard, 1-small O

m. Did the firing port configuration aid in laying on target when just the standard sight was used? 1-yes, 9-no

Explain: Port restricted vision greatly, made targets difficult to detect. One recommendation to increase lateral width 2 inches

n. Rank the three sights in order of your preference:

4-1st, 5-2nd Standard

6-1st, 3-2nd Small circle

8-3rd Large circle

2 men only selected first choice and did not rank

o. How could the experiment be improved? Main comments concerned weather and track conditions. Other comments: second burst during engagement and more targets or area type targets.

PLEASE LOOK OVER EACH QUESTION TO INSURE YOU HAVE ANSWERED ALL OF THEM.

THANK YOU FOR YOUR HELP IN PERFORMING THIS EXPERIMENT!

APPENDIX B. ORIENTATION BRIEFING

1. INTRODUCTION

Gentlemen, I am Maj. Miller. I appreciate the fact that you are here today and hope you will find this experiment interesting as a participant. Basically, the experiment is to test the M16 rifle modified with two sizes of circular bracketing sights, as you see mounted on these weapons, against standard quick-fire (mod. aimed) type techniques. Previous tests have been done using these sights against pop-up and moving targets. This phase consists of firing from a moving vehicle against pop-up targets at short ranges. A side effect will be to see if a firing port configuration for the proposed MICV (Mechanized Infantry Combat Vehicle) is a valid concept if special sighting techniques are used. I am interested not only in your hits on the targets, but also in your own personal views as to sighting system preference.

The experiment will consist of firing the M16 rifle with each of the three sight configurations from a moving vehicle at pop-up targets at ranges of 25 and 50 yards. The targets will be exposed for approximately 4.5 seconds for each trial. During this time interval you will engage the target with a three-round burst. We shall now look at the technique of fire that will be used.

2. TECHNIQUE OF FIRE/DEMONSTRATION
(Presented by 6th AMTU personnel - US Army Marksmanship Training Unit)

For this experiment certain modifications of standard aimed fire techniques are necessary. For firing, your weapon will be placed through a port hole, which is your only field of view and this results

in several problems. The movement of the vehicle will be transmitted to you both through the seat and through the sidewalls, if either your hand or the weapon remains in contact with it, thus we have found that by avoiding sidewall contact you can dampen out some of this movement. A second problem of the port is the small field of view, with the weapon further restricting it. To counter this, and thus speed target acquisition, tilt the weapon opposite the way you fire (i.e., left if you fire right handed) and then look over the top of this tilted weapon until the target is acquired. From this point on, move into firing position.

The firing position for the standard sight is the same as normal off hand. Insure proper spot weld, sight picture and trigger squeeze as far as vehicular movement permits. For the circular bracketing sights the technique is changed. You now want to place the target in the center of the bracket and use what was the rear peep sight as your post. In other words the sights are reversed.

Some of you have probably engaged moving targets and know what a lead is; those of you who haven't are better off as this is just the reverse. You are moving, the target isn't; therefore, you must aim behind the target and allow the forward movement of the vehicle to take the strike of the bullet into the target. In this case aim at the edge of the target you are approaching.

The last area I want to cover is fire commands. Once the jeep moves into position for its run you will receive the following sequence of commands:

(1) "Lock and load" - insure the weapon is locked and load one magazine

(2) "Unlock and be ready" - Unlock the weapon and get in position to observe out of the port.

(3) "Okay driver" - this tells the driver all safety conditions are met and he may commence the run.

After you have fired your three-round burst, the command "lock and clear" will be given. At this time lock the weapon, remove the magazine and cant the weapon so that the Safety NCO may insure that it is clear.

Do you have any questions at this point? A firing demonstration will be given prior to your familiarization firing. (Assistant Instructors will demonstrate all points as they are discussed.)

