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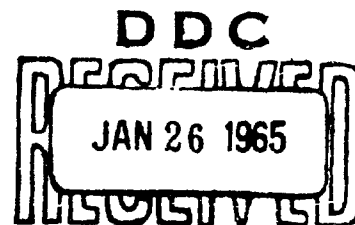
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An Evaluation of a New Reticle Design System for Gunlaying Against Flashes

David L. Ensley

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U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

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HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

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ABSTRACT

The purpose of the research was to determine the effectiveness of utilizing a grid-type reticle, graduated in turns of the azimuth and elevation controls of the M60 tank, for gunlaying against enemy gun fire at night. Using the experimental reticle in a simulated firing situation, six experienced and seven inexperienced gunners localized and laid an M60 tank gun on each of 40 flashes. Though no group differences were significant, these two groups of gunners performed somewhat more accurately, but laid less quickly on the average, than a third group, which used the standard reticle. In the simulated situation, performance was better than it was in a field study. Factors which may have operated in the field study to degrade performance are discussed.

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AN EVALUATION OF A NEW RETICLE DESIGN
SYSTEM FOR GUNLAYING AGAINST FLASHES

INTRODUCTION

Background

In a study in which the fire control system of the M48 tank was employed, Kraemer (1962, pp. 15-16) concluded that accuracy of gun-flash localization at night was reduced because of two factors: a) The gunner's periscope reticle covered only a small central portion of the field of view (approximately 25%), and therefore provided too few reference points to enable the gunner to locate flashes accurately. b) Suitable instruments were not available for translating readings in mils into movements of the gunlaying controls.

For these reasons, he made three proposals (1962, p. v) for changing the fire control system of the tank to provide for more accurate laying against gun flashes.¹ It was recommended in his report "that at least one of the optical systems on any tank be designed to permit accurate flash localization," and that the development of "one of the systems proposed" be considered.

The three proposed optical systems vary in the amount of improvement to be expected in flash localization and subsequent gunlaying

¹The three proposals are the following: "1. An optical system incorporating...an image retention surface in the sight...a grid-type reticle graduated in mils...and mil counters for azimuth and elevation, visible in the sight.

"2. An optical system incorporating...a grid-type reticle graduated in mils...and mil counters for azimuth and elevation, visible in the sight.

"3. An optical system incorporating a grid-type reticle graduated in turns of the hand-traversing drive assembly and the elevation hand-pump assembly."

accuracy. The first would result in the greatest improvement, but would require the most extensive modification of current tank fire control systems. The third would require the least modification—installation of a new reticle—but with such a change, accuracy would depend largely on the skill and training of the gunner.

United States Continental Army Command concurred in the recommendation in the report, "subject to the conduct of a field...experiment to determine whether a redesign in the optical and fire control system of the tank is warranted,"² and requested that such an experiment be conducted jointly by the USA Armor School and the USA Armor Human Research Unit.

The Problem

In these studies the problem was to determine the gain in accuracy in flash localization provided by a grid-type reticle graduated in turns of the hand-traversing drive assembly and the elevation hand-pump assembly.

The experimental reticle is shown in Figure 1. Because one complete turn of the turret traverse hand crank moves the gun 16 mils horizontally, the width of each rectangle in the grid is 16 mils. The height of each rectangle is 12 mils because one turn of the elevation hand pump moves the gun that distance vertically. Because of the optical design of the system, the extent of the reticle was limited to .7 of the field of view.

Two studies of gunlaying against flashes were conducted. The first

²Letter, ATTNG-TNG 200.3, 26 March 1962, HQ USCONARC to Chief of Research and Development, DA, subject, "Comments on HumRRO draft technical report, Subtask ARMORNIE X."

