FIELD TEST OF AN EXPERIMENTAL BRACKETING SIGHT FOR THE M 16 A1 RIFLE

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THESIS

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September 1971

Approved for public release; distribution unlimited.

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1971

Thesis
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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, quick reaction type engagements. Two bracket sizes (1.32 and 2.64 inches in diameter) were mounted on M16A1 rifles. Targets at ranges of 25 and 50 yards, were exposed individually in random sequence for 1.6 seconds. Ten enlisted infantrymen each fired 20 rounds at the targets using each bracketing sight and an unmodified control sight. Results showed that a 23% increase in hits resulted with the smaller bracketing sight.

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ACKNOWLEDGEMENT

The authors wish to express their gratitude to the following people: Major F. A. Isgrig, MSC, U. S. Army for unlimited assistance in formulating, preparing for and conducting the experiments. Mr. Kenneth Mothersell for the excellent fabrication of the bracketing sights; and the officers and men of the Experimentation Command who cooperated so fully. Thank you.

I. BACKGROUND

A. GENERAL PROBLEM

The Small Arms Advisory Committee Summer Conference sponsored by the Advanced Research Projects Agency, Office of the Secretary of Defense and held at Stanford Research Institute, Menlo Park, California, from 22 June to 10 July 1970, sought to identify areas in small arms systems which needed improvement or change, and to isolate ideas and concepts which could lead to the development or modification of equipment and techniques to meet these needs. The fact that changes were needed was illustrated by statistics such as nearly 60,000 rounds per casualty as the average rate in Vietnam, compared to 10,000 in World War II and 20,000 in Korea.

B. SPECIFIC PROBLEM

Among the general areas investigated was the function of target acquisition. Target acquisition was defined as "the integrated process of detecting, identifying, in some cases designating, bringing weapon sights to bear, and firing."

In the sub-area of sighting, the committee concluded that while existing sighting systems on rifles and machine guns were rugged and reliable, and while they permitted the average rifleman to deliver accurate fire under firing range conditions, they appeared to contribute little to the infantryman's performance in the combat environment.

This was considered particularly true in most short range engagements and in all night actions.

C. RESEARCH EFFORT

The present project describes research which was conducted to determine the effects of a proposed concept for sighting system modification. The modification was proposed to enhance the effectiveness of an individual rifleman in short-range, quick-reaction engagements.

The primary goal of the research was to provide information which would aid in answering the following questions:

Would modification of the sighting system using the proposed concept increase the effectiveness of the individual rifleman?

What should the physical characteristics of the proposed modification be?

D. MODIFICATION

The proposed concept was to reverse the existing arrangement of the rifle sights. The rear sight would be a post, and the front sight a relatively large frame. The modified system would enable the infantryman to bracket the target quickly and relatively accurately.

II. EQUIPMENT DESIGN

A. PRELIMINARY CONSIDERATIONS

The facts that the modified sights would only be applicable to a portion of the situations in which a rifle would be employed and that the existing sighting systems were adequate for most other situations indicated that the modification should augment the existing sights and not impair the ability of the rifleman to use them.

This requirement could be satisfied by employing a frame around the front sight and leaving the rear sight unmodified.

B. SHAPE

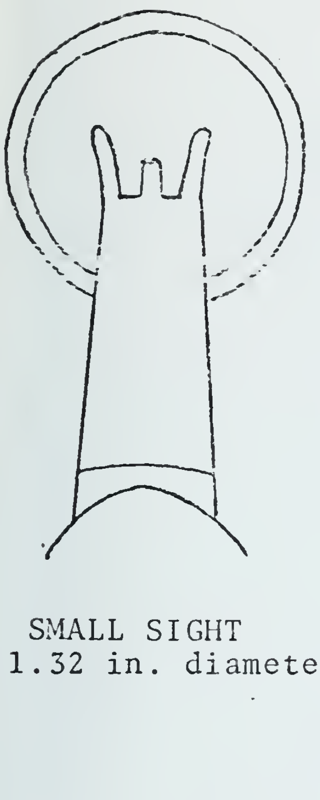
Two basic shapes were considered as potential candidates for the frame. These were a circle, and an open-topped rectangle. Mock-ups of two sizes of each type were mounted on a standard M16A1 rifle, and preliminary testing was conducted which indicated that the circular design more adequately bracketed a typical target.

The fact that the M16A1 rifle had been selected by the U. S. Armed Forces for use in jungle warfare, which is characterized by short-range, quick-reaction engagements, suggested using that rifle as a test vehicle.

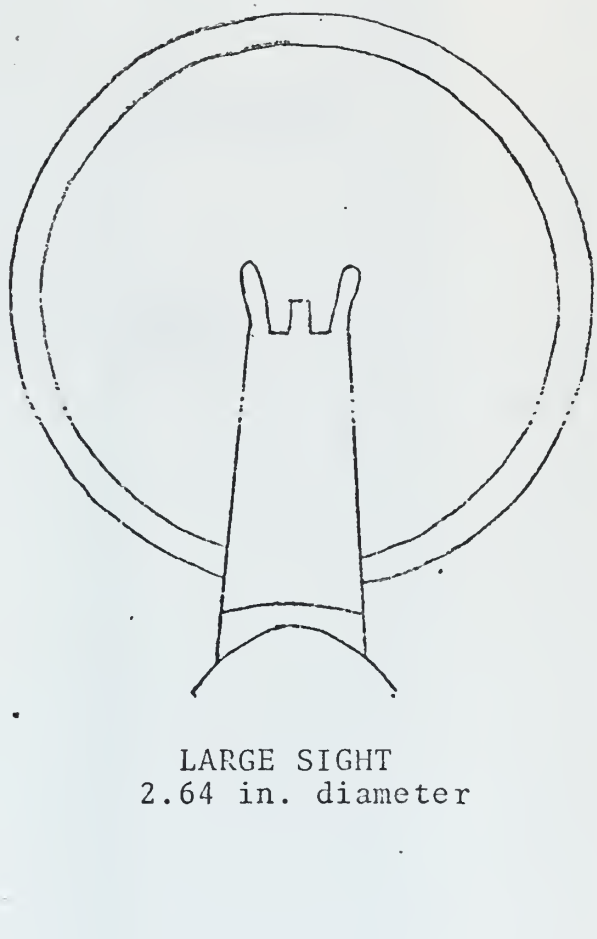
C. SIZE

To obtain information concerning the optimum diameter of the frame, it was necessary that more than one size be

tested. Frames were designed which when mounted on the M16A1 rifle would encompass the breadth of three average men, and six average men at a distance of 25 yards. The breadth of an average man was taken as 20 inches, so the sights would encompass 60 inches and 120 inches, respectively, at the prescribed distance [1]. The corresponding radii were .66 inches and 1.32 inches respectively. Figure 1 shows a sketch of the small and large bracketing sights as they would be seen by the shooter in relation to the front sight of an M16A1 rifle. Figures 2 and 3 show side views of the experimental sights mounted on the M16A1 rifle, Figures 4 and 5 show front views of experimental sights mounted on the M16A1 rifle, and Figures 6 and 7 show a rifleman at the ready holding an M16A1 rifle with the experimental sights.



SMALL SIGHT
1.32 in. diameter



LARGE SIGHT
2.64 in. diameter

Figure 1. Experimental Bracketing Sights (Circular).