3. EXPLANATION OF THE TARGET RANGE

Now that you've seen and heard the correct firing techniques, I will explain the range setup and operation for the experiment. (Show diagram, point out features)

A. Targets will be raised when the moving vehicle is in the vicinity of the Blue stakes.

B. The vehicle will be travelling between 5-10 mph and as close to the latter speed as possible.

C. The target will stay up 4.5 seconds during which you will travel 22 yards at 10 mph.

D. If the target is hit while exposed, it will go down and light a light on the control board. A hit will then be recorded. The target will come up again if there is exposure time remaining. It WILL NOT be re-engaged if you have rounds remaining. See me as you leave the vehicle if you desire your score for a particular phase. Do not ask the scorer/controller.

4. EXPLANATION OF FIRING PROCEDURE

A. Two firers will be in the vehicle at the same time. Firing will be done from the mock seat with the non-firer sitting on the wheel well on his side.

B. You will be assigned a subject number. Do not forget this number as it will determine the order, position, and sight configurations you will be firing.

C. Prior to the record firing, you will fire a familiarization course that will consist of engaging each target once with each sight and moving in each direction.

D. After familiarization firing, the test firing will commence. Test firing will be done in a random manner, but to insure no lost data, subjects will do all record firing in one day. Within this constraint the firing order, sight, and target presentation order are all random. Firing will consist of 10 three-round bursts fired with each sight in each direction of movement.

E. You'll fire all ranges, directions, and sight configurations according to the test plan and subject number assigned to you.

5. SAFETY/SECURITY

As with any live fire program, thinking safety is essential. Due to the different nature of firing in this experiment safety becomes even more important and is the responsibility of all of us. Going from general to specific, the rules we will observe on this range are as follows:

A. A copy of Fort Ord Range Regulations (Reg 350-5, dtd 2 May 1972) will be found in the VIP briefing file. Under this regulation, the following items are important to us:

1. Cease fires

a. Visibility less than one (1) mile

b. Aircraft over the impact area

c. Phone messages from range central

d. Ten (10) to fifteen (15) second ring on tower bell system in emergencies.

2. Emergency reporting - Phone guard will lift phone from cradle and flip cradle several times to denote emergency to switch.

B. There will be no smoking within 60 feet of the firing line, ammunition breakdown point, or the range shed. Smoking will be conducted only in the area designated by the NCOIC.

C. There will be no running on the range.

D. If you sight an unsafe condition, yell out "CEASE FIRING." All persons firing will observe the cease fire until I give a resume firing.

E. No ammunition will leave the range. This also applies to brass.

F. Listen to the instructions of all range control personnel.

G. When not being used, rifles will be stored in a cleared condition (bolts pulled and locked to rear, safeties locked, magazines out) by the magazine loading area and secured by loaders.

H. All firers, driver, and RSNCO riding in the vehicle will wear earplugs.

I. The RSNCO riding in the vehicle will wear goggles to protect his eyes from flying brass.

J. Weapons will be carried with the muzzle up and down range. The exception to this will be the non-firer's weapon in the firing vehicle. This weapon will be pointed down and to the rear of the vehicle in a cleared condition.

K. Weapons will be loaded on order of the RSNCO riding in the vehicle.

L. Weapons will be fired in the automatic mode and in one three-round burst.

M. Loaders will load three (3) rounds only per magazine.

N. After firing, all weapons will be checked to insure they are clear. The vehicle will not turn around for its return run until this is done.

O. Range limits are as shown on the range schematic and will not be violated.

P. Personnel not working with/or firing will remain behind the line designated PLD.

APPENDIX C. SUPPLEMENTARY TABLES

Tab 1 (Firing Orders) to APPENDIX C (Supplementary Tables)

