A FIELD EXPERIMENT TO DETERMINE THE EFFECTIVENESS OF A CIRCULAR BRACKETING SIGHT AT LOW-LIGHT LEVELS FOR THE M16A1 SERVICE RIFLE

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Monterey, California

THESIS

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A field experiment was conducted to determine the effectiveness of a circular bracketing sight in improving the hit capability of the M16A1 rifle at low-light levels at short range in quick-reaction situations. Eight riflemen fired at four pop-up targets that appeared for 2.5 seconds at ranges of 20 and 40 meters. The subjects used weapons fitted with the standard sight (control) and a circular bracket sight. Testing was conducted on the Live Fire Instrumented Range at Fort Hunter-Liggett, Ca., at a low-light level

20. (continued)

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by

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I. BRIEF

A. PROBLEM

The problem investigated was to determine the effectiveness of a circular bracketing sight in improving the hit capability of the M16A1 rifle at low-light levels at short range in quick-reaction situations.

B. PROCEDURE

In a field experiment, eight riflemen fired single-shot at four pop-up targets that appeared for 2.5 seconds to the right and left of the firer at ranges of 20 and 40 meters. The subjects used weapons fitted with the standard sight (control) and a circular bracket sight.

Testing was conducted on the Live Fire Instrumented Range at Fort Hunter-Liffett, Ca., at a low-light level of 0.25 footcandles. This light level criterion was chosen in order to measure the capability of the eight subjects to detect and hit a target under conditions of reduced illumination, such as twilight, and for comparison with the results of previous field tests under daylight conditions.

The performance of the subjects was analyzed to determine whether significant differences in hit capability existed between the two sight configurations, ranges, and directions of fire.

C. FINDINGS

The circular bracket sight resulted in a significant increase in the number of targets hit. The results show that the bracket sight was 42% better than the standard sight over the entire experiment. It was better by 33% at 20 meters and 56% at 40 meters. Statistically significant effects were found for sights and for ranges.

D. UTILIZATION OF FINDINGS

The findings clearly support the advantages of the bracket sight at low-light levels over the standard sight in quick-fire situations. Other indications were that the bracket sight might serve as a useful training aid in quick-fire techniques and as an aid to permit capturing and holding the target picture when the body is working against recoil forces of the M16A1 firing automatic or the M-60 machine gun.

II. BACKGROUND

A. CONCEPT DEVELOPMENT

Among the general areas investigated by the Department of Defense Conference on Small Arms held at Stanford Research Institute in 1970 was the function of fast target acquisition using quick-fire with the standard service rifle sights in the combat environment. Target acquisition was defined as "the integrated process of detecting, identifying, bringing weapon sights to bear, and firing."

An activity analysis of this type of fire suggested that a sight that would aid the firer in quickly acquiring his target might improve the accuracy and quickness of fire. One of the conference attendees, Mr. J. K. Arima, a professor at the Naval Postgraduate School (NPS), Monterey, Ca., later conceived the idea of a sight to bracket the target, rather than aligning a weapon on the target as a means to improve pointing fire [4].

An explanation of the current military quick-fire method, target acquisition, and the role that bracketing sights play in it is as follows. The standard quick-fire technique is to start from a slightly crouched port-arms position, snap the weapon to the shoulder obtaining a firm stock-weld, and with both eyes open and using an instinctive pointing technique, sight over the front blade sight focusing on the target, and

fire. The method for using a bracket sight is the same as previously described except that the firer is instructed to close one eye and look through the sights until the target is bracketed in the circular frame.

When time to the first hit is of paramount importance, very rapid acquisition or capturing of the target is a necessity. If the weapon is already at the shoulder, it must be slewed to where it is pointing at the target. If the weapon is at port arms, bringing the weapon to the shoulder and pointing it at the target may be accomplished in a more-or-less single movement. However, final adjustment using a smaller slewing movement will be required to acquire the target properly. Thus, taking the shoulder as a point of reference, the muzzle end of the weapon must be slewed to where it is pointing directly at the target. This is the simple, but all-important process of target acquisition in the quick-fire situation [4].

B. PREVIOUS RESEARCH

1. Sight Design

The basic concept in designing an appropriate sight was to reverse the existing arrangement of rifle sights. That is, the rear sight was to be the post and the front sight, a relatively large bracket.

Such a sight was subsequently created with the participation of Captain W. G. Kemple, USMC, a student at NPS, as part of a thesis project [2]. A circular sight that would bracket the target was designed

and mounted on the front blade sight of an M16A1 rifle. A large and small sight were designed since it was not known what size would be optimum.

The smaller bracketing sight was designed to encompass the breadth of three average men at a distance of 25 yards (22.86 m) and the larger frame to encompass six men at that distance. Because of time constraints regarding constant low-light levels and because of the greater efficiency of the smaller sight in previous research on stationary targets, only the small circular bracketing sight was used in this field experiment.

The actual diameter of the small sight was 1.32 in. (3.35 cm.) and the ring metal as viewed by the firer was 1/8 in. (3.18 cm.). The entire bracketing sight, made in three pieces, is shown attached to the front sight of the M16A1 rifle in a front and side view in Figures 1 and 2, respectively. The mounting piece had a long vertical slit which permitted the vertical adjustment of the bracketing sight using a knurled set screw as shown in Figure 1. The separate component parts of the small bracketing sight are displayed in Figure 3. In contrast, a front view of the standard blade sight on the M16A1 rifle is shown in Figure 4.

2. Previous Field Experiments

In a stationary target experiment by Kemple and McKinney [2], riflemen fired single shots at pop-up targets that appeared for 1.6

seconds at ranges of 25 and 50 yards. They used weapons with the standard sight (control) and the two bracketing sights. The small bracketing sight was found to be better than the other two and was better by 31% at 50 yards and by 19% at 25 yards when compared with the standard sight using quick-fire doctrine.

This test was followed by a field experiment conducted by Fisher and McLeskey [1] using moving targets. In this test riflemen fired at a pop-up silhouette target that appeared for 2.5 seconds while moving laterally at 6 mph at ranges of 25 and 50 yards. The three sight conditions were as before. The small and large bracketing sights were significantly better than the control sight; however, the larger bracketing sight achieved the most hits and was better by 118% at 25 yards and by 275% at 50 yards over the standard sight.

The above results showed that a sight aid, such as the bracketing sights, could improve short range, quick-fire markedly. The degree of improvement was greater as the task became more difficult.

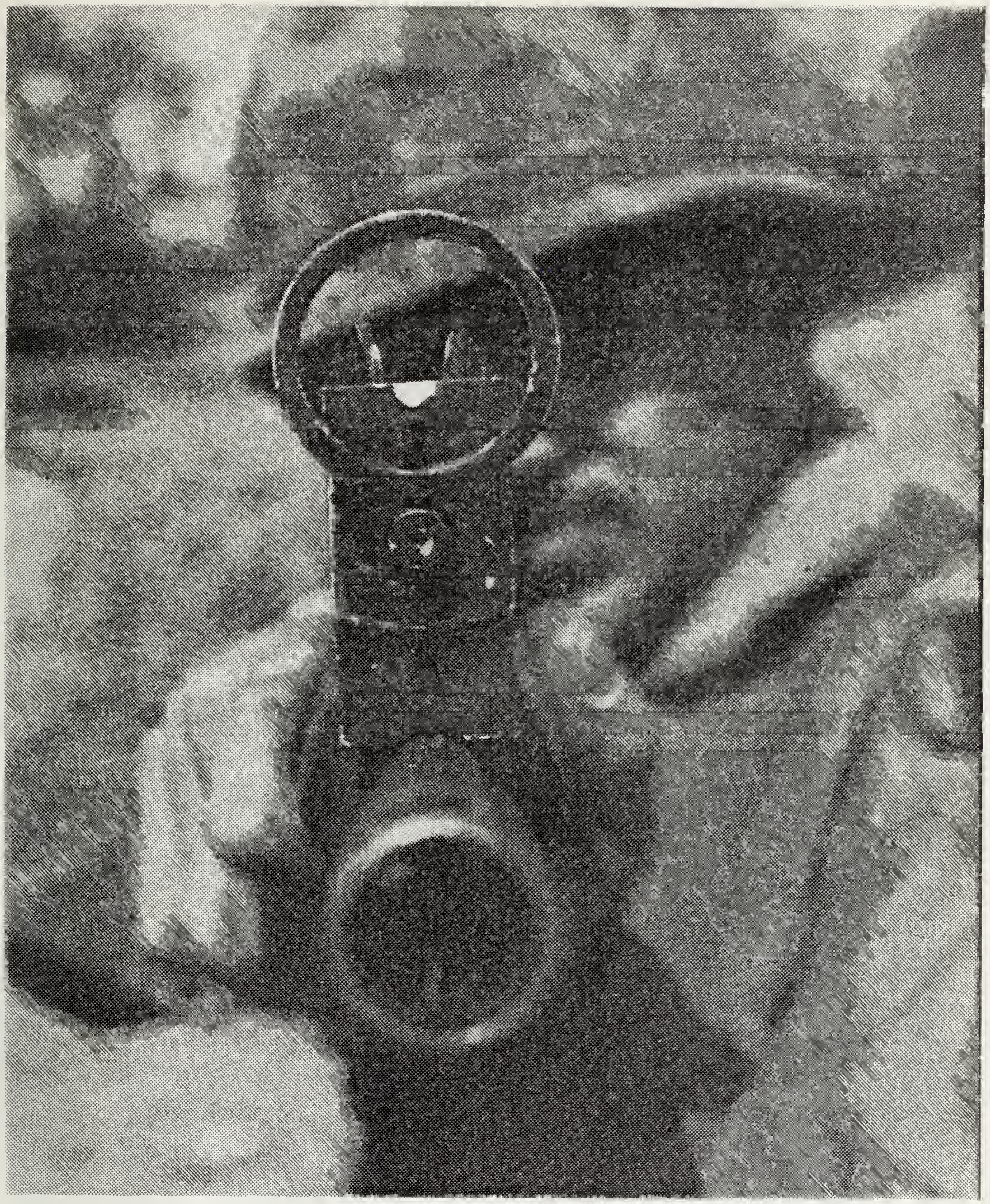

Figure 1. Front View of Small Bracket Sight on M16A1 Rifle.