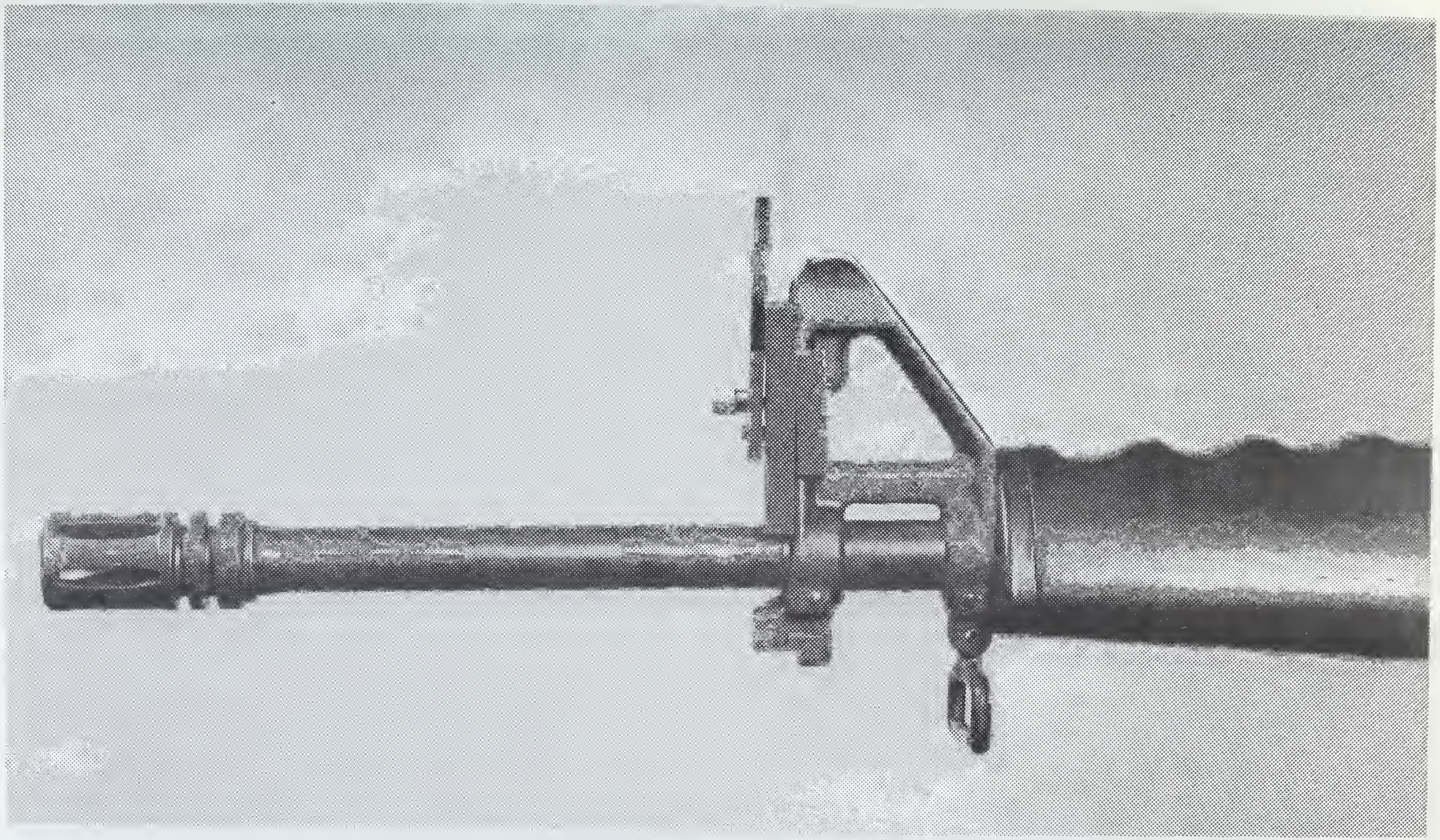


Figure 2. Side View of 1.32" dia Experimental Bracketing Sight on M16A1 Rifle.

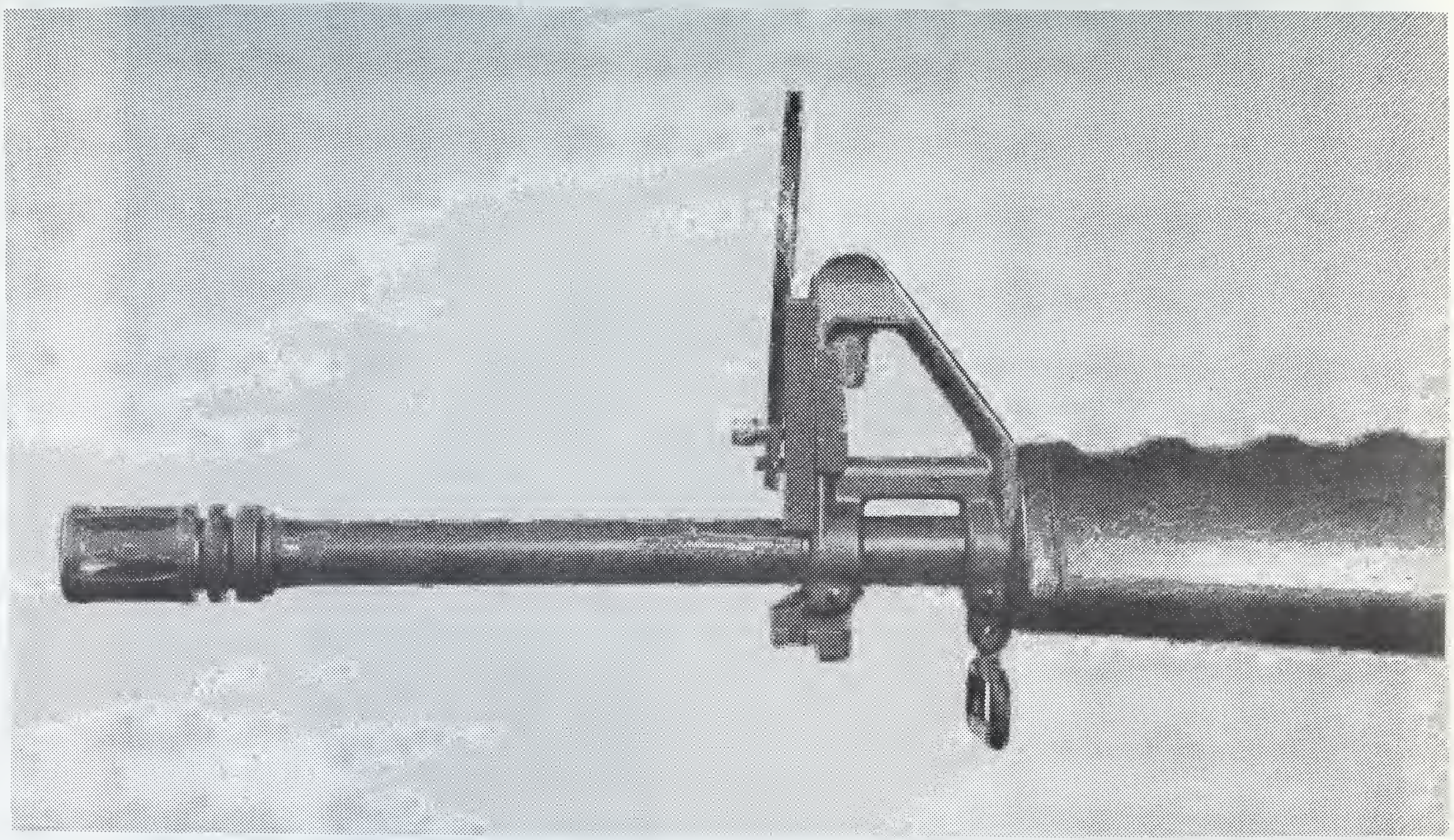


Figure 3. Side View of 2.64" dia Experimental Bracketing Sight on M16A1 Rifle.

Figure 4. Front View of 1.32" dia Experimental Bracketing Sight on M16A1 Rifle.