Experimental Reticle Used in Both Studies

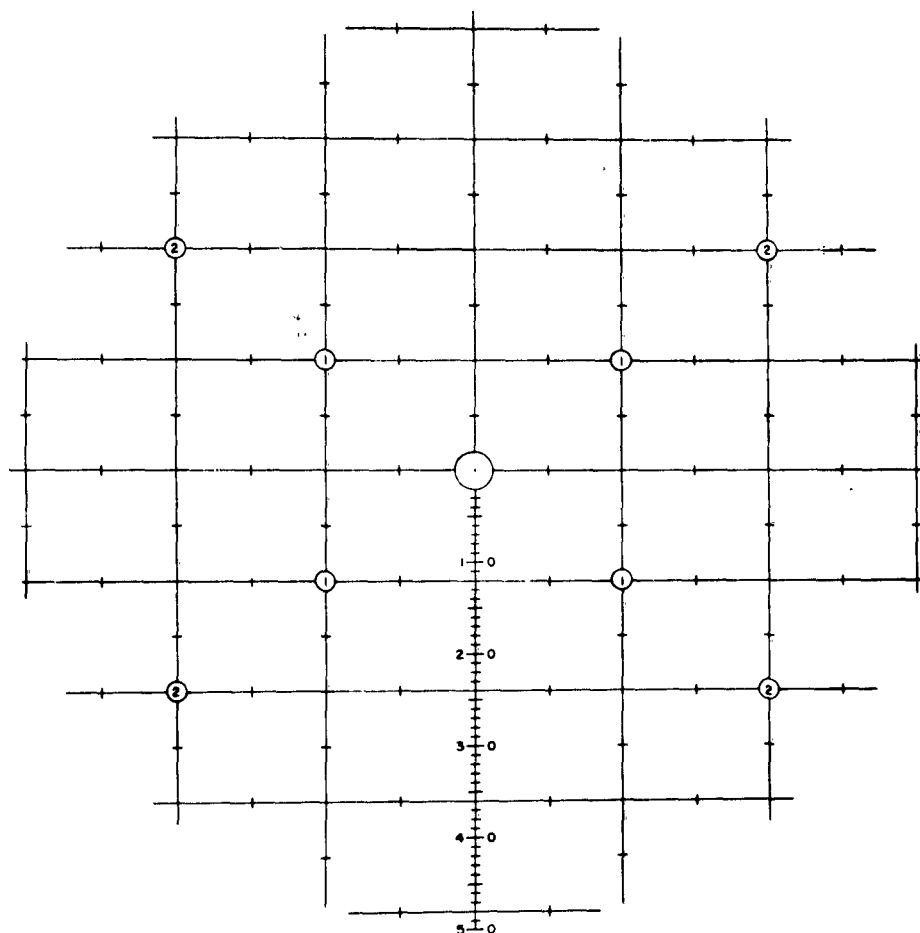


Figure 1

was an evaluation under simulated starlight conditions; the second was an evaluation in the field at night.

THE LABORATORY STUDY

Method

Subjects. Three groups (a total of 20 gunner subjects) were used. All Ss attained near and far visual acuity scores of at least 20/40 on the Armed Forces Vision Tester. A group of seven inexperienced Ss and a

group of six experienced Ss used a new (experimental) reticle. A third group of seven experienced Ss used the old (standard) reticle. The experienced Ss were currently assigned to armor; the inexperienced Ss were infantrymen who had no familiarity with tanks. The purpose of employing an inexperienced group was to determine if the results might be biased because of a preference for the familiar reticle.

Apparatus. An M60 tank was stationed in a darkened building. The inside of the turret was blacked out by taping all openings. Only the 8-power channel of the M31 gunner's periscope remained untaped. The periscope reticle was illuminated in red by the instrument light. A diagram of the experimental apparatus is shown in Figure 2.

Gun flashes were simulated by an electronic flash unit (Heiland Model 64-A) which had a flash duration of $1/2000$ sec. The reflector of this unit was masked down to 4.5 cm. in diameter. The flashes were set off from precise locations on a plywood panel, 122 cm. high and 244 cm. wide, mounted vertically in front of the tank; the center of the board was 15 m. from the periscope window. At this distance 1.5 cm. on the board represented 1 mil from the gunner's point of view. A matrix of small holes had been drilled in the center of the panel. These holes were 5 mils apart, and covered an area 50 mils high by 80 mils wide. The flash unit, which was held in a special mount, could therefore be placed in any location desired. To reduce the intensity of the flash and to prevent the gunner from seeing the flash unit or receiving other undesirable cues, two welder's