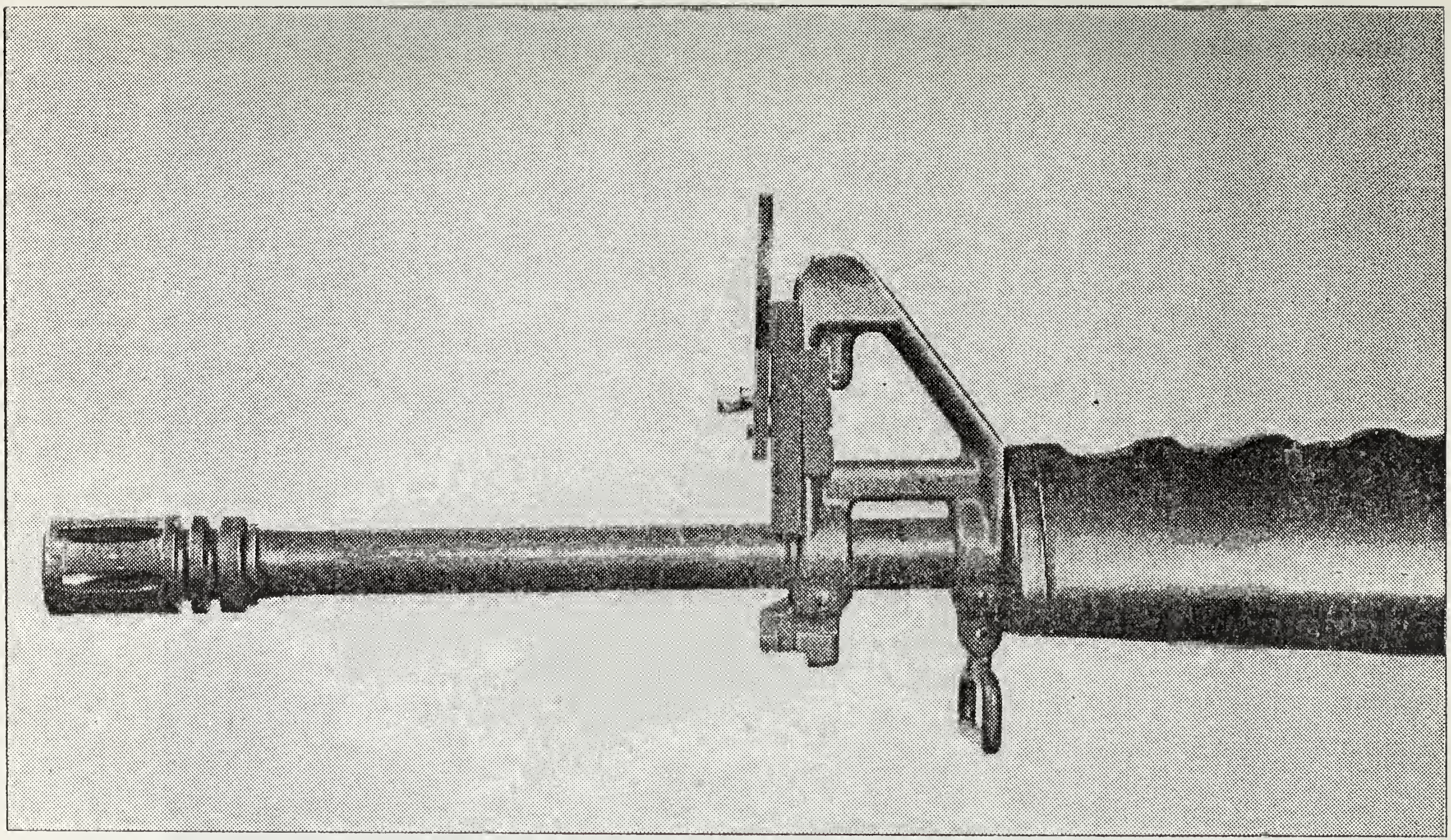

Figure 2. Side View of Small Bracket Sight on M16A1 Rifle.

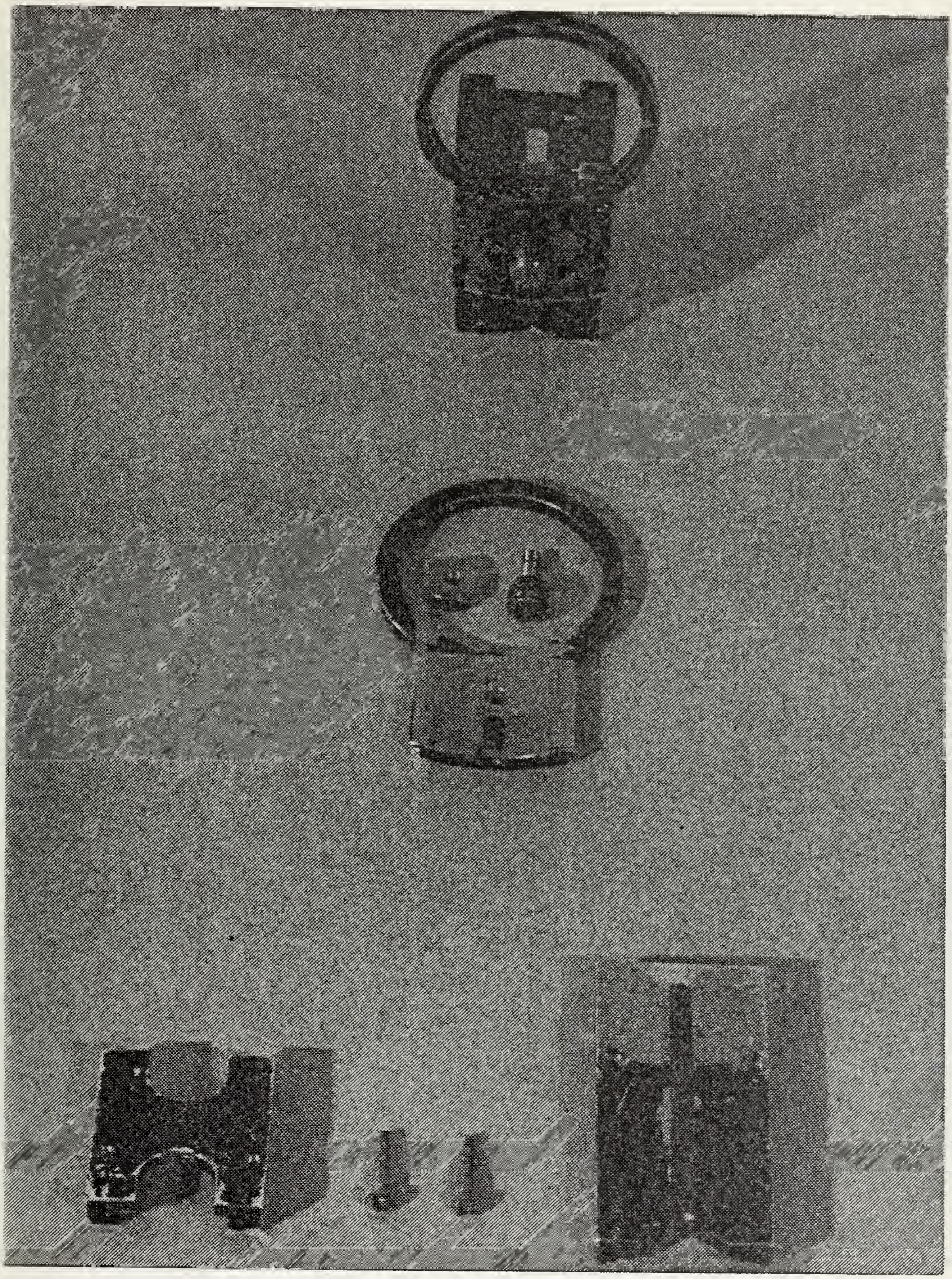

Figure 3. Component Parts of the Small Bracket Sight.