Figure 5. Front View of 2.64" dia Experimental Bracketing Sight on M16A1 Rifle.

Figure 6. Infantryman at the Ready Holding M16A1 Rifle with 1.32" dia Experimental Bracketing Sight.

Figure 7. Infantryman at the Ready Holding M16A1 Rifle with 2.64" dia Experimental Bracketing Sight.

III. PROCEDURES

A. TEST VARIABLES

Two standard M16A1 rifles were modified with the circular frames, and a third rifle was left unmodified. The primary variables were sight configurations, range to target, and direction to target relative to the rifleman. The second and third factors were chosen so that, in the event that a difference was detected between the sight configurations, it could be determined whether the differences were consistent under range and direction changes.

B. TEST PROCEDURE

A total of 10 subjects (Ss) was tested, all of whom were trained in the technique of quick-fire shooting. Performance with the different sight configurations was tested in a standardized testing situation. The test bed was an open area of flat terrain between two approximately 10 ft. high berms. The Ss stood at a designated firing position and fired at four pop-up targets which appeared in random order 10° right or left at ranges of 25 and 50 yards as shown in Figure 8. Only one round was fired at each target exposure, and each target appeared five times.

Each subject (Ss) fired the standardized test with each sight configuration. The order of firing and the sight configuration were randomly assigned. The firing was done under normal daylight conditions. The sky was partially

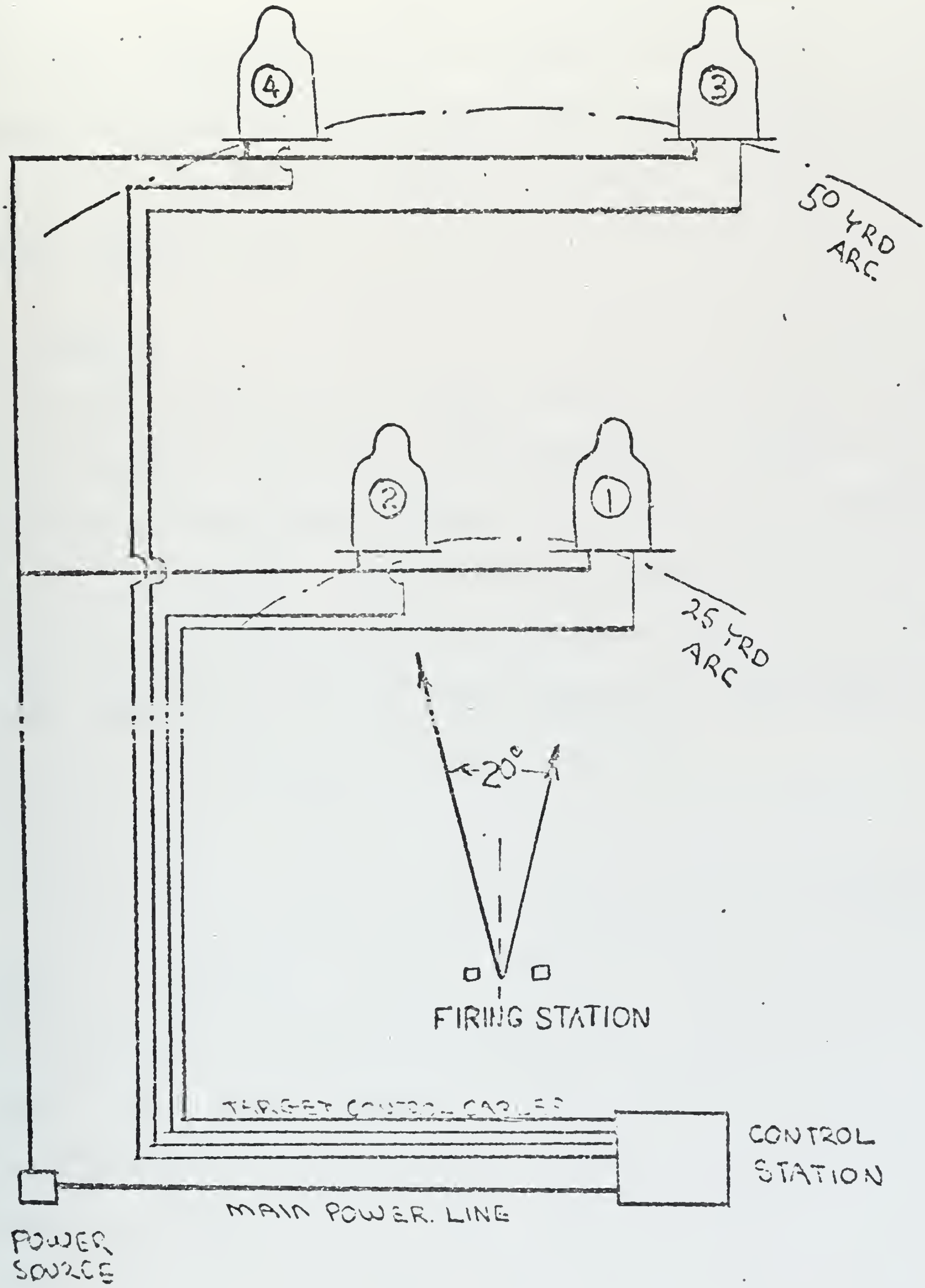


Figure 8. Layout of Test Range.

overcast, and the temperature was moderate to cool. All firing was done in the standing or offhand position, and all target exposures were 1.6 seconds in duration. Prior testing had indicated that this time interval would produce a hit probability slightly less than .5 with an unmodified M16A1 rifle.

C. SUBJECTS

The Ss were 10 U. S. Army enlisted men from "F" Company, Experimentation Battalion, Experimentation Brigade, U. S. Army Combat Development Command Experimentation Command, Ft. Ord, California. Each S had an infantry Military Occupational Speciality and all had previously been trained in the technique of quick-fire shooting. Other than that, no special selection criteria were used.

D. TRAINING

Prior to testing, the Ss were given approximately two hours of training. A short refresher lecture was given in the principles of quick-fire shooting, followed by brief instructions in the changes in that technique to be employed with the modified sight configurations. The Ss fired five rounds with each of the sight configurations to familiarize themselves with the proper body-weapon-target alinement, and then a complete training run of the experiment was conducted.

E. MEASURE OF EFFECTIVENESS

During testing, the ability of Ss to hit suddenly appearing targets at close range was determined. Ss were

required to fire one round at each exposed target, firing 20 rounds with each sight configuration. The measure of effectiveness was the number of hits scored on each target by each shooter with each sight configuration.

IV. FINDINGS AND THEIR IMPLICATIONS

A. SIGHT CONFIGURATIONS

Use of the smaller version of the sight modification yielded significantly more hits than use of either of the other two configurations. Use of the larger version of the modification did not yield a significantly different number of hits than the standard sight configuration. Using the small frame, 51.5% of the shots fired were hits, while with the large frame, 41.5% were hits, and with the standard rifle 42% of the shots hit the target. With 200 rounds fired using each sight configuration, the small bracketing sight yielded a 23% improvement over the standard sights.

These findings suggest that the experimental bracketing sight can considerably enhance performance in a short-range, quick-reaction situation, but that the effect is dependent upon the size of the sight modification.

B. RANGES

The targets which were 25 yards from the firing position were hit by a significantly larger proportion of the rounds fired at them than were those at 50 years. The closer targets were hit by 68.5% of the rounds fired at them, while those farther away received 31.5% hits.

These findings suggest that the inverse relation between distance and accuracy is severe at short ranges in quick-reaction firing.

C. DIRECTION OF FIRE

The targets on the right-hand side of the shooters were hit significantly more often than those on the left. The right hand targets received 55% hits, while those on the left received 45%.