ORDER OF FIRINGS

4 FIRERS IN GROUP

ORDER IN 1/4T TRK	LEFT TO RIGHT (DRIVER) SUBJECT	SIGHT*	TARGETS PRESENT	RIGHT TO LEFT (PAX) SUBJECT	SIGHT*	TARGETS PRESENT
1 (24)	3 (7)	2	A4	4 (8)	3	B2
2 (23)	1 (5)	3	A3	3 (7)	1	B3
3 (22)	1 (5)	1	A1	4 (8)	2	B1
4 (21)	2 (6)	1	A2	1 (5)	3	B3
5 (20)	4 (8)	3	A2	1 (5)	1	B1
6 (19)	4 (8)	1	A4	2 (6)	3	B4
7 (18)	2 (6)	3	A4	3 (7)	2	B4
8 (17)	3 (7)	1	A3	1 (5)	2	B2
9 (16)	2 (6)	2	A3	4 (8)	1	B4
10 (15)	1 (5)	2	A2	2 (6)	1	B2
11 (14)	3 (7)	3	A1	2 (6)	2	B3
12 (13)	4 (8)	2	A1	3 (7)	3	B1
25	9	3	A3	10	2	B3
26	9	1	A1	10	3	B4
27	10	1	A2	9	2	B2
28	10	3	A4	9	1	B1
29	10	2	A3	9	3	B3
30	9	2	A2	10	1	B2

* 1-Standard, 2-Small "0", 3-Large "0"

( )-Indicates second group of four subjects

**EXPLANATION OF THE TABLE

ORDER IN $\frac{1}{4}$T TRK - Each S had six different firing combinations of sight and direction of movement, thus with two Ss in the vehicle at a time (order) it took 12 orders to complete each four man group. Orders 1-12 were subject group 1; orders 13-24 were subject group 2; and orders 25-30 were subject group 3 (the two-subject group).

LEFT TO RIGHT (DRIVER) and RIGHT TO LEFT (PAX) - This gives the vehicle direction of movement for the firing runs and the word in the parenthesis indicates the side of the vehicle the firer sits on and fires from for that particular direction of movement (i.e., DRIVER means the driver's side and PAX means the passenger's side).

SUBJECT - The number listed indicates the subject to be tested.

SIGHT - The number listed indicates the sight to be used.

TARGETS PRESENT - This is the set of 10 targets to be presented during the firing runs. The meanings of these designations are found in Tab 2 of this appendix.

EXAMPLE: The first row of the table thus reads that order 1 (or 24) has subject 3 (or 7) seated behind the driver, firing on left-to-right firing runs, using the small"O" sight, and firing at target set A4 which, from Tab 2, Appendix C, presents targets in the order of targets 4, 1, 2, 3, 3, 2, 4, 1, 4, 2. Simultaneously, on right-to-left (seated behind the passenger's seat) firing passes, subject 4 (or 8) will use the large "O" sight and fire at target set B2, or targets 2, 2, 4, 3, 1, 3, 4, 3, 1, 1.

Tab 2 (Target Presentation Sets) to APPENDIX C (Supplementary Tables)

TARGET	LOCATION
1	is on LEFT at 25 YDS.
2	is on LEFT at 25 YDS.
3	is on RIGHT at 50 YDS.
4	is on RIGHT at 50 YDS.

TARGETS PRESENTED

A1	B1
3 3 3 1 4 4 1 1 2 2	1 1 2 4 3 2 4 2 3 4
A2	**B2**
2 4 1 1 3 2 2 3 4 4	2 2 4 3 1 3 4 3 1 1
A3	**B3**
1 4 4 3 1 3 1 2 3 2	1 4 1 4 2 2 3 1 2 3
A4	**B4**
4 1 2 3 3 2 4 1 4 2	4 1 2 1 2 4 3 1 3 3

Tab 3 (Record Score Sheet) to APPENDIX C (Supplementary Tables)

SCORE SHEET

1. Subject Number: 1 2 3 4 5 6 7 8 9 10 11 12

2. Direction of Movement:

   Left to Right (Driver Side) Right to Left (Pax Side)

3. Sight: Standard (1) Small 0 (2) Large 0 (3)

4. Targets Presented: A1 A2 A3 A4 B1 B2 B3 B4

5. Record:

	25 Yards					50 Yards				
	1	2	3	4	5	1	2	3	4	5
Hit										
Miss										

SCORE SHEET

1. Subject Number: 1 2 3 4 5 6 7 8 9 10 11 12

2. Direction of Movement:

   Left to Right (Driver Side) Right to Left (Pax Side)