Experimental Apparatus for the Laboratory Study

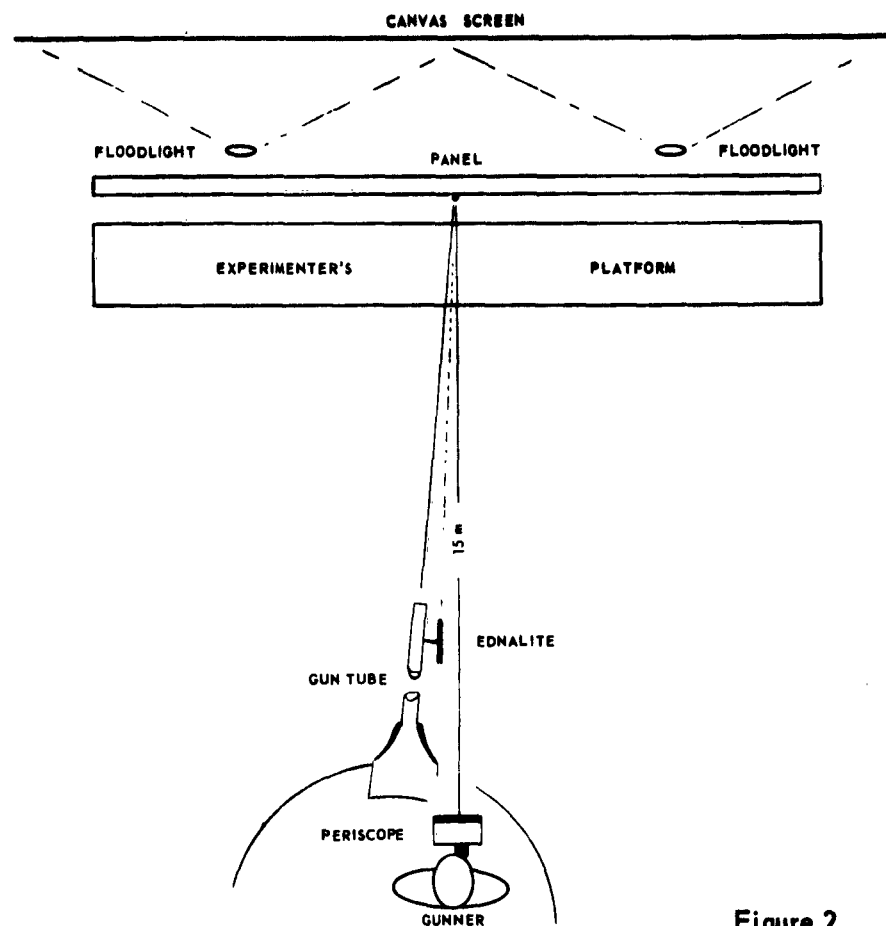


Figure 2

mask lens plates, each a shade No. 6, were used as filters in front of the periscope window.

A horizon was simulated in the gunner's field of view by a canvas screen which provided a background behind the top edge of the plywood panel. Floodlights were used to make this background intensely bright.

The combination of lighting and filters was such that S had to be dark-adapted before he could see the simulated horizon. There were no other outside spatial cues. When the periscope sight was laid on the center of

the panel, the horizon bisected the upper half of the field of view.

A projection pointer (Ednalite Model 120-A) was mounted on the gun tube as close as possible to the line of sight of the periscope and zeroed in with it. The pointer projected a spot of light (.25 cm in diam.) on the target panel to indicate the exact position of the lays made by the gunner.

Intercommunication was provided between the target panel and the inside of the turret to facilitate the giving of "ready" signals and relaying instructions.

Procedure. The same procedure was used with each group of Ss, except that one group of experienced gunners employed the standard reticle during the study. The other experienced group and the inexperienced group used the experimental reticle. The following pretraining and testing procedures were used for all groups.

1. Reticle Reading. For each group of Ss, the appropriate reticle design had been reproduced on sheets of paper (8 by 10.5 in.). On each of 50 sheets, a dot was marked to represent one of 50 randomly selected flash positions. After instruction, the Ss were required to read these positions in terms of hand cranks, giving the azimuth readings first, then the elevation readings. The Ss continued this practice until they could read the 50 locations with an error of no more than 1 mil (1/16 or 1/12 of a hand crank).