These findings, combined with the fact that all Ss fired the rifle right-handed suggest that a rifleman is considerably more likely to hit a target on the side which matches the handedness of his shooting in a short-range, quick-reaction situation.

D. INTERACTIONS

The pairwise interactions between the test variables were not significant, and neither was the three-way interaction as shown in Figure 9.

The lack of significant interactions indicates that the improvement in hit probability achieved with the small sight modification is consistent over changes in range and direction, at least within the parameter values employed. This suggests that the rifleman could configure his weapon one way when he expected a short-range quick-reaction engagement, and not be concerned with range or direction to the target.

F. PREFERENCES

The Ss agreed significantly in the preference ordering of the sight configurations. The small bracketing sight was most preferred, the standard configuration second most

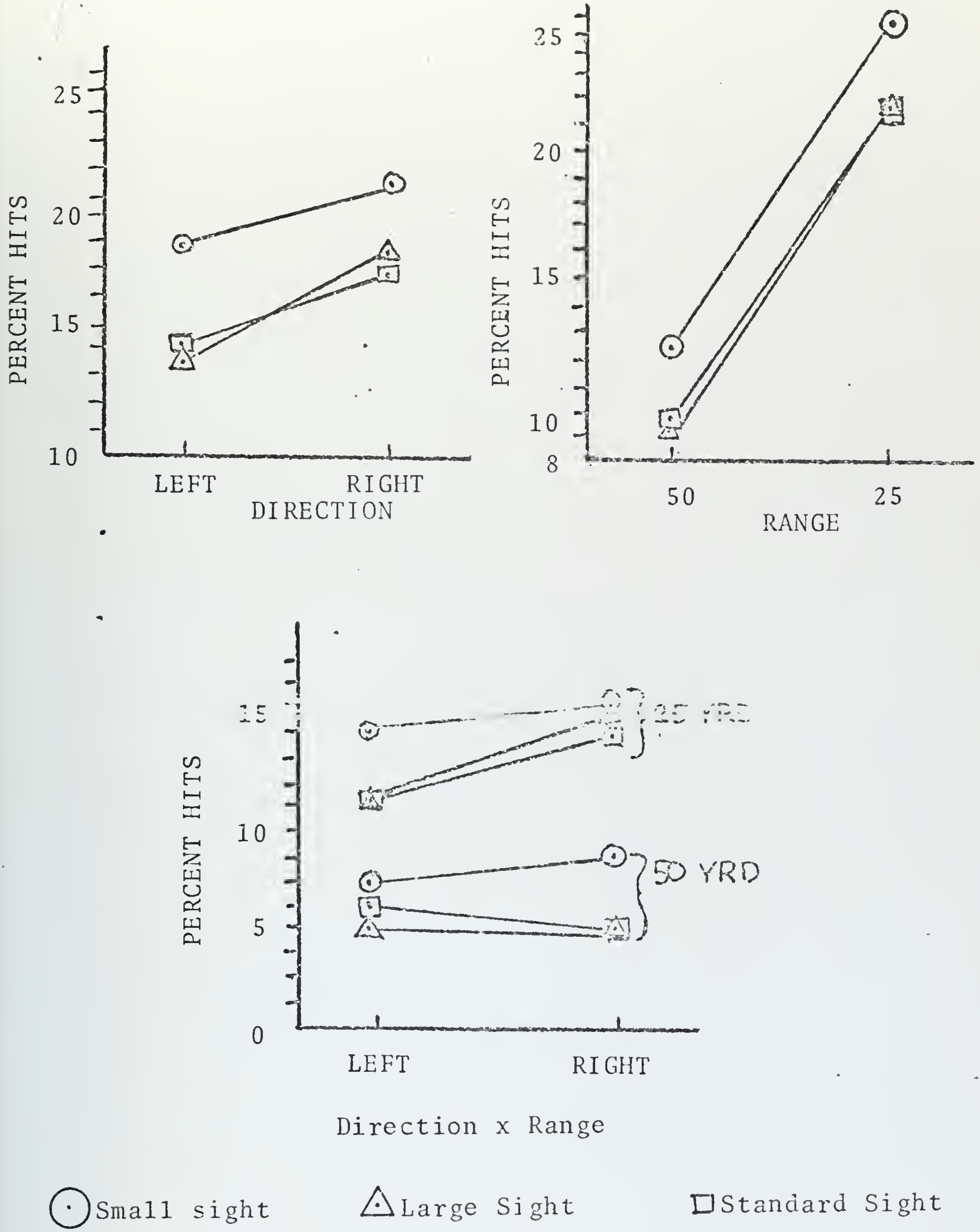


Figure 9. Relationships of Direction of Fire Range to Target and Sight Configuration to Percent Hits.

preferred, and the large bracketing sight was the least preferred.

V. CONCLUSIONS

The proportion of rounds which impact the target in short-range, quick-reaction engagements could be increased by the employment of a front sight modification in the form of a circle which surrounds the sight.

A modification of this type could be designed as an add-on modification to existing M16A1 rifles, at relatively low cost.

This modification would be beneficial in the training of the individual rifleman as well as in the employment of the weapon as it tended to increase the Ss confidence, by increasing the proportion of hits scored, and was preferred by the Ss above the standard sights.

VI. RECOMMENDATIONS

A. PRESENT CONCEPT

The question of whether or not the concept of augmenting the front sight with a frame could increase the probability of a hit in a short-range, quick-reaction engagement was answered in the affirmative. The question of what shape and size this frame should assume was not fully answered. Since it was demonstrated that a circular sight could significantly enhance a rifleman's performance, further testing could determine the optimum size, or set of sizes for such a circle to assume. This dimension having been determined, frames of other shapes, but sharing this major dimension could be tested to determine an optimum set of shapes. The final choice of physical characteristics for the frame would then be reduced to engineering considerations, i.e., lowest cost to manufacture, most rugged, most practical, etc.

The two areas of sighting in which the Small Arms Advisory Committee felt there was great need for improvement were short-range and night engagements. By placing a thin line of luminous material on the rear surface of several optimum or near-optimum frames, and conducting additional tests under varying levels of reduced visibility, it could be determined whether or not this concept would aid in the night engagement problem.

B. ALTERNATE CONCEPTS

The need for aids to sighting has been apparent for many years. Some of the items growing out of this need were the telescopic sight, and the single point sight. Advances in technology have led to rugged, economical models of these aids which could be adapted to military use. Additional testing could determine whether or not these devices would be superior to the concept expressed in this thesis.

C. TRAINING

It has been observed that personnel who are very familiar with rifles or shotguns have little or no problem adapting to military firing. The cost and time necessary to give a man not experienced with weapons this familiarity, however, precludes this solution to the small arms systems effectiveness problem. Testing beginning with untrained subjects could determine whether the front sight frame, used as a training aid, could enhance the individual rifleman's effectiveness with his weapon.

D. MOVING TARGETS

Targets fired at in this experiment, while fleeting, were stationary. The need to fire at a moving target in short-range, quick-fire engagements is no doubt high. In addition, small arms must be used effectively against helicopters and low-performance, fixed-wing aircraft in the event of a sophisticated enemy. There is every reason to believe

that the aid provided by the sight modification used in this project could be even more effective against moving targets. The optimum diameter, however, might change with the size and lateral speed of the target. Accordingly, this experiment should be repeated using moving personnel targets to achieve direct comparisons.

VII. TECHNICAL SUPPLEMENT

. EXPERIMENTAL PROCEDURE

1. Equipment

The weapons used in the experiment were three stan-dard U. S. Army issue M16A1 rifles. One rifle was modified with the 1.32 inch circular frame, and another with the 2.64 inch frame. The third rifle was used unmodified as a control. Two additional rifles were on hand in case one of the test weapons malfunctioned. All weapons were in aver-age issue condition.