3. Sight: Standard (1) Small 0 (2) Large 0 (3)

4. Targets Presented: A1 A2 A3 A4 B1 B2 B3 B4

5. Record:

	25 Yards					50 Yards				
	1	2	3	4	5	1	2	3	4	5
Hit										
Miss										

Tab 4 (Observed and Normalized Hit Data for Sight, Range, Direction of Movement, and Subject) to APPENDIX C (Supplementary Tables)

SIGHT (B)		STANDARD (1)			
RANGE (R)		25 YDS (1)		50 YDS (2)	
DIRECTION (D) OF MOVEMENT		L-to-R (1)	R-to-L (2)	L-to-R (1)	R-to-L (2)
S	1	2 1.3694	1 0.9273	0 0.0000	1 0.9273
U	2	4 2.2143	3 1.7722	0 0.0000	1 0.9273
B	3	0 0.0000	2 1.3694	1 0.9273	0 0.0000
J	4	0 0.0000	3 1.7722	0 0.0000	0 0.0000
E	5	1 0.9273	0 0.0000	0 0.0000	1 0.9273
C	6	0 0.0000	0 0.0000	0 0.0000	0 0.0000
T	7	3 1.7722	2 1.3694	1 0.9273	1 0.9273
S	8	2 1.3694	3 1.7722	0 0.0000	1 0.9273
(S)	9	1 0.9273	2 1.3694	0 0.0000	0 0.0000
	10	2 1.3694	4 2.2143	2 1.3694	0 0.0000

Tab 4 (Observed and Normalized Hit Data for Sight, Range, Direction of Movement, and Subject) to APPENDIX C (Supplementary Tables)(Cont.)

SIGHT (B)		SMALL "0" (2)			
RANGE (R)		25 YDS (1)		50 YDS (2)	
DIRECTION (D) OF MOVEMENT		L-to-R (1)	R-to-L (2)	L-to-R (1)	R-to-L (2)
S	1	3 1.7722	0 0.0000	1 0.9273	1 0.9273
U	2	2 1.3694	2 1.3694	0 0.0000	0 0.0000
B	3	2 1.3694	3 1.7722	1 0.9273	0 0.0000
J	4	2 1.3694	1 0.9273	0 0.0000	0 0.0000
E	5	2 1.3694	3 1.7722	0 0.0000	1 0.9273
C	6	3 1.7722	3 1.7722	0 0.0000	1 0.9273
T	7	1 0.9273	2 1.3694	1 0.9273	0 0.0000
S	8	2 1.3694	0 0.0000	1 0.9273	0 0.0000
(S)	9	3 1.7722	2 1.3694	0 0.0000	0 0.0000
	10	2 1.3694	4 2.2143	0 0.0000	0 0.0000

Tab 4 (Observed and Normalized Hit Data for Sight, Range, Direction of Movement, and Subject) to APPENDIX C (Supplementary Tables)(Cont.)

SIGHT (B)		LARGE "0" (3)			
RANGE (R)		25 YDS (1)		50 YDS (2)	
DIRECTION (D) OF MOVEMENT		L-to-R (1)	R-to-L (2)	L-to-R (1)	R-to-L (2)
S	1	2 1.3694	1 0.9273	0 0.0000	0 0.0000
U	2	2 1.3694	1 0.9273	0 0.0000	1 0.9273
B	3	0 0.0000	0 0.0000	0 0.0000	0 0.0000
J	4	0 0.0000	3 1.7722	0 0.0000	0 0.0000
E	5	0 0.0000	1 0.9273	0 0.0000	0 0.0000
C	6	2 1.3694	0 0.0000	0 0.0000	1 0.9273
T	7	1 0.9273	2 1.3694	0 0.0000	1 0.9273
S	8	0 0.0000	2 1.3694	0 0.0000	1 0.9273
(S)	9	2 1.3694	4 2.2143	0 0.0000	0 0.0000
	10	0 0.0000	1 0.9273	1 0.9273	0 0.0000