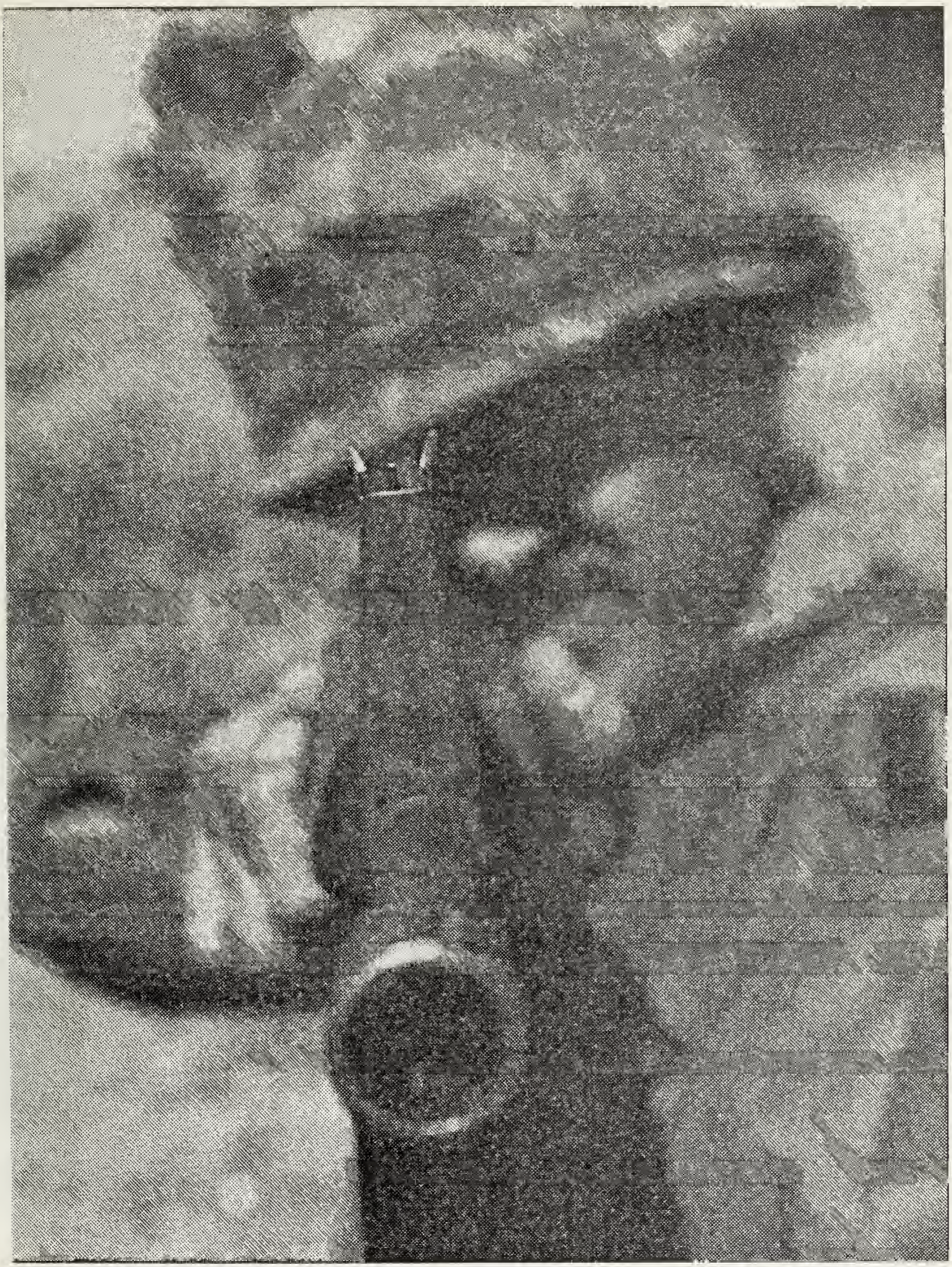

Figure 4. Front View of Standard Blade Sights on M16A1 Rifle.

III. EXPERIMENT DESIGN

A. TEST VARIABLES

The independent variables selected for use in the field experiment were as follows:

VARIABLE	LEVEL
Sight Configuration	Standard Bracket Circle
Range	20 meters 40 meters
Direction of Fire	Left Right

The above variables were chosen in order to be consistent with previous tests and for comparison of results. Additionally, the range and direction variables were chosen in the event a significant difference between sights occurred, when it could be determined if the differences were consistent over changes in range and direction [2].

The dependent variable was the number of target hits by each subject out of the five shots fired at any one sight, range, direction of fire combination.

B. TEST DESIGN

The experimental design was a repeated measures design with each subject firing under all conditions or level of variables. The subjects'

exposure to each sight-range-direction configuration was completely random. Under such configuration a firer was unaware of the range to target (20 or 40 m) or the direction of fire (L or R) until he actually observed the target activate. All firing was done at a fixed low-light level of .25 footcandles.

The two-sight, two-range, two-direction set-up made a 2 x 2 x 2 factorial design and since all eight subjects encountered the variables at random the final design was a 2 x 2 x 2 random block design with the eight subjects as blocks.

C. MEASURE OF EFFECTIVENESS

The experimental measure of effectiveness for this test was the number of hits by each subject for a particular sight-range-direction combination.

IV. CONDUCT OF TEST

A. SUBJECTS

An army rifle squad of eight enlisted men from "B" Company, Experimentation Battalion, U. S. Army Combat Developments Experimentation Command (CDEC), Fort Hunter-Liggett, Jolon, Ca., served as subjects for the experiment. All subjects were frequent participants in weapons experiments at CDEC and all were considered above average soldiers and marksmen by their company commander.

B. WEAPONS, SIGHTS, AND AMMUNITION

The weapons used in the experiment were two standard U. S. military issue M16A1 service rifles with 20 round magazines. One rifle was modified with the small circular bracketing sight, and the second weapon was left unmodified to serve as a control. Two additional rifles were on hand in case of a malfunction during the test. In Figure 5 the unmodified weapon with standard sight is shown and the modified rifle with bracketing sight is shown in Figure 6 as they appeared in the field test.

The ammunition used was standard military issue 5.56mm ball and contained no tracers. A total of 320 rounds was fired during the test. Another 720 rounds was used during the training period prior to testing.

C. TARGETS

The targets were sponge-foam covered, aluminum personnel silhouettes, approximately a man's head and upper shoulders in dimension, which when hit vibrated causing a transducer to generate a hit signal to a range computer console. The target mechanisms were mounted in a "coffin box" enclosure containing target raising and lowering mechanism, gun simulator, and transducer (Figure 7), and were computer controlled through underground signals and power cables. The targets as viewed through the standard sight and bracket sight at a range of 20 meters (m) are shown in Figures 8 and 9 respectively.

D. RANGE FACILITIES AND OPERATIONS

1. Range Facilities

The field experiment was conducted at Live Fire Range Bravo, a fully instrumented range, located at Fort Hunter-Liggett. Live Fire Range Bravo is used for the purpose of testing the fire effectiveness of various army weapons and units in the defense and closely approximates realistic combat conditions.

The range consisted of six different target arrays of from five to 12 targets each as illustrated in Figure 10. Four targets were selected from array number one of which two targets were located at 20 m (one left and one right) and two targets at 40 m from the firing line with the same left-right configuration as shown in Figure 11.

The range control can be described as sophisticated and was located in four modular buildings on a hill to the rear of the range (Figure 12). From the range control console shown in Figure 13 the operator could initiate and terminate a test trial and monitor its progress.

2. Operations

For this experiment the computer-operated range console was programmed to raise and lower the four preselected targets in a random order for a target exposure of 2.5 sec. with a 3-4 sec. interval between target operations. The gun simulator was activated for the first 1.5 sec. of the target-up time providing the test subject with a muzzle flash and sound of automatic fire to aid in identifying the target.

A program interrupt button located on the range control console provided for a recoverable halt in the event of a weapon malfunction or safety hazard on the firing line. An intercom handset and speaker allowed for direct communication between the operator and the firing line.

E. LIGHT LEVEL AND WEATHER

1. Low-Light Level Measurement

As previously stated the purpose of the experiment was to test the circular bracketing sight at a light level low enough to cause some difficulty in using the standard "iron-sights" employed on the M16A1 rifle but still with enough illumination to detect target movement.

This would provide a base for testing the increase in effectiveness of the circular bracketing sight (if any) over the unmodified sights (control) and as a comparison against previous research.

The time chosen was the period of twilight after sunset (dusk) and before darkness. A low level of illumination of .25 footcandles (fc) was selected since by previous observation this low-light level remained constant enough (approximately 20 min.) to test four of the eight subjects each evening. The level of illumination was monitored by a Gossen Luna Pro lightmeter and did remain at the specified level of illumination during the test period each evening.

2. Weather

During the field experiment the temperature was 60-70^{o}F with clear skies and no wind. Weather conditions were not a factor in the experiment.

F. TESTING

1. Orientation

Upon arrival at the range all eight subjects were given an orientation briefing covering the purpose of the test, sequence of events, test procedures, and range safety requirements. They were then given a weapons demonstration and review of the techniques they would use for standard quick-fire with the unmodified rifle and quick-fire techniques to be used with the modified bracketing sight.

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2. Training

Prior to actual test firing the subjects were given approximately three hours of training. Each subject was allowed to fire five rounds with each sight configuration to familiarize himself with the proper body-weapon-target alignment and also to permit correction of faulty firing techniques. The training was concluded with two complete training runs of the field experiment resulting in a total of 90 training rounds fired per subject. This would pay off later in permitting the actual field experiment to run smoothly and quickly in order to enable the four subjects per evening to complete the test within the allowable 20-min. window of the low-light level criterion.

3. Test Sequence

The test was accomplished during the two evenings of 25-26 February 1976. In the actual test firing, one test trial consisted of a subject firing a magazine of 20 rounds with a particular sight configuration at the four targets. Each of the targets appeared five times in a random order, with only one appearing at any one time. The order in which a particular subject fired the two sight configurations and the order in which he fired were randomized. Only one shot was fired at each target appearance with the subject being informed verbally whether the shot was a hit or miss.

G. DATA RECORDING

A computer located at range control recorded the number of target hits achieved by subject, sight configuration, range, and direction of fire for each trial. The results were subsequently printed in tabular form on a teletype adjacent to the computer as viewed in Figure 14.

H. OBSERVATIONS

While the test was simple and structured, the reader should be aware of the features that made it a reasonably valid test of quick-fire using the two sight configurations at a low-light level. The test was combat realistic -- a muzzle flash and the blast of an automatic weapon accompanied each target appearance. The light level was low, the targets showed only the head and shoulders of an enemy and were hard to see. The targets were located naturally on the side of a hill at realistic ranges of 20 and 40 m amidst rocks, brush, and foxholes. There was target uncertainty -- that is, the subject did not know exactly when or which target would appear. The subject was under a time stress -- the targets just "flashed" and were gone. An additional stress originated from the fact that the subject fired alone out front with observers and peers watching and hearing the hit or miss feedback provided him.