Four target mechanisms (M31A1) were employed to provide the sudden target exposures, and initiate the hit indicator circuit.

An interval timer (Lafayette, Model 5004B) was used to initiate and control the target exposure.

A home-made control console was used to select the target for exposure, and indicate hits. A hit was in-dicated by illumination of two 115v. flourescent bulbs. Figure 10 is a schematic diagram of the control system.

The target mechanism control and hit signals were carried on a four pair cable, formed from two pairs of wire, communications, WD-1 TT. One cable was employed for each target mechanism. The A. C. power harness was fabri-cated from number 10 and number 12 copper wire (figure 8).

2. Terrain

The terrain was part of a known-distance rifle on Fort Ord, California. The firing position, and

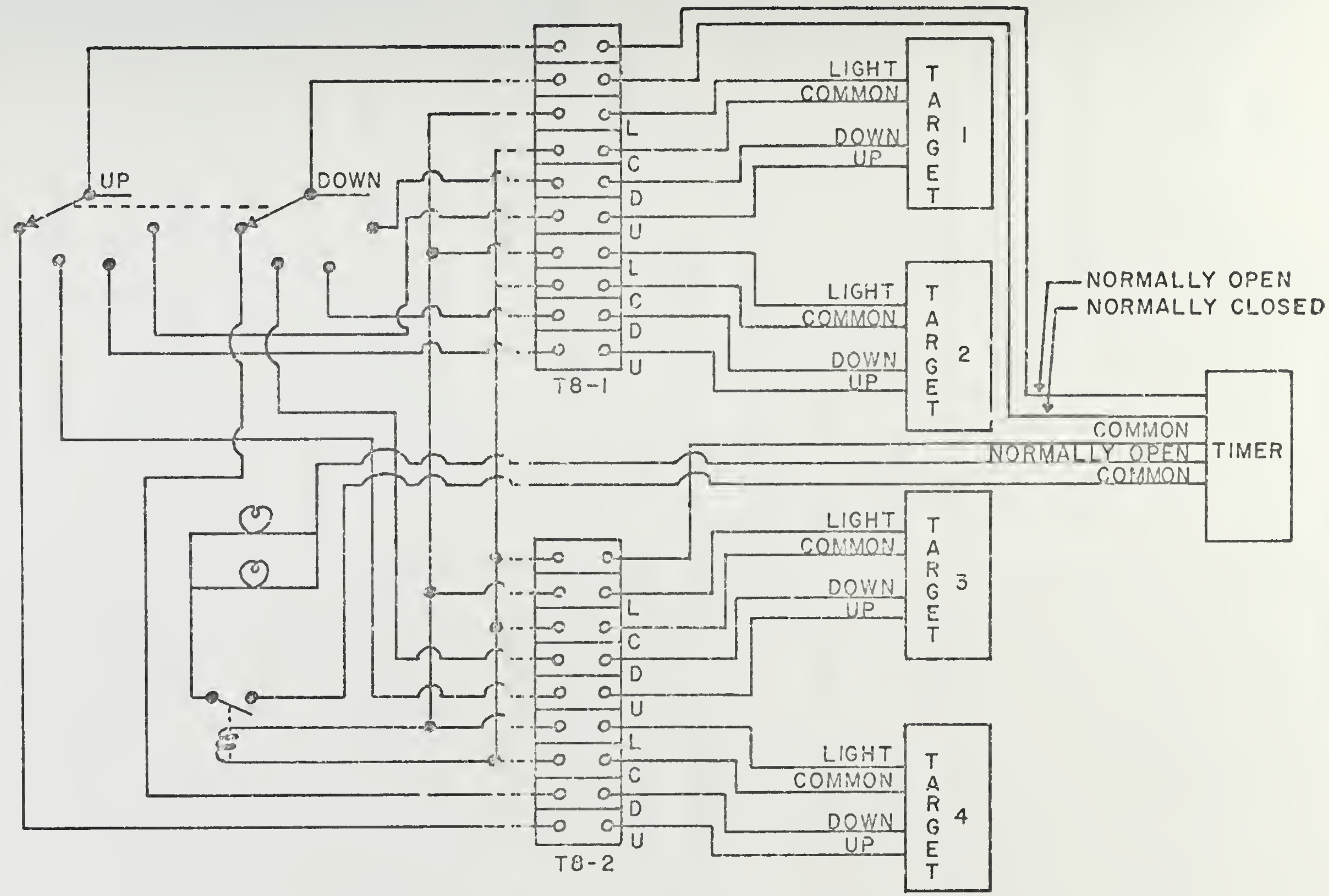


FIGURE 10. SCHEMATIC DIAGRAM FOR CONTROL SYSTEM.

all four target emplacements were situated in a flat area between the two approximately 10-ft. high berms which formed the 200 and 300 yard lines. The natural vegatation was short and sparce, and was not a factor in the target acquisition process.

3. Targets (Figure 11)

The targets at all four locations were "E" type polyethylene silhouettes, measuring 40.25 inches in height and 19.5 inches in breadth. The targets were mounted on the M31A1 target holding mechanisms.

The targets were displayed in a random order which was constrained so that each S faced each target an equal number of times with each sight configuration.

4. Subjects

The subjects were 10 enlisted men from "F" Company, U. S. Army Combat Development Command Experimentation Battalion, Experimentation Brigade, Experimentation Command, Fort Ord, California. Five different Ss were tested each day. Each S was tested using each sight configuration. All Ss had an Infantry Military Occupational Specialty, and had received quick-fire training in the past. Seven had experience in Vietnam.

5. Orientation

Upon arrival at the test site the Ss were given an orientation briefing. The target-acquisition problem was explained, as was the purpose of the experiment. The range configuration was explained, and its operation was demonstrated.