Tab 5 (Analysis of Variance for Sight, Range, Direction of Movement, and Subject) to APPENDIX C (Supplementary Tables)

SOURCE	d.f.	SS	MS
Sight Configuration (B)	2	1.9507340	0.9753671
Target Range (R)	1	18.7177000	18.7177000
Direction of Movement (D)	1	0.5359873	0.5359873
Subjects (S)	9	2.9951780	0.3327975
BxR Interaction	2	0.9170332	0.4585166
BxD Interaction	2	1.2288630	0.6144314
BxS Interaction	18	7.3294440	0.4079130
RxD Interaction	1	0.0184560	0.0184560
RxS Interaction	9	3.4021150	0.3780127
DxS Interaction	9	1.2789310	0.1421034
BxRxD Interaction	2	0.0802641	0.0401321
BxRxS Interaction	18	4.9100480	0.2727804
BxDxS Interaction	18	4.7876970	0.2659831
RxDxS Interaction	9	6.7362660	0.7484740
BxRxDxS Interaction	18	4.7287370	0.2627076

Tab 6 (Observed and Normalized Hit Data for Sight, Range, Bank of Targets, and Subject) to APPENDIX C (Supplementary Tables)

SIGHT (B)		STANDARD (1)			
RANGE (R)		25 YDS (1)		50 YDS (2)	
BANK OF TARGETS (T)		NEAR (1)	FAR (2)	NEAR (1)	FAR (2)
S	1	2 of 6 1.2239	1 of 4 1.0472	1 of 4 1.0472	0 of 6 0.0000
U	2	3 of 4 2.0944	4 of 6 1.9177	0 of 6 0.0000	1 of 4 1.0472
B	3	2 of 5 1.3694	0 of 5 0.0000	0 of 4 0.0000	1 of 6 0.8500
J	4	2 of 4 1.5708	1 of 6 0.8500	0 of 6 0.0000	0 of 4 0.0000
E	5	0 of 6 0.0000	1 of 4 1.0472	1 of 4 1.0472	0 of 6 0.0000
C	6	0 of 4 0.0000	0 of 6 0.0000	0 of 6 0.0000	0 of 4 0.0000
T	7	0 of 4 0.0000	5 of 6 2.2916	2 of 6 1.2239	0 of 4 0.0000
S	8	3 of 6 1.5708	2 of 4 1.5708	1 of 4 1.0472	0 of 6 0.0000
(S)	9	0 of 4 0.0000	3 of 6 1.5708	0 of 6 0.0000	0 of 4 0.0000
	10	4 of 5 2.2143	2 of 5 1.3694	1 0f 4 1.0472	1 0f 6 0.8500

Tab 6 (Observed and Normalized Hit Data for Sight, Range, Bank of Targets, and Subject) to APPENDIX C (Supplementary Tables)(Cont.)

SIGHT (B)		SMALL "0" (2)			
RANGE (R)		25 YDS (1)		50 YDS (2)	
BANK OF TARGETS (T)		NEAR (1)	FAR (2)	NEAR (1)	FAR (2)
S	1	1 of 4 1.0472	2 of 6 1.2239	0 of 6 0.0000	2 of 4 1.5708
U	2	2 of 5 1.3694	2 of 5 1.3694	0 of 4 0.0000	0 of 6 0.0000
B	3	2 of 4 1.5708	3 of 6 1.5708	1 of 6 0.8500	0 of 4 0.0000
J	4	2 of 6 1.2239	1 of 4 1.0472	0 of 4 0.0000	0 of 6 0.0000
E	5	2 of 4 1.5708	3 0f 6 1.5708	1 of 6 0.8500	0 of 4 0.0000
C	6	3 of 5 1.7722	3 of 5 1.7722	1 of 4 1.0472	0 of 6 0.0000
T	7	3 of 6 1.5708	0 of 4 0.0000	0 of 4 0.0000	1 of 6 0.8500
S	8	1 of 4 1.0472	1 of 6 0.8500	1 of 6 0.8500	0 of 4 0.0000
(S)	9	4 of 5 2.2143	1 of 5 0.9273	0 of 4 0.0000	0 of 6 0.0000
	10	2 of 4 1.5708	4 of 6 1.9177	0 of 6 0.0000	0 of 4 0.0000