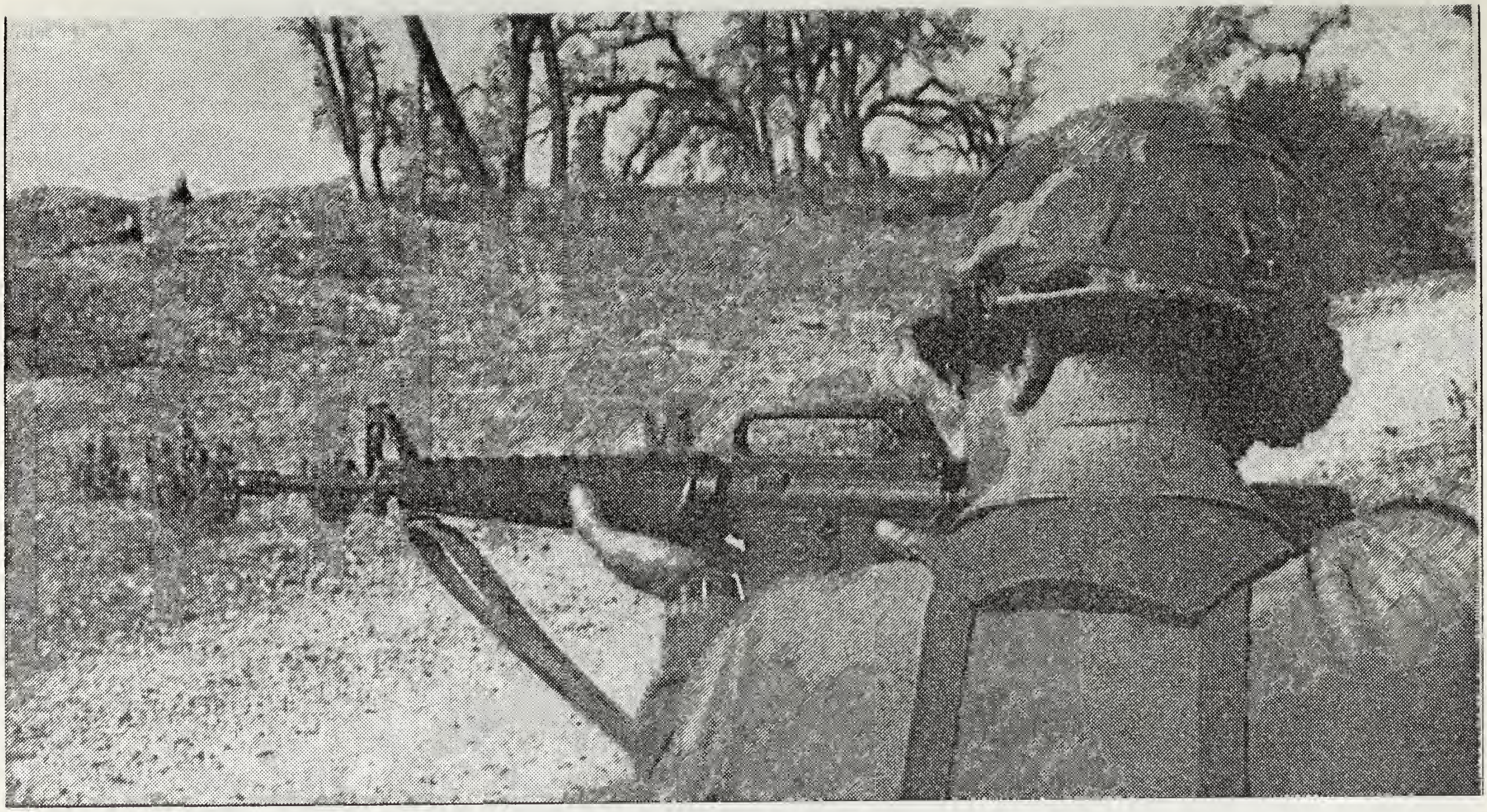

Figure 5. Test Subject Firing Unmodified Weapon with Standard Sight During Field Experiment.

Figure 6. Test Subject Firing Modified Weapon with Bracketing Sight During Field Experiment.

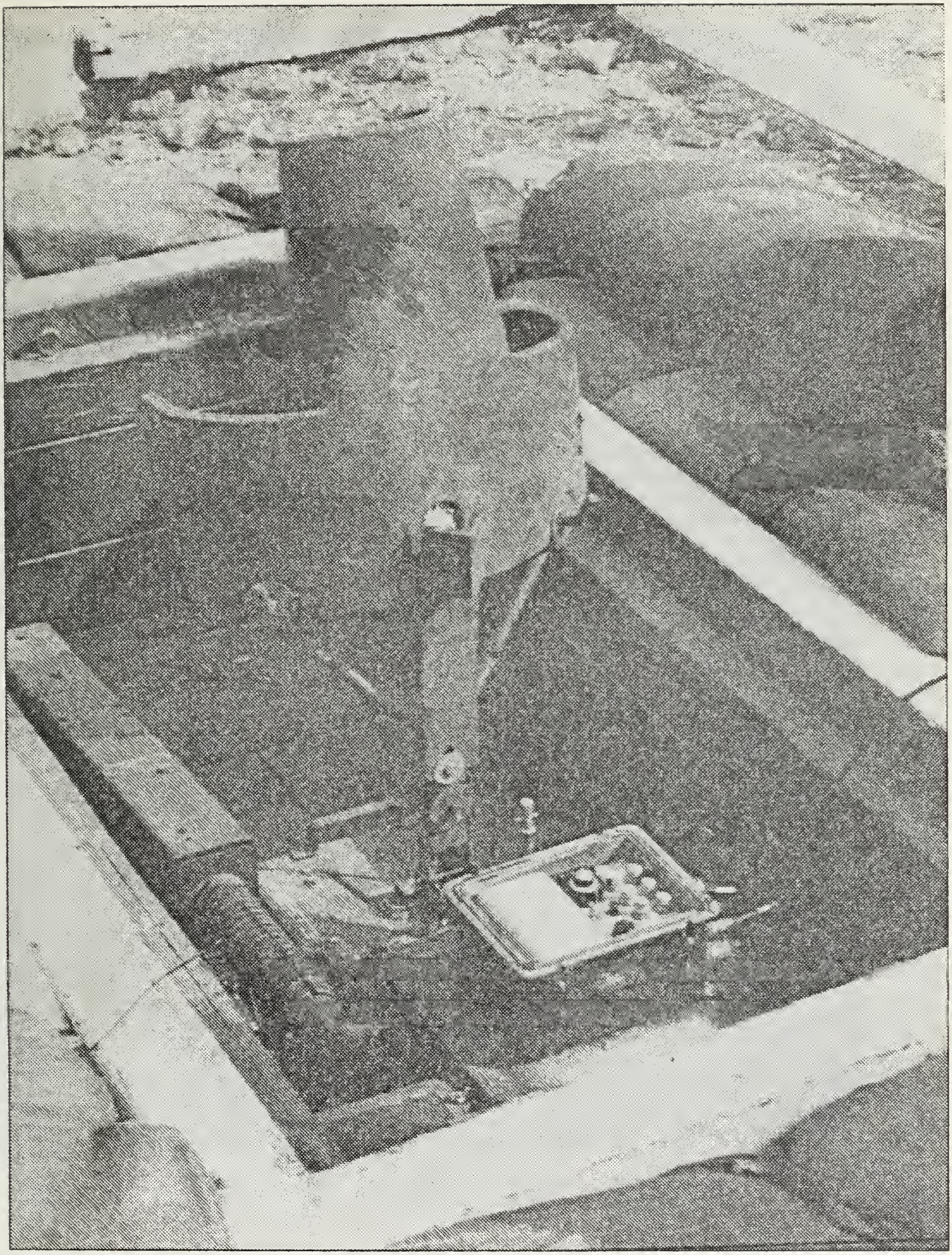

Figure 7. Target Mechanism Enclosure Showing Target, Gun Simulator, and Transducer.