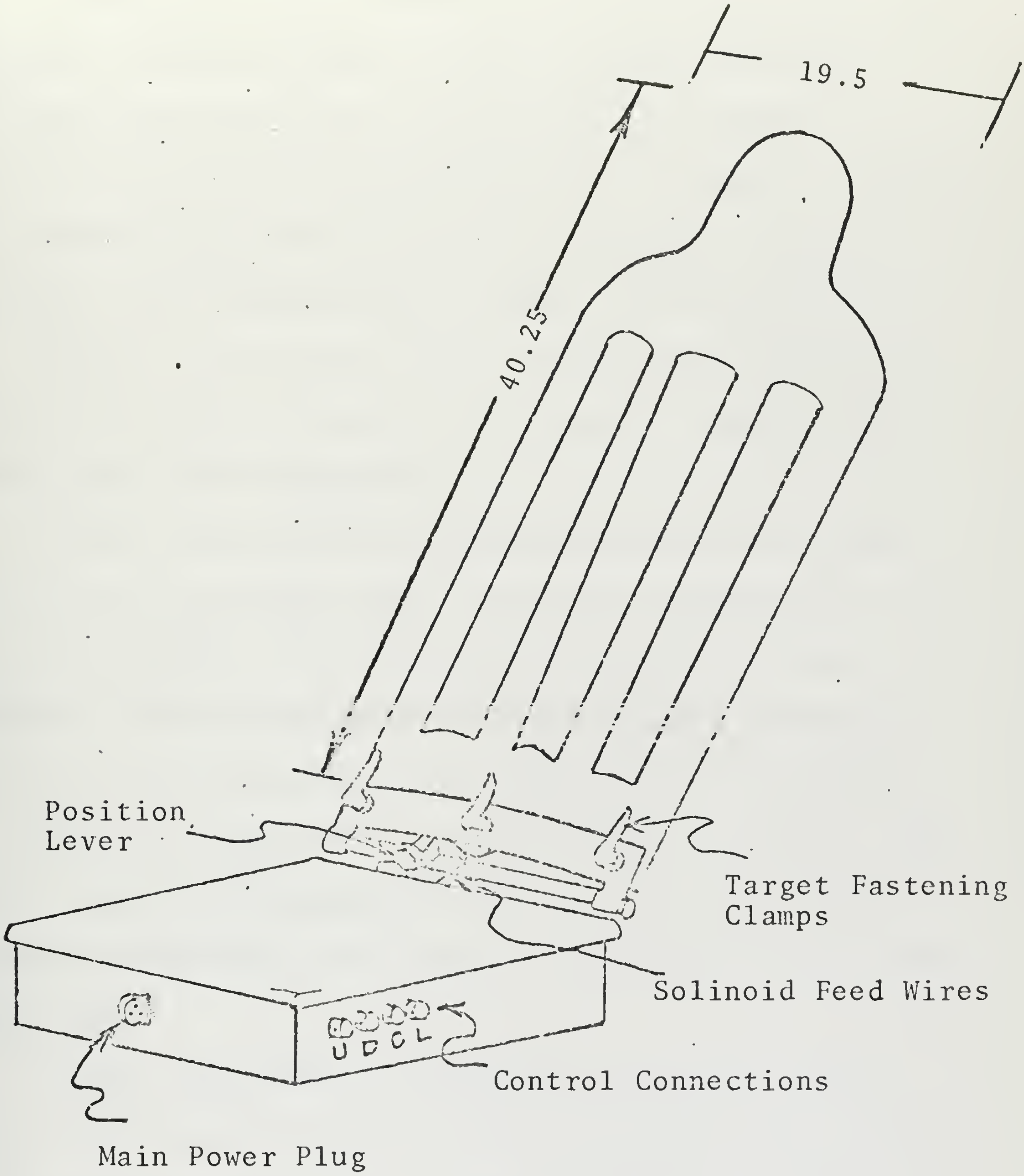


Figure 11. M31A1 Target Mechanism.

6. Training

Prior to actual testing with the weapons, the Ss were given a brief refresher lecture in the background principles, and objectives of the quick-fire technique. The lecture ended with an explanation of the modifications to the quick-fire method which were necessary to properly utilize the sight augmentation frames. These modifications were: firing with one eye closed, and looking *through* the frame at the target, as opposed to *over* the sights in the standard quick-fire procedure.

After an orientation demonstration of the range, each S fired five rounds with each sight configuration to familiarize himself with the proper body-weapon-target alinement. During this phase of training, the target exposures were of sufficiently long duration that time was not a factor (3-4 seconds). It was stressed, however, that standard sighting techniques should not be used since in the actual experiment, the exposure time would be too short to allow this.

After all Ss had fired fifteen familiarization rounds, a training run of the entire experiment was conducted. This run was identical to the actual experiment, except that different random orders of Ss, sight configurations and target exposures were employed.

7. Testing

Testing began after a break for the noon meal. When it became time for a S to fire, his number and the appropriate sight configuration were announced. The S then

took 1 magazine with twenty rounds, and the appropriately configured weapon to the firing position. The command was given to load and lock the weapon, and the question asked, "Are you ready?" At this time the S unlocked the weapon and replied that he was ready.

The targets were presented in random order, one at a time. When a target appeared, the S fired one round at it. He was told whether the shot was a hit or a miss, and, after a short unspecified interval, another target appeared. This process was repeated until 20 targets had appeared. The S then cleared the weapon, moved behind the firing line, reload the magazine, and waited until his next turn to fire. Since time was a factor, a shot did not indicate a hit if it was fired after the target started down. If the S failed to fire during an exposure, and the weapon had not malfunctioned, a miss was recorded.

8. <u>Post-testing</u>

Each day, after all Ss for the day had fired, the Ss were asked to fill out a questionnaire giving personal data and commenting on the problem, the concept, and the experiment. Appendix A is a copy of the post experiment questionnaire administered to the Ss, and Appendix B lists a summary of the responses.

B. DETAILED RESULTS

1. <u>Data</u>

The data was collected in 120 cells. Each cell described the number of hits achieved by each Ss with each

sight configuration for each target. Since the total number of rounds fired per cell was small (5), and the statistical analysis required data which was distributed according to the laws of a member of the normal family of distributed functions, the proportional variates were transformed using the transformation

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

where

P_{ijk} = the proportion from cell (i,j,k) [2].

Table I lists the data by cells. The number in the upper left-hand corner of each cell is the total number of hits for the given Ss, sight, target combination. This total, divided by five, formed the proportional variate which was transformed using the arcsine transformation. The resulting normal variates are the primary cell entries.

2. Initial Hypothesis

Seven primary null hypotheses were tested simultaneously, utilizing a four-factorial, randomized block design of an analysis of variance model. The Ss were considered blocks, since each S received all combinations of the test variables. The analysis of variance calculations were performed on an IBM 360 digital computer, utilizing the BMD02V program prepared by the Health Sciences Computing Facility, University of California at Los Angeles, revised Septebmer 12, 1969 [3].

TABLE I. TABLE OF OBSERVED AND NORMALIZED DATA

SIGHT (i)	STANDARD (1)			
DISTANCE (j)	25 YRD (1)		50 YRD (2)	
DIRECTION (k)	R(1)	L(2)	R(1)	L(2)
SUBJECTS (m) 1	3 1.7722	1 .9273	0 .0000	1 .9273
2	5 3.1416	2 1.3694	0 .0000	2 1.3694
3	4 2.2143	2 1.3694	2 1.3694	2 1.3694
4	4 2.2143	2 1.3694	1 .9273	1 .9273
5	3 1.7722	3 1.7722	2 1.3694	0 .0000
6	1 .9273	4 2.2143	2 1.3694	1 .9273
7	3 1.7722	2 1.3694	0 0.000	2 1.3694
8	5 3.1416	5 3.1416	2 1.3694	2 1.3694
9	3 1.7722	0 .0000	1 .9273	1 .9273
10	3 1.7722	3 1.7722	2 1.3694	2 1.3694
	34	24	12	1[illegible]

TABLE I. TABLE OF OBSERVED AND NORMALIZED DATA

SIGHT (i)	SMALL (2)			
DISTANCE (j)	25 YRD (1)		50 YRD (2)	
DIRECTION (k)	R(1)	L(2)	R(1)	L(2)
SUBJECTS (m) 1	3 1.7722	1 .9273	1 .9273	1 .9273
2	5 3.1416	4 2.2143	2 1.3694	2 1.3694
3	2 1.3694	1 .9273	1 .9273	1 .9273
4	4 2.2143	1 .9273	1 .9273	1 .9273
5	4 2.2143	4 2.2143	4 2.2143	2 1.3694
6	3 1.7722	5 3.1416	2 1.3694	3 1.7722
7	4 2.2143	5 3.1416	2 1.3694	0 .0000
8	5 3.1416	5 3.1416	3 1.7722	2 1.3694
9	3 1.7722	4 2.2143	1 .9273	1 .9273
10	3 1.7722	3 1.7722	2 1.3694	2 1.3694

TABLE I. TABLE OF OBSERVED AND NORMALIZED DATA

SIGHT (i)		LARGE (3)			
DISTANCE (j)		25 YRD (1)		50 YRD (2)	
DIRECTION (k)		R(1)		L(2)	
SUBJECTS (m)	1	2 1.3694	1 .9273	0 .0000	0 .0000
	2	4 2.2143	3 1.7722	1 .9273	1 .9273
	3	3 1.7722	0 .0000	2 1.3694	3 1.7722
	4	4 2.2143	1 .9273	3 1.7722	2 1.3694
	5	3 1.7722	3 1.7722	2 1.3694	0 .0000
	6	3 1.7722	3 1.7722	1 .9273	1 .9273
	7	5 3.1416	2 1.3694	0 .0000	3 1.7722
	8	4 2.2143	4 2.2143	2 1.3694	1 .9273
	9	5 3.1416	3 1.7722	0 .0000	0 .0000
	10	2 1.3694	3 1.7722	1 .9273	2 1.3694

The null hypotheses were of the forms: There is no difference between the levels of variable (i), i=1,2,3, there is no interaction effect between the levels of variable (i) and variable (j), i=1,2,3; j=1,2,3, i≠j, and there is no interaction effect between the levels of variable 1, variable 2, and variable 3 combined.