2. Hand-Crank Estimation. This pretraining took place on a training device which consisted of the two fire control hand assemblies mounted in

the same position, relative to each other and to the gunner, as in the tank. The "feel" of the controls approximated that in the tank. Giant scales providing readout in fractions of hand cranks were connected to the controls by means of selsyn motors. Because whole turns of the hand crank were not difficult, the Ss were given practice in making fractions of a turn. An informal procedure, lasting approximately 30 min., was employed in teaching the Ss to operate the hand controls in this fashion. The practice ended when S demonstrated the ability to adjust the azimuth crank within sixteenths of a turn and the elevation crank within twelfths of a turn.

3. Practice in Reading the Reticle. The Ss were seated in the M60 tank one at a time; each S was presented with the same set of 20 successive pretest flashes, each in a different position. These flashes were different from those used for the test and were selected at random from the matrix. After each flash, S was required to report azimuth and elevation readings (in that order), in terms of hand-crank turns.

All pretraining took place on the afternoon before testing. The Ss were pretrained in pairs, one S following the other.

4. Experimental Test. The experimental test took place the morning after pretraining. The Ss were required to call out their reading of the position of the flash, in hand-crank turns, then to turn the hand cranks a corresponding amount. After making three practice readings and gun lays, each gunner made one reading and lay of the gun against each of the 40 test-flash positions. Lays were made at approximately 3-min. inter-

vals, with about a 50-min. rest period after the first 20 trials.

Before each flash, the S fixated on the center of the reticle, which was aimed at the center reference point of the panel, and announced through the intercom that he was ready; 5 sec. later the flash was set off. Immediately after the gunner announced that he had completed a lay, the flash was set off again in the same position to provide him with knowledge of results.

One experimenter was stationed in the tank with the gunner. He recorded the reticle readings called out by the gunner and gave him relaying instructions. To reposition the line of sight on the center of the board after each lay, the gunner was required to make, in reverse, the amount of hand-crank movement which he had used to lay the gun. Further adjustments needed to bring the light of the projection pointer back to the center of the board were given by the experimenter at the board to the experimenter in the tank.

The accuracy of the lay, and of the gunner's relay, was determined by reading the location of both, as shown by the projection pointer on a .25-cm grid on the board.

Results

The results of the study are summarized in Table 1. The data are presented as error scores computed as deviations from true values without regard to sign. The medians as well as the means are shown, because the data were badly skewed. The Ss occasionally read and laid

Table 1

**Mean and Median Reading and Laying Errors in Mills
(Laboratory Study)**

	Old Reticle		Experimental Reticle					
	Experienced Group		Combined Groups		Inexperienced Group		Experienced Group	
	Azim	Elev	Azim	Elev	Azim	Elev	Azim	Elev
20 Pretest Readings								
MEAN	4.26	3.95	2.32	2.51	1.94	2.25	2.77	2.82
MEDIAN	3.00	2.00			1.50	2.00	1.50	1.50
40 Test Readings								
MEAN	3.34	3.36	2.31	2.37	2.33	2.44	2.29	2.29
MEDIAN	2.00	3.00			2.00	2.00	1.25	2.00
40 Test Lays								
MEAN	4.27	3.56	3.38	3.14	3.54	3.62	3.19	2.57
MEDIAN	3.19	2.93			2.24	2.58	2.37	2.55
40 Return Lays								
MEAN	1.32	1.12	1.44	1.41	1.69	1.81	1.15	.94
MEDIAN	.69	.69			.52	.69	.35	.60
Mean Time in Seconds to Make a Lay								
	33.00		35.82		37.74		33.69	

*For the combined experimental groups, no medians were computed.

on the reflection of the flash rather than on the flash itself. This circumstance resulted in large error scores, which are of course reflected in the means.

Mann-Whitney U tests (Siegel, 1956, pp. 116-127, 276-277) of differences between all the error scores of inexperienced and experienced gunners who used the new reticle were computed, for each flash separately. No more significant U's than can be explained on the basis of chance were obtained. The data for both groups which used the new reticle were therefore combined for comparison with the error scores of the group which used the standard reticle. Mann-Whitney U tests of all the score differences between the groups which used the two reticles were computed; no more significant U's than can be explained on the basis of chance were obtained.

As shown in the table, however, on the basis of reading scores alone the new reticle appeared to be superior to the old reticle, though the differences were not significant. On the whole task of laying the gun, which included both reading and control movements, use of the new reticle tended to result in more accurate performance than use of the old. The return error, which is independent of reading accuracy, was smaller for the group that used the old reticle. In the average time required to lay the gun, the group that used the old reticle appeared to be better.