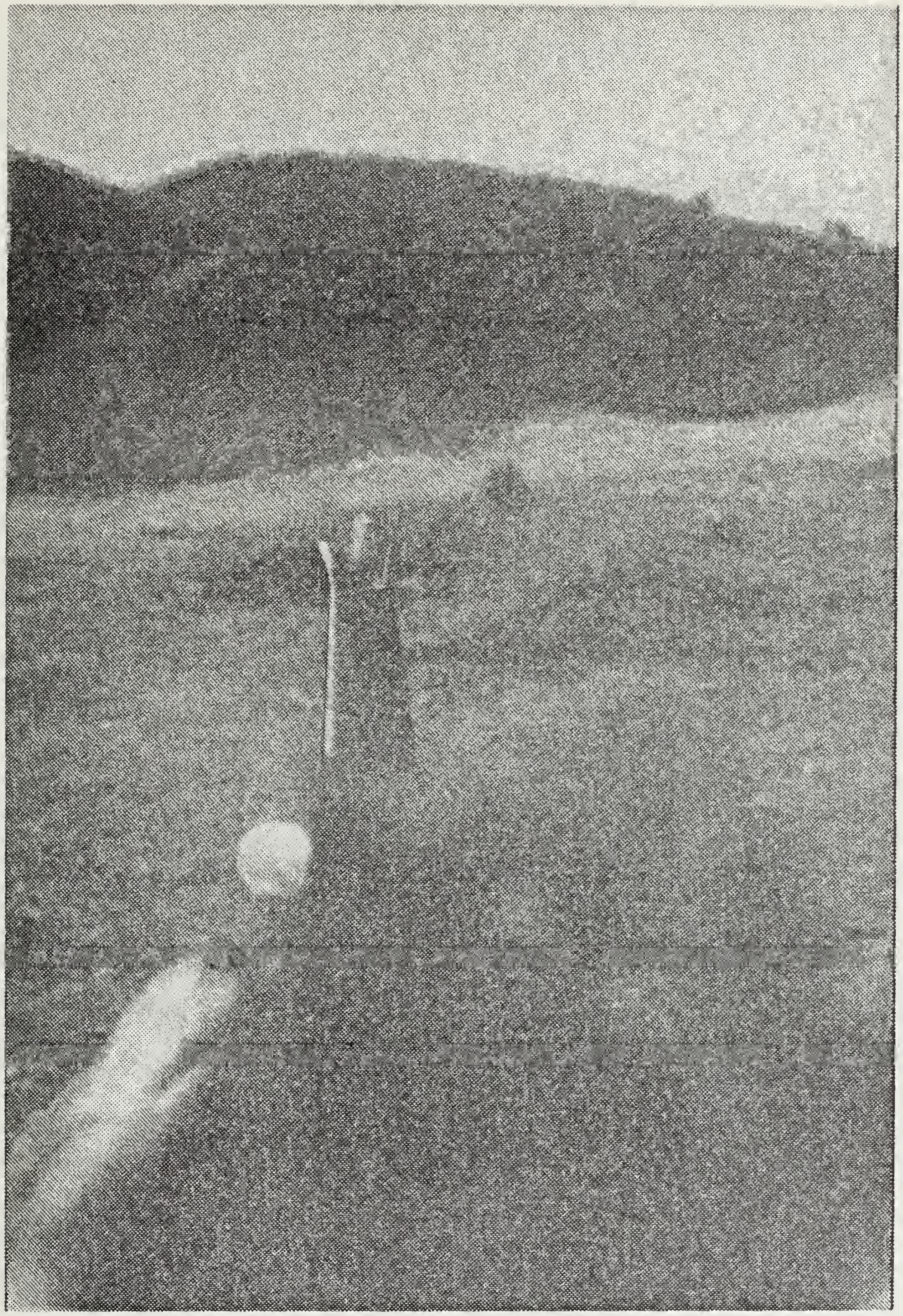

Figure 8. View of Target at 20 Meters as Seen Through Standard Sight.

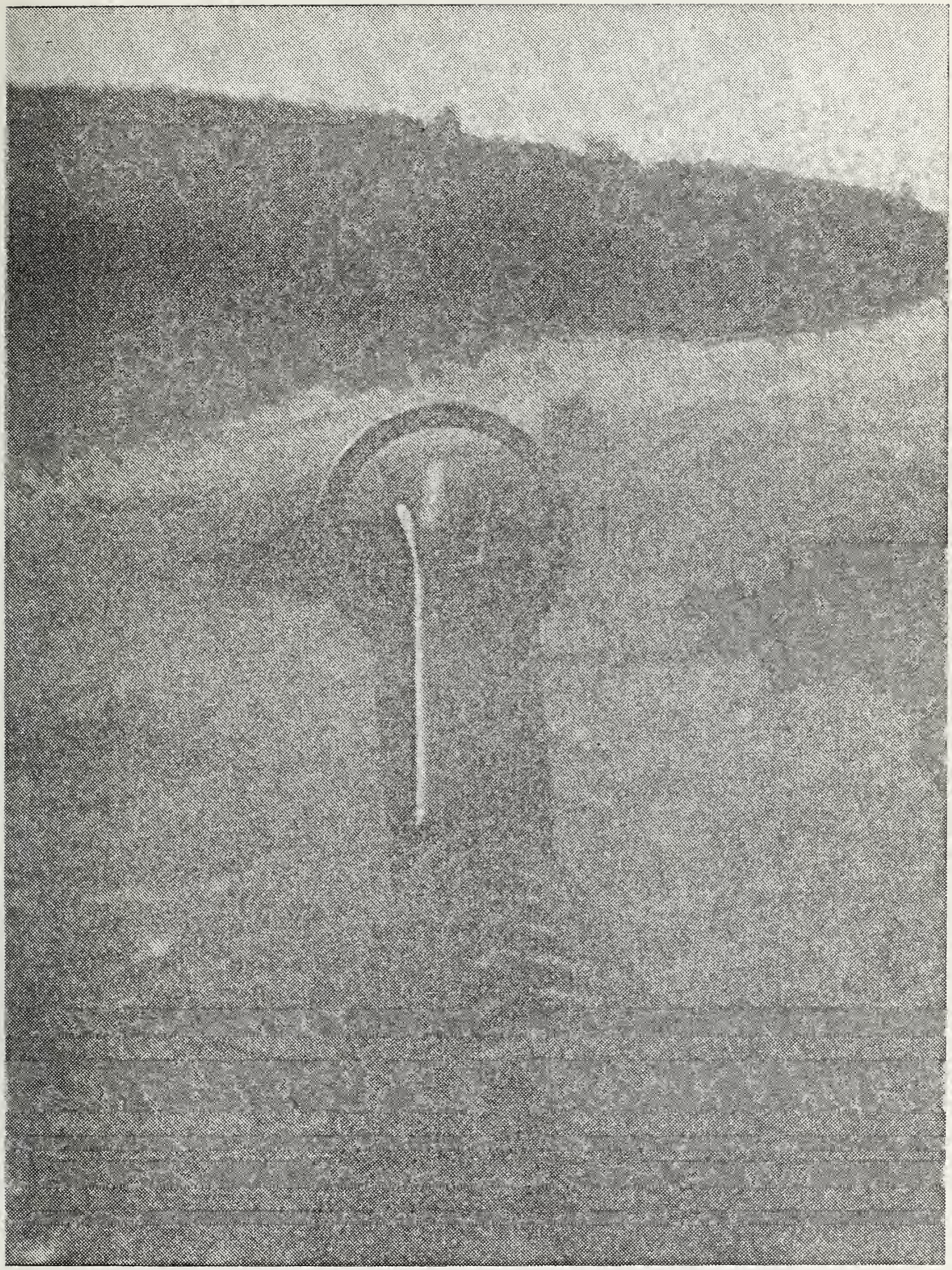

Figure 9. View of Target at 20 Meters as Seen Through Bracketing Sight.

Figure 10. View of Live Fire Range Bravo Showing Target Array No. 1.

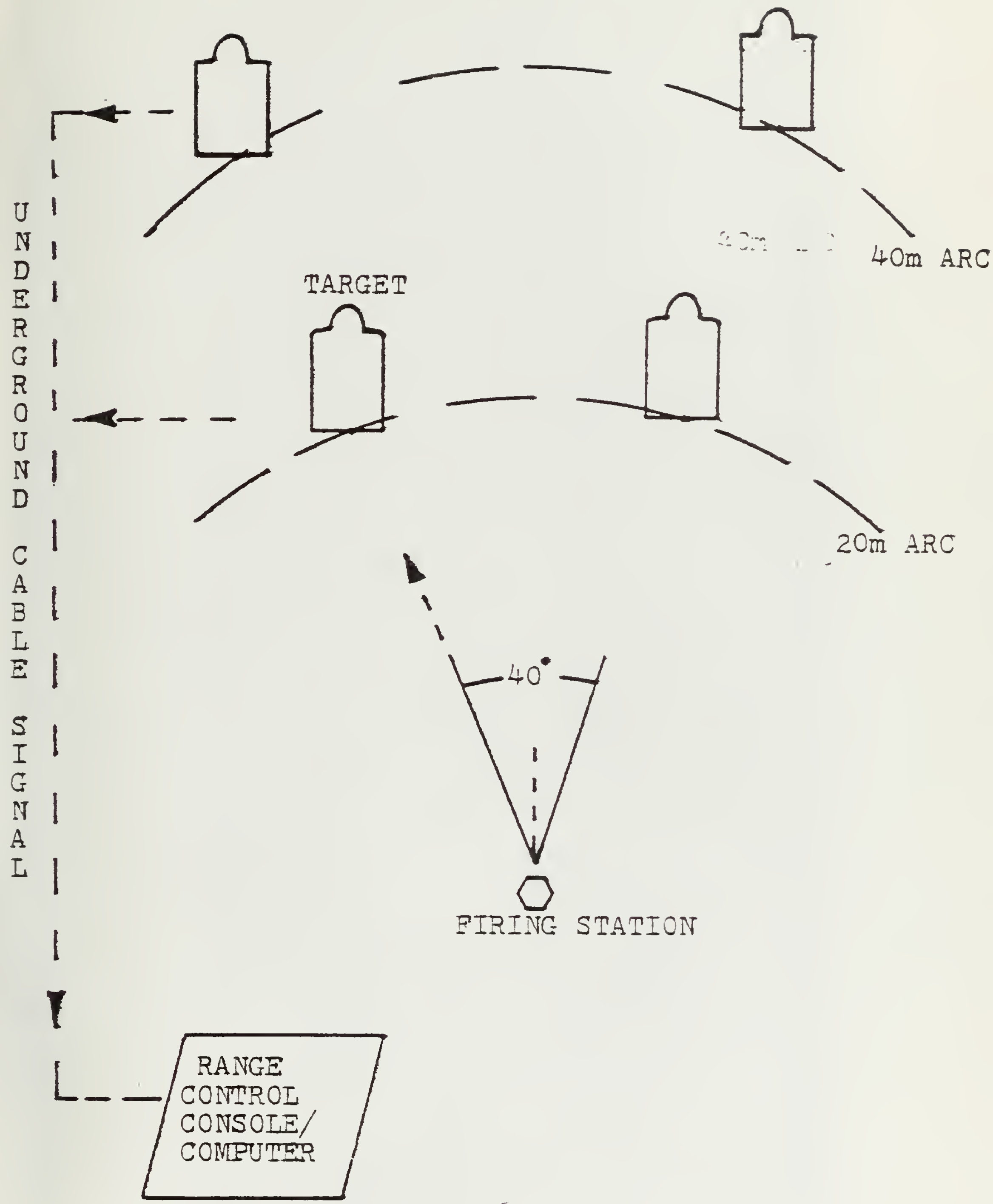

Figure 11. Layout of the Range for Field Experiment.