The alternate hypotheses were then of the forms there is a difference, or there is an interaction.

The hypotheses were tested in the following manner [4]:

a) Assume H_o true $\quad F \sim F_d^n$

b) Reject H_o if $F > F_d^n$ (α=.05)

c) Do not reject H_o if $F \leq F_d^n$ (α=.05)

The results of the F-ratio tests were as follows:

a) The null hypothesis (H_o): There was no difference between sight configurations was tested against the alternate hypothesis (H_A): there was a difference between sight configurations. The H_o was rejected at the α=.05 level ($F = 4.21039 > 3.55 = F_{18}^2$ (α=.05)).

b) The H_o: There was no difference between ranges to the targets was tested against the H_A: There was a difference between ranges. The H_o was rejected at the α=.05 level. ($F = 31.79702 > 5.12 = F_9^1$ (α=.05)).

c) The H_o: There was no difference between directions to the targets was tested against the H_A: There was a difference between directions to the target. The H_o could not be rejected at the α=.05 level, but could be at

the α=.10 level. (F_9^1 (α=.05) = 5.12 > F = 3.90604 > F_9^1(α=.10) = 3.36).

d) The H_o: There was no interaction between sight configuration and range to the target was tested against the H_A: There was an interaction between sight configuration and range to the target. The H_o could not be rejected at either the α=.05 level, or at the α=.10 level. (F_{18}^2 (α=.10) = 2.02 > F = .04368).

e) The H_o: There was no interaction between sight configurations and directions to the targets was tested against the H_A: There was an interaction between sight configurations and directions to the targets. The H_o was not rejected at either the α=.05 level or the α=.10 level. (F_{18}^2(α=.10) = 2.02 > F = 1.00519).

f) The H_o: There was no interaction between ranges to the targets and directions to the targets was tested against the H_A: There was an interaction between ranges to the targets and directions to the targets. The H_o was not rejected at either the α=.05 level or the α=.10 level. (F_9^1 = 3.36 > F = 2.07092).

g) The H_o: There was no three-way interaction between sight configurations, ranges to the targets, and directions to the targets was tested against the H_A: There was a three-way interaction between sight configurations, ranges to the targets, and directions to the targets. The H_o was not rejected at either the α=.05 level or the α=.10 level (F_{18}^2(α=.10) = 2.02 > F = 1.7426).

Tables II and III list the results of the analysis of variance calculations and the formulas for computing the F-ratios with the test results respectively.

3. Subsequent Hypothesis

Analysis of variance calculations, and F-ratio tests only serve to demonstrate that a statistically significant difference exists between the effects of different levels of the variables. For those variables with more than two levels, further testing is required to determine which levels or groups of levels differ significantly [4].

The Scheffé multiple comparison test was used to determine which sight configuration differed from which others. Using the method described in [5], a set of F-values were calculated to test the null hypotheses, that the various sight types and groups of sight types did not differ. These F-values were then compared to critical values derived from the F-distribution family to test whether or not the null hypotheses could be rejected at the α=.10 level of significance. Table IV lists the coefficient and calculation values used in the Scheffé test. The F ratios were formed by dividing the A value for a given comparison by the associated mean square value listed in the analysis of variance calculations. The degrees of freedom (df) for the numerator of this statistic is equal to the number of levels (k) minus one. (In this case 3-1=2.) The denominator df is equal to the number of data points per level (N) minus one, times the number of levels 3(40-1) = 117. If

TABLE II. ANOVA TABLE OF NORMALIZED DATA FOR 4 FACTORIAL RANDOMIZED BLOCK DESIGN

SOURCE	d.f.	SS	MS
Sight Configuration (1)	2	2.42621	1.21310
Target Distance (2)	1	22.74823	22.74823
Target Direction (3)	1	1.38020	1.38020
Subjects (4)	9	10.89221	1.21025
1x2 Interaction	2	0.02859	0.01430
1x3 Interaction	2	0.19362	0.09681
1x4 Interaction	18	5.18617	0.28812
2x3 Interaction	1	1.39899	1.39899
2x4 Interaction	9	6.43877	0.71542
3x4 Interaction	9	3.18015	0.35335
1x2x3 Interaction	2	1.24936	0.62481
1x2x4 Interaction	18	5.90927	0.32829
1x3x4 Interaction	18	1.73357	0.09631
2x3x4 Interaction	9	6.07984	0.67754
1x2x3x4 Interaction	18	6.44965	0.35831
TOTALS	119	75.29498	

TABLE III. COMPUTATIONAL FORMULAS OF TEST STATISTICS AND RESULTS OF HYPOTHESIS TESTING

TEST		TEST STATISTIC*	STATISTIC VALUE	DIST. UNDER H_o	$F_d^n(.05)$	RESULT
1	H_o: No effect H_A: Sight effect	MS_1/MS_{1x4}	4.21039	F(2,18)	3.55	REJECT
2	H_o: No effect H_A: Distance effect	MS_2/MS_{2x4}	31.79702	F(1,9)	5.12	REJECT
3	H_o: No effect H_A: Direction effect	MS_3/MS_{3x4}	3.90604	F(1,9)	5.12	FAIL
4	H_o: No interaction H_A: Sight-Dist. Interaction	MS_{1x2}/MS_{1x2x4}	.04368	F(2,18)	3.55	FAIL
5	H_o: No interaction H_A: Sight-Dir. Interaction	MS_{1x3}/MS_{1x3x4}	1.00519	F(2,18)	3.55	FAIL
6	H_o: No interaction H_A: Dist.-Dir. Interaction	MS_{2x3}/MS_{2x3x4}	2.07092	F(1,9)	5.12	FAIL
7	H_o: No interaction H_A: Sight-Dist-Dir. Interact.	$MS_{1x2x3}/MS_{1x2x3x4}$	1.7426	F(2,18)	3.55	FAIL

*SUBSCRIPTS: 1 = Sights, 2 = Distance, 3 = Direction, 4 = Subjects

TABLE IV. TABLEAU FOR SCHEFFÉ MULTIPLE COMPARISON TEST FOR SIGHT CONFIGURATIONS

GROUPS COMPARED*	COEFFICIENTS a_1	a_2	a_3	Σa^2	D	A
1 vs 2	1	-1	0	2	-11.0752	1.5333
1 vs 3	1	0	-1	2	1.7820	.0397
2 vs 3	0	1	-1	2	12.8572	2.0663
2 vs 1+3	-1	2	-1	6	23.9324	2.3865

*Subscripts 1 = Standard 2 = Small 3 = Large

$\Sigma X_1 = 55.0632$ $\Sigma X_2 = 66.1384$ $\Sigma X_3 = 53.2812$

this F-ratio is called F, then the statistic (1/k-1)F has the $F^{(k-1)}_{(n-1)}$ distribution. The critical value for F was, therefore formed, $F_{crit} = 2F^{2}_{117}$ (=.10) = 4.70. The test used was:

a) If $F > F_{crit}$, reject H_o

b) If $F \leq F_{crit}$, do not reject H_o

The hypotheses, F values and results for the Scheffe test are tabulated in Table V.