Tab 6 (Observed and Normalized Hit Data for Sight, Range, Bank of Targets, and Subject) to APPENDIX C (Supplementary Tables)(Cont.)

SIGHT (B)		LARGE "0" (3)			
RANGE (R)		25 YDS (1)		50 YDS (2)	
BANK OF TARGETS (T)		NEAR (1)	FAR (2)	NEAR (1)	FAR (2)
S	1	1 of 5 0.9273	2 of 5 1.3694	0 of 4 0.0000	0 of 6 0.0000
U	2	1 of 4 1.0472	2 of 6 1.2239	1 of 6 0.8500	0 of 4 0.0000
B	3	0 of 6 0.0000	0 of 4 0.0000	0 of 4 0.0000	0 of 6 0.0000
J	4	2 of 4 1.5708	1 of 6 0.8500	0 of 6 0.0000	0 of 4 0.0000
E	5	0 of 5 0.0000	1 of 5 0.9273	0 of 4 0.0000	0 of 6 0.0000
C	6	0 of 4 0.0000	2 of 6 1.2239	1 of 6 0.8500	0 of 4 0.0000
T	7	2 of 4 1.5708	1 of 6 0.8500	1 of 6 0.8500	0 of 4 0.0000
S	8	1 of 5 0.9273	1 of 5 0.9273	1 of 4 1.0472	0 of 6 0.0000
(S)	9	3 of 4 2.0944	3 of 6 1.5708	0 of 6 0.0000	0 of 4 0.0000
	10	1 of 6 0.8500	0 of 4 0.0000	0 of 4 0.0000	1 of 6 0.8500

Tab 7 (Analysis of Variance for Sight, Range, Bank of Targets, and Subject) to APPENDIX C (Supplementary Tables)

SOURCE	d.f.	SS	MS
Sight Configuration (B)	2	1.5419350	0.7709675
Target Range (R)	1	19.3763600	19.3763600
Bank of Targets (T)	1	0.4968162	0.4968162
Subjects (S)	9	2.2080590	0.2453399
BxR Interaction	2	0.9814262	0.4907131
BxT Interaction	2	0.1026287	0.0513144
BxS Interaction	18	8.2448410	0.4580467
RxT Interaction	1	0.2482094	0.2482094
RxS Interaction	9	3.0835570	0.3426175
TxS Interaction	9	0.9892821	0.1099202
BxRxT Interaction	2	0.4524546	0.2262273
BxRxS Interaction	18	4.4353690	0.2464094
BxTxS Interaction	18	4.3763680	0.2431315
RxTxS Interaction	9	3.2830710	0.3647856
BxRxTxS Interaction	18	9.0694570	0.5038587

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13. ABSTRACT

A field experiment was conducted to determine whether a circular bracketing sight, framing the front sight on a standard rifle, could enhance the effectiveness of the rifle system in short range, stationary target engagements from a moving vehicle (5-10 mph). Two bracket sights (1.32 and 2.64 inches in diameter) were mounted on M16A1 rifles. "Type E" personnel targets, at ranges of 25 and 50 yards, were exposed individually in random sequence for 4.5 seconds. Ten enlisted subjects each fired 20 (3-round) bursts at the targets using each bracket sight and an unmodified control sight. Results showed that there was no significant difference between sights nor were there any significant interactions. Hit probability per burst was low (20.3%) due to vehicle bounce.

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A moving vehicle field experiment to determine the effectiveness of circular bracketing sights on the M16A1 rifle.