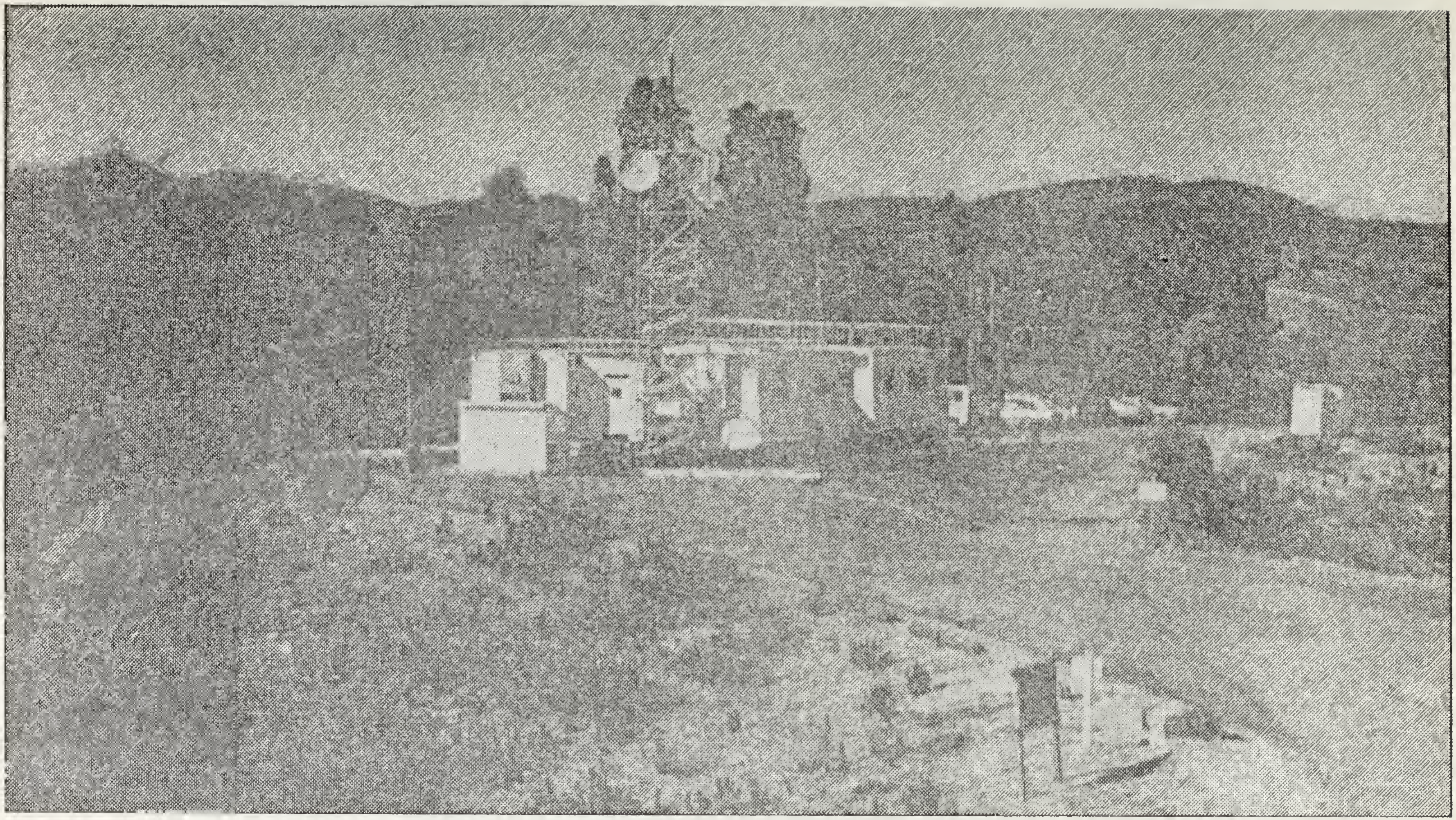

Figure 12. View of Range Control Complex, Live Fire Range Bravo.

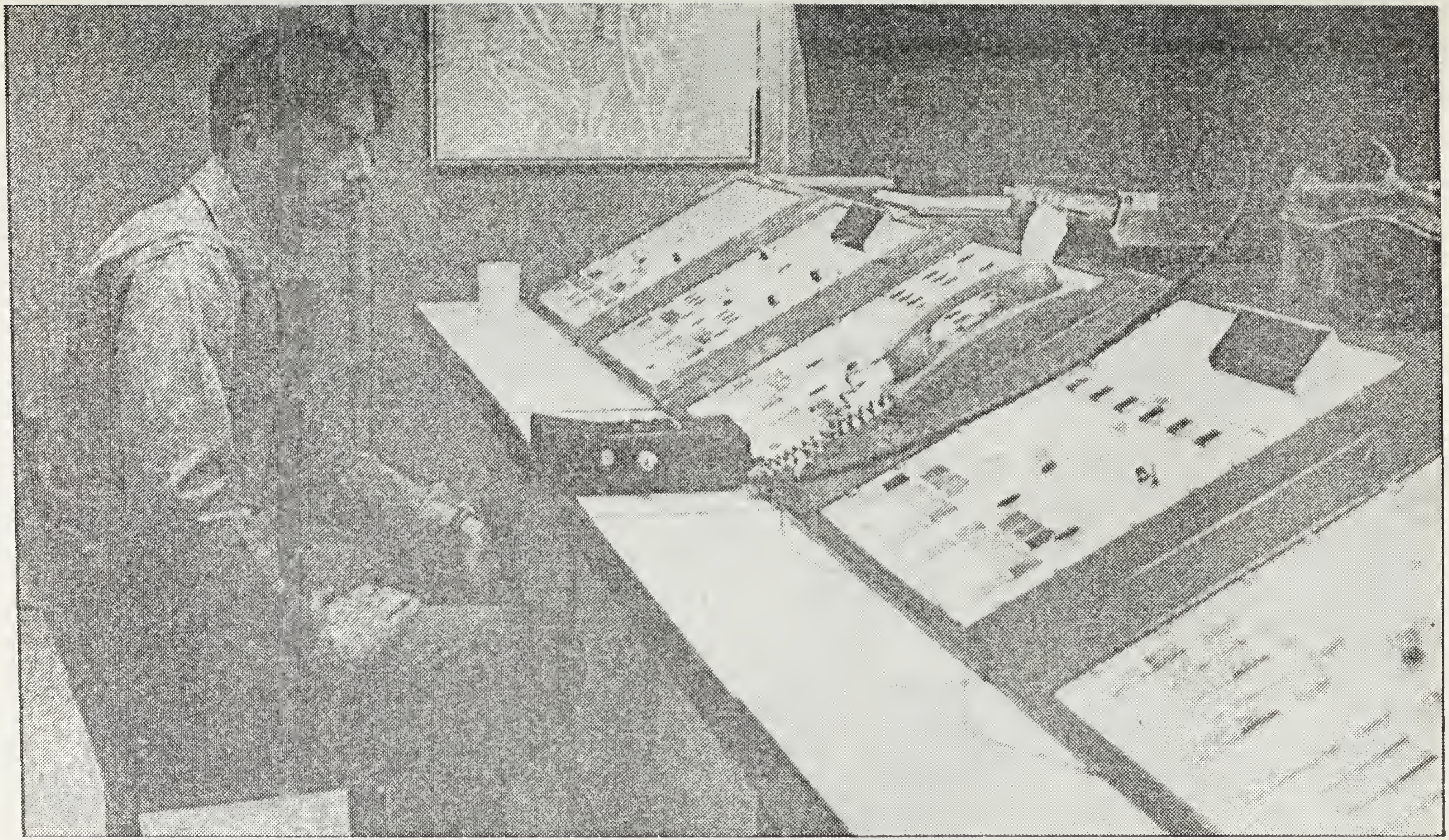

Figure 13. Range Control Console and Operator.