4. <u>Post-Experiment Testing</u>

In order to characterize the Ss preferences for the different sight configurations, their preference ordering responses from the questionnaires were analyzed using the Kendall Coefficient of Concordance Test [6].

Using Kendall's test, the

H_o: There is no agreement in the Ss preferences for sight configurations was tested against the

H_A: There is agreement.

The H_o was rejected at the α=.01 level. ($S^{3}_{10}(\alpha=.01) = 85.1 \leq S = 98$). The data, calculations and results of the Kendall test are listed in Table VI.

TABLE V. RESULTS OF TESTS OF HYPOTHESIS FOR SCHEFFE MULTI-VARIABLE COMPARISON TEST

TEST	HYPOTHESES	F_{test} Value	F_{crit} (α=.1)	RESULT
1	H_o: Standard same as small H_A: Small better	5.3217	4.70	REJECT
2	H_o: Standard same as large H_A: Standard better	.1363	4.70	FAIL
3	H_o: Small same as large H_A: Small better	7.1717	4.70	REJECT
4	H_o: Small same as std., large combination H_A: Small better	8.2830	4.70	REJECT

TABLE VI. DATA OF SUBJECT SIGHT PREFERENCE AND CALCULATIONS FOR KENDALL'S COEFFICIENT OF CONCORDANCE TEST.

	N=3 K=10	STANDARD	SMALL	LARGE	
SHOOTERS	1	1	2	3	
	2	2	1	3	
	3	2	1	3	
	4	2	1	3	
	5	1	2	3	
	6	1	2	3	
	7	3	1	2	
	8	3	1	2	
	9	1	2	3	
	10	1	2	3	
	R_i	17	15	28	$\Sigma R_j = 60$
	$R_i - \Sigma R_i/N$	- 3	- 5	8	
	$(R_j - \Sigma R_j/N)^2$	9	25	64	$S = (R_j - \Sigma R_j/N)^2 = 98$

$$W = .49 = S/\frac{1}{12}k^2(N^3-N)$$

$S(3,10)^{\alpha=0.1} = 85.1 \leq S = 98$ REJ H_o: No Agreement in Preference

APPENDIX A: POST EXPERIMENT QUESTIONNAIRE

I. BACKGROUND INFORMATION

1. Shooter number.
2. Name.
3. Rate
4. Soc. Ser. Number.
5. M.O.S.
6. Age.
7. Yrs Active Duty.
8. Are you right/left handed?
9. Are you quick-fire trained?
   If yes, where and when?
10. Have you been stationed in Vietnam?
    If yes, how long?
    Did you use quick-fire techniques?
11. Non-Military Shooting Experience?
    a. Have you hunted?
       1. Never
       2. 1-2 times
       3. 3-5 times
       4. 6-10 times
       5. 11-15 times
       6. over 15 times
    b. If you hunt, is your weapon experience with?
       1. Shotgun only
       2. Rifle only
       3. Some shotgun, mostly rifle
       4. Some rifle, mostly shotgun
       5. Other
12. Do you enjoy firing weapons?
13. Do you own a weapon?
14. Are you a member of NRA?
15. Were you raised in urban or rural community?

II. COMMENTS UPON THE EXPERIMENT

1. Do you feel there is a need to improve quick-fire shooting techniques? Yes or no. Explain answer.
2. Do you feel the concept behind the special sights are valid? Yes or no. Explain answer.
3. Does the testing method seem as though it will determine which sight configuration is best? Yes or no. Explain answer.
4. Do you feel that target time was?
   a. too long
   b. too short
   c. adequate
5. Do you feel the target distances were correct? Yes or no. If not what distance would you suggest.

6. Was the training given prior to testing beneficial to you? Yes or no.
7. Would more training have yielded better results? Yes or no. If yes, what type?
   a. more lectures
   b. more practice
   c. both

III. COMMENTS AND RECOMMENDATIONS

1. How could the experiment be improved in the following areas?
   a. Gaining knowledge about which sight is superior
   b. Benefit to shooters
   c. Benefit to armed forces
   d. Treatment of shooters
   e. Obtaining general knowledge
2. Which target(s) did you feel most confident in hitting?
3. Do you feel you scored significantly better with one particular sight configuration and, if so, which one?
4. Do you feel you would have scored significantly better with anyone of the sights if exposure time was longer? If so, which sight(s) and explain.
5. Rank the 3 sights in order of preference.

APPENDIX B: SUMMARY OF SUBJECTS RESPONSES TO POST EXPERIMENT QUESTIONNAIRE

I. BACKGROUND INFORMATION

1. Age: Ages ranged from 17 to 23 yrs; avg. 20.9

2. Yrs. Active Duty: Range from 6 mos to 4 yrs; avg 21 mos.

3. Vietnam Tour: 80% had a tour with avg length of 10 mos. Range 2-12 mos.

4. 100% quick-fire trained within 6 mos of entering service

5. Non-military shooting experience
   Never 20%
   1-10 20%
   over 15 60%

   Weapon experience: (of the 8 men with non-mil exp)
   37.5% rifle only
   25 % some shotgun mostly rifle
   37.5% some rifle mostly shotgun

6. Enjoy firing 80%

7. Own weapon 50%

8. NRA member 10%

9. Rural community 50%

II. 1. 90% - need to improve
   why - most tgts in a fire fight are close range and moving. Q.F. training needed to handle this, to kill and increase of protection

2. 90% valid concept

3. 90% testing determine best

4. 60% too short
   40% adequate

5. 100% correct range

6. 100% beneficial

7. 80% more training - 52.5% practice - 37.5% both

III. 1.a. 30% response. Summary: More practice. More background as to reason for choosing special sights. Do not tell shooter when recording hits. Test the sights with the same weapon and have shooter fire the 3 sights consecutively.

b. 30% response. Summary: More practice. Do not tell shooter when recording to eliminate tension.

c. 10% response. Summary: Actual combat trials.

d. 10% response. Summary: Run on warmer day.

e. 10% response. Summary: A class session of sight configurations.

2. 80% felt closer range targets
10% felt right direction targets
10% felt target number three

3. 30% no response
15% standard sight
55% small sight

4. 20% no response
10% no advantage since purpose of quick fire is not to aim
50% advantage on all three sights since more time would calm down shooters, allow weapon to be brought to firing position, and would teach shooters particular sight characteristics to be used with shorter times.
20% tandard and small sight advantage, not large

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Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

ORIGINATING ACTIVITY (Corporate author)

Naval Postgraduate School
Monterey, California 93940

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

REPORT TITLE

FIELD TEST OF AN EXPERIMENTAL BRACKETING SIGHT FOR THE M16A1 RIFLE

DESCRIPTIVE NOTES (Type of report and, inclusive dates)

Master's Thesis; September 1971

AUTHOR(S) (First name, middle initial, last name)

William G. Kemple
John W. McKinney

REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1971	57	6

CONTRACT OR GRANT NO.

PROJECT NO.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

DISTRIBUTION STATEMENT

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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, quick reaction type engagements. Two bracket sizes (1.32 and 2.64 inches in diameter) were mounted on M16A1 rifles. Targets at ranges of 25 and 50 yards, were exposed individually in random sequence for 1.6 seconds. Ten enlisted infantrymen each fired 20 rounds at the targets using each bracketing sight and an unmodified control sight. Results showed that a 23% increase in hits resulted with the smaller bracketing sight.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Small Arms						
Bracketing Sights						
Sighting Systems						

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