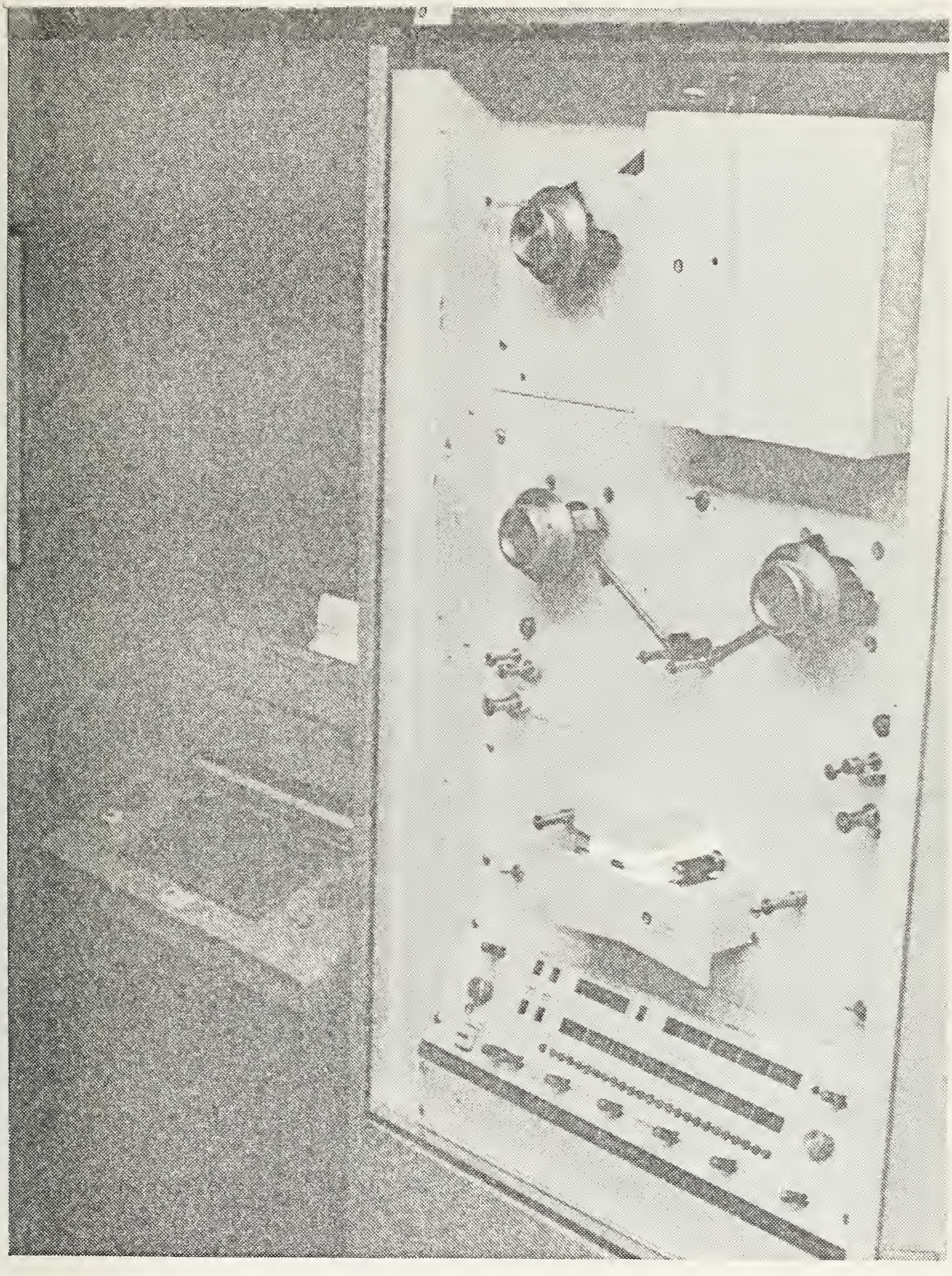

Figure 14. View of Range Computer and Teletype Printing Test Results.

V. RESULTS

The overall results of the experiment are shown in Tables I and II and in Figure 15. Table I shows a summary of hits by sight, range, and direction of fire, while Table II shows the percentage of hits by sight and range.

A. SIGHT DIFFERENCES

The bracket sight appeared to be significantly better since it yielded the most hits across the range and direction variables. The bracket sight had a 70% hit rate at 20 m as opposed to a 52.5% hit rate for the standard sight at the same range. At a range of 40 m the bracket sight attained a 48.8% hit rate while the standard sight yielded a 31.3% hit rate. Over the entire experiment the bracket sight attained a 59.4% hit rate and the standard sight 21.8%.

B. RANGE DIFFERENCES

The 20 m range yielded a greater number of hits (61.3%) than the 40 m range (40%) with an overall increase in hit effectiveness at 20 m of 53%. This was to be expected since the low-light levels used during the experiment caused target visibility and detection at 40 m to deteriorate markedly from the 20 m range.

TABLE I. SUMMARY OF HITS BY SIGHT, RANGE, AND DIRECTION OF FIRE

SIGHT and TOTALS	RANGE			
	20 METERS		40 METERS	
	LEFT	RIGHT	LEFT	RIGHT
STANDARD	16	26	10	15
BRACKET	25	31	17	22
TOTALS	41	57	27	37

NOTE: Sight block entry is number of hits out of a possible 40.

TABLE II. PERCENT HITS BY SIGHT AND RANGE

SIGHT	RANGE		
	20 m	40 m	overall
STANDARD	52.5	31.3	41.8
BRACKET	70.0	48.8	59.4
OVERALL	61.3	40.0	50.1

C. DIRECTION DIFFERENCES

The right hand targets were hit more often than those on the left. The right hand targets had a hit rate of 58% as opposed to 42% for the targets on the left. These findings, combed with the fact that all subjects fired the rifle right-handed, suggest that a right-handed shooter is more likely to hit a target while swinging pointing) the weapon to the right than in the opposite direction.

D. ANALYSIS OF RESULTS

The test results were subjected to a four-way factorial, randomized block design, analysis of variance (ANOVA). The test subjects were considered as blocks since each subject received all combinations of the main variables. The subjects were also considered as a random factor, with sight configuration, range, and direction of fire as fixed factors.

1. Analysis of Variance (ANOVA)

The ANOVA used to test the data results was a statistical technique that assessed the effects of one or more categorical independent variables or factors (sight, range, direction, subject) measured at each level upon a continuous dependent variable (hits) measured at an interval level of zero to five. Conceptually the blocks were divided into categories based on their values for each of the independent variables, and the differences between the means of these categories

on the dependent variable were tested for statistical significance. The relative effect upon the dependent variable of each of the independent variables, their combined effects, and interactions were then assessed [5].

2. Data

The test data was collected in the matrix of 64 cells found in Table III. Each cell described the number of hits achieved in five shots by a test subject using each sight configuration, at each range, and firing in each direction.

Because the number of observations in each cell was relatively small (5) and the use of ANOVA techniques required data which are normally distributed around linear effects, an arcsine transformation was used to adjust the data [6]. The number of hits per cell was transformed as follows:

$$Z_{ijkm} = 2 \text{ arcsine } \sqrt{X_{ijkm}/5}, \text{ where}$$

Z_{ijkm} = transformed variate

X_{ijkm} = original no. of hits in cell i, j, k, for subject m.

A test using the arcsine statistic is more appropriate for ANOVA than just using the proportion $X_{ijkm}/5$. The homogeneity of variance cannot be assumed when using proportional variates. However, if all proportions are based on the same number of observations and if each

TABLE III. TABLE OF OBSERVED DATA

RANGE		20 m				40 m			
DIRECTION		Left		Right		Left		Right	
SIGHT		U	M	U	M	U	M	U	M
SUBJECTS	1	2	3	5	5	1	2	2	3
	2	0	2	3	4	0	1	1	2
	3	2	3	3	2	2	2	2	3
	4	3	5	3	5	1	3	0	3
	5	4	5	2	3	2	3	3	2
	6	1	2	3	4	1	2	2	2
	7	2	3	3	5	2	2	3	4
	8	2	2	4	3	1	2	2	3

U = unmodified M16A1 rifle

M = modified M16A1 rifle with small circle bracketing sight

Note: cell entry is number of hits of the 5 rounds fired at each target.

is transformed to an angle (as in the arcsine transformation), the homogeneity of variance assumption is valid because each angle has the same variance, 1/N, even though the proportions may differ. The transformed or normalized data for the unmodified and modified sights is listed in Tables IV and V respectively.

3. Hypotheses Testing

The actual ANOVA calculations were performed using the Naval Postgraduate School's IBM 360 computer system's program SPSS -- Statistical Package for the Social Sciences, subprogram "ANOVA" [5].

The null hypotheses tested were that there was no main effect for each variable and that there were no interactions. These were tested against alternate hypotheses that there were main effects and interactions. In each case an F-ratio test was used with an alpha level of .05.

Tables VI and VII list the results of the ANOVA calculations and the formulas for computing the F-ratios with the test results, respectively. Statistically significant results were found for only the sight and range main effects as shown in Table VII.

The hypothesis that there was no difference between directions to the targets could not be rejected at the $\alpha = .05$ level, but as in Kemple and McKinney's test [2], could be rejected at the $\alpha = .10$ level.

TABLE IV. TABLE OF NORMALIZED DATA (1)

SIGHT (i)		unmodified (1)			
RANGE (j)		20 m (1)		40 m (2)	
DIRECTION (k)		Left (1)	Right (2)	Left (1)	Right (2)
SUBJECTS(m)	1	1.3694	3.1416	.9273	1.3694
	2	.0	1.7722	.0	.9273
	3	1.3694	1.7722	1.3694	1.3694
	4	1.7722	1.7722	.9273	.0
	5	2.2143	1.3694	1.3694	1.7722
	6	.9273	1.7722	.9273	1.3694
	7	1.3694	1.7722	1.3694	1.7722
	8	1.3694	2.2143	.9273	1.3694

TABLE V. TABLE OF NORMALIZED DATA 2)

SIGHT (i)		MODIFIED (2)			
RANGE (j)		20 m (1)		40 m (2)	
DIRECTION (k)		Left (1)	Right (2)	Left (1)	Right (2)
SUBJECTS(m)	1	1.7722	3.1416	1.3694	1.7722
	2	1.3694	2.2143	.9273	1.3694
	3	1.7722	1.3694	1.3694	1.7722
	4	3.1416	3.1416	1.7722	1.7722
	5	3.1416	1.7722	1.7722	1.3694
	6	1.3694	2.2143	1.3694	1.3694
	7	1.7722	3.1416	1.3694	2.2143
	8	1.3694	1.7722	1.3694	1.7722

TABLE VI. ANOVA TABLE OF NORMALIZED DATA FOR 4-WAY FACTORIAL RANDOMIZED BLOCK DESIGN

SOURCE OF VARIATION	NO. OF LEVELS	SUM OF SQUARES	DF	MEAN SQUARE
Main Effects:				
(1) Sight	2	3.730	1	3.730
(2) Range	2	5.036	1	5.036
(3) Direction	2	2.432	1	2.432
(4) Subject	8	4.385	7	0.625
2-Way Interactions:				
1 x 2		0.037	1	0.037
1 x 3		0.074	1	0.074
1 x 4		2.400	7	0.343
2 x 3		0.253	1	0.253
2 x 4		2.356	7	0.337
3 x 4		4.530	7	0.647
3-Way Interactions:				
1 x 2 x 3		0.068	1	0.068
1 x 2 x 4		0.708	7	0.101
1 x 3 x 4		0.847	7	0.121
2 x 3 x 4		1.590	7	0.227
Residual:				
1 x 2 x 3 x 4		0.351	7	0.050
	TOTALS	28.796	63	

TABLE VII. RESULTS OF TEST STATISTICS AND HYPOTHESIS TESTING

TEST	TEST STATISTIC*	TEST STAT VALUE	DISTR. UNDER H_o	$F_d^n(.05)$	RESULT
1 H_o : No effect H_A : Sight effect	MS_1/MS_{1x4}	10.874	F(1, 7)	5.59	REJECT H_o
2 H_o : No effect H_A : Range effect	MS_2/MS_{2x4}	14.943	F(1, 7)	5.59	REJECT H_o
3 H_o : No effect H_A : Direction effect	MS_3/MS_{3x4}	3.758	F(1, 7)	5.59	ACCEPT H_o
4 H_o : No interaction H_A : Sight x Range	MS_{1x2}/MS_{1x2x4}	0.366	F(1, 7)	5.59	ACCEPT H_o
5 H_o : No interaction H_A : Sight x Direct	MS_{1x3}/MS_{1x3x4}	0.611	F(1, 7)	5.59	ACCEPT H_o
6 H_o : No interaction H_A : Range x Direct	MS_{2x3}/MS_{2x3x4}	1.114	F(1, 7)	5.59	ACCEPT H_o
7 H_o : No interaction H_A : Sight x Range x Direction	$MS_{1x2x3}/MS_{1x2x3x4}$	1.360	F(1, 7)	5.59	ACCEPT H_o

* MEAN SQUARE (MS) subscripts: 1 = Sight, 2 = Range, 3 = Direction, 4 = Subjects

The pairwise interactions between the test variables were not significant and neither were the three-way interactions as shown in Table VI.

F. SUMMARY OF RESULTS

The results (Table VIII) show that the bracket was 42% better than the standard sight over the entire experiment. It was better by 33% at 20 m and 56% at 40 m. The lack of significant interaction between sight and range, clearly evident in Figure 15, indicates that the improvement in hit probability is consistent over changes in range and direction. The results also show that as firing conditions became more extreme, that is, increased range accompanied by reduced visibility, the advantages of the bracket over the standard sight became much greater. While the main effect for direction was not statistically significant, these findings replicate the results found by Kemple and McKinney [2].

TABLE VIII. SUMMARY OF RELATIVE EFFECTIVENESS

VARIABLE		EFFECTIVENESS MEASURE OF BRACKET OVER STANDARD SIGHT
RANGE:	20 m	33% better
	40 m	56% better
	overall	42% better
DIRECTION:		BRACKET AND STANDARD
	LEFT	42% of hits
	RIGHT	58% of hits

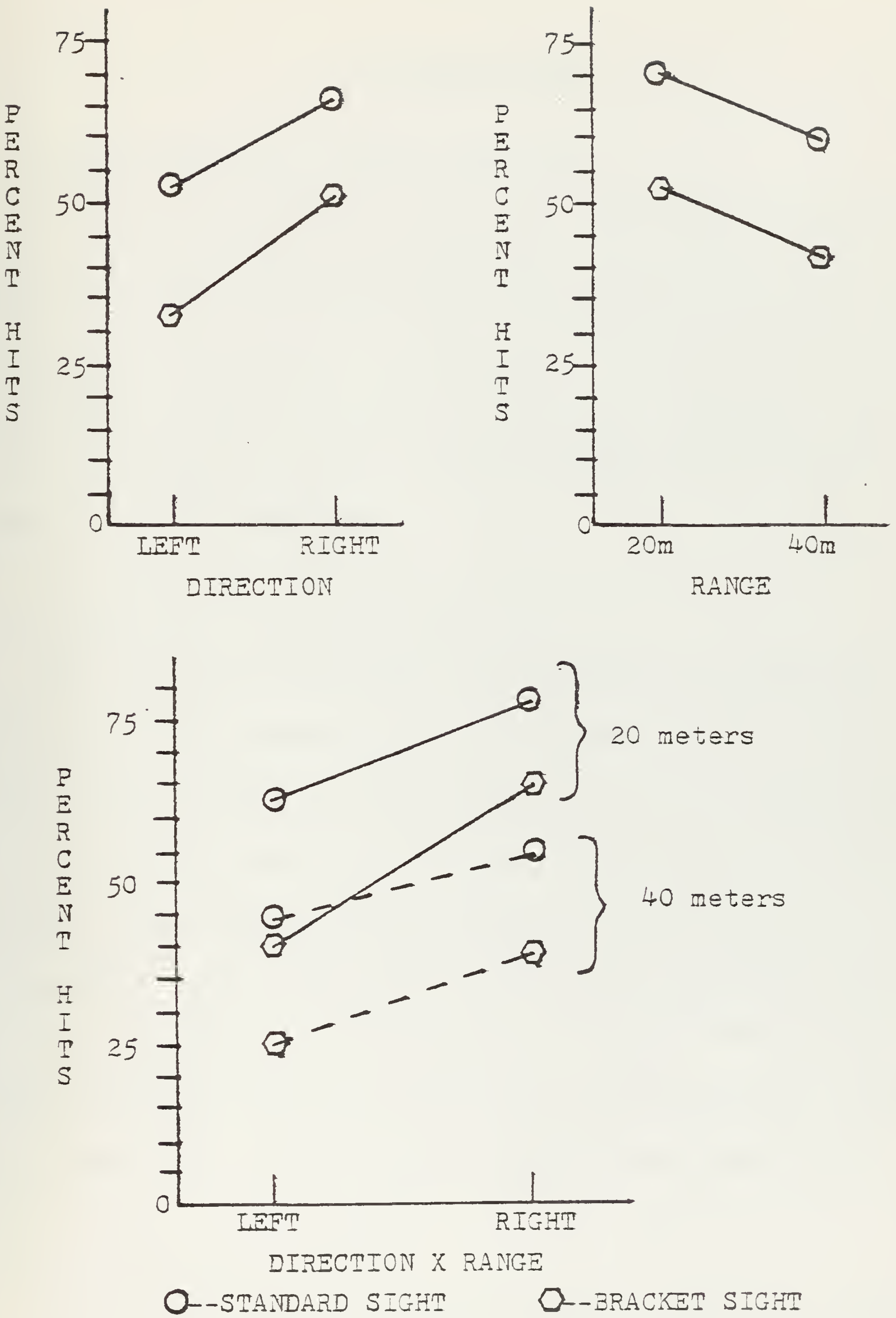

Figure 15. Graphical Representation of Relationship Between Sight Configuration, Direction, and Range to Percent Hits.

VI. CONCLUSIONS

A. SIGNIFICANCE OF OVERALL RESULTS

The overall results clearly support the conclusion that the bracket circle sight significantly increased the hit capability of the M16A1 rifle as opposed to the normal quick-fire procedures using the standard sight. It is apparent that the effectiveness or advantage of the bracket sight versus the standard increases with range and difficulty of firing conditions such as low-light levels.

B. COMPARISON WITH PREVIOUS TESTS

The results were comparable to those obtained by Kemple and McKinney [2] in a previous field experiment using daylight conditions. Their results yielded a 23% improvement of the small bracketing sight over the standard sight as compared to a 42% improvement obtained in this test. Aside from the obvious difference in light levels used, Kemple and McKinney used a target exposure of 1.6 sec. as compared to 2.5 sec. for this experiment. The longer exposure time was chosen to offset the effects of using a smaller target (head and upper shoulders) as compared to the head-to-waist target size used in the previous experiments.

C. TRAINING IMPLICATIONS

During the preliminary training period prior to the test it required approximately 3 hours of intensive training to bring the subjects to a

level of expertise with the standard sight that was considered minimum to begin the test (approximately a 40% hit capability at 20 m). (This was necessary to leave sufficient variance for the bracket sight to show an increase or decrease in effectiveness.) The important point is that the subjects almost immediately attained the same level of hit capabilities with the bracket sight. This would suggest that the bracket sight might be successfully employed as a training aid to teach quick-fire and fast target acquisition in a minimum amount of time.

D. OTHER APPLICATIONS

One observation by the author came during the firing of all the excess ammunition after each evening's testing. The subjects were asked to fire 3-5 round bursts of automatic fire at targets activated at random using the standard and the bracket sights as in the actual tests. The bracket sight was efficient in aiding the firer in "capturing" his target and holding it even though the recoil forces of automatic fire were working to dislodge his line of sight. The standard sight was almost impossible to hold on target and hits other than the first round were rare.

E. QUALIFICATION

The findings in this study are a function of the fixed parameters that were used. Especially important in this respect were the duration for target exposures and the low-light levels used. These had to be established in preliminary experimentation to provide a range of hit

probabilities that would be useful in evaluating the sight configurations. Essentially, this meant that hit probabilities would have to be high enough using the standard configuration and procedure to permit the bracketing sight to be better or worse. As it turned out, the overall hit probability was near 50% (50.1%) in the field experiment where the variance is the greatest for data that are collected as proportions. This permitted a good separation of relative differences among the sight configurations. If the targets were impossible to hit or so easy to hit that misses were infrequent, no differences could have been demonstrated.

F. RECOMMENDATIONS

It is recommended that some consideration be given to incorporating a bracket sight of the type used in this field experiment as a training aid in quick-fire, quick-reaction, type marksmanship training.

Informal observations by this author suggest that the bracket sight could be extremely advantageous if used on the M16A1 rifle while firing automatic bursts and on the M-60 machine gun when being fired from the shoulder off-hand position.

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