THE FIELD STUDY

Method

Subjects. Two groups (a total of 12 gunner subjects) were used. A group of five Ss had received experience in the simulated situation approximately a month earlier. A group of seven Ss had received no experience in flash localization, but were currently assigned to Armor.

Apparatus. Three M60 tanks were lined up on a level surface facing an M48A2 tank which had an M4A1 gun-flash simulator mounted on the gun tube. The three M60 tanks were approximately 800 m. from the M48A2. Each M60 had a different version of an experimental reticle mounted in the M31 gunner's periscope. Two of these experimental reticles are shown in Figures 3 and 4. The other reticle used in the field study was the experimental reticle used in the first study.³ (See Figure 1.) An M1 gunner's quadrant was employed for making elevation readings, and the

³Kraemer, Easley, & Hall (1962, p. 9) found no differences in performance with these three reticles.

azimuth indicator was used for recording azimuth readings. The unity sight of the M31 periscope was taped, so that the gunner could see only the view from his 8-power sight.

The study was conducted on an overcast night with one quarter moon-light.

Version of Experimental Reticle Used in the Field Study

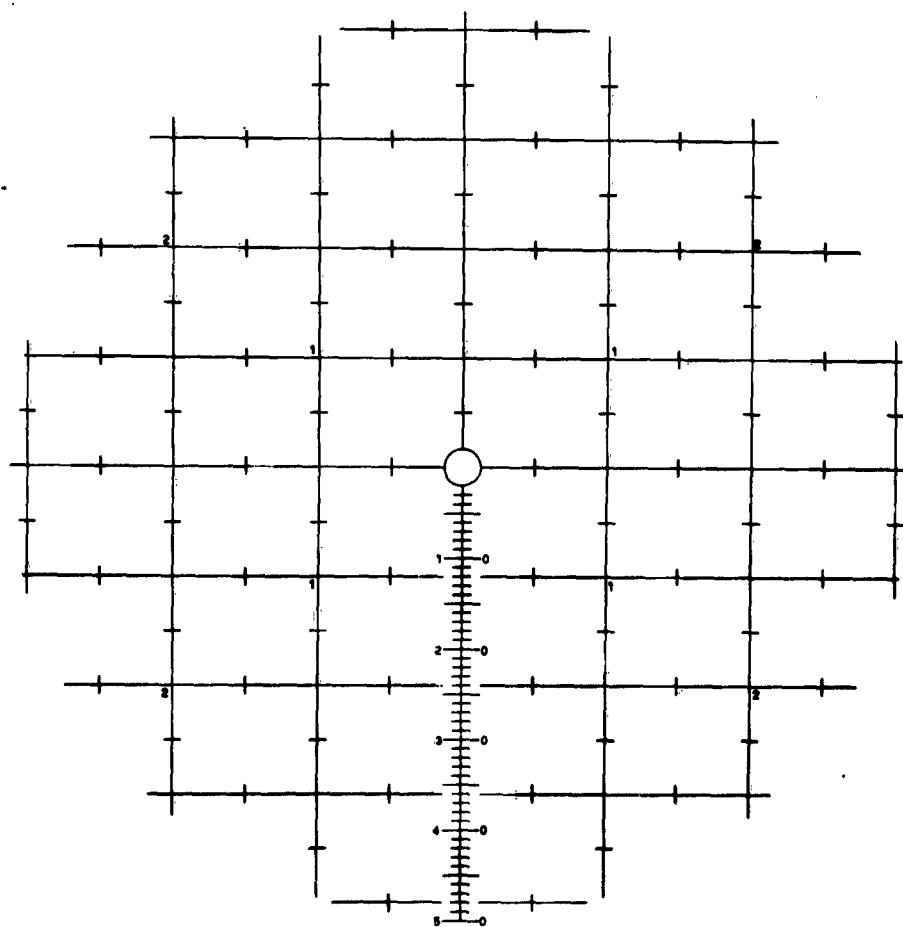


Figure 3

Procedure. The procedure followed was the same for the two groups of Ss, experienced and inexperienced. The same 18 flashes were localized by every S, and the flashes were presented one at a time. Flash

Version of Experimental Reticle Used in the Field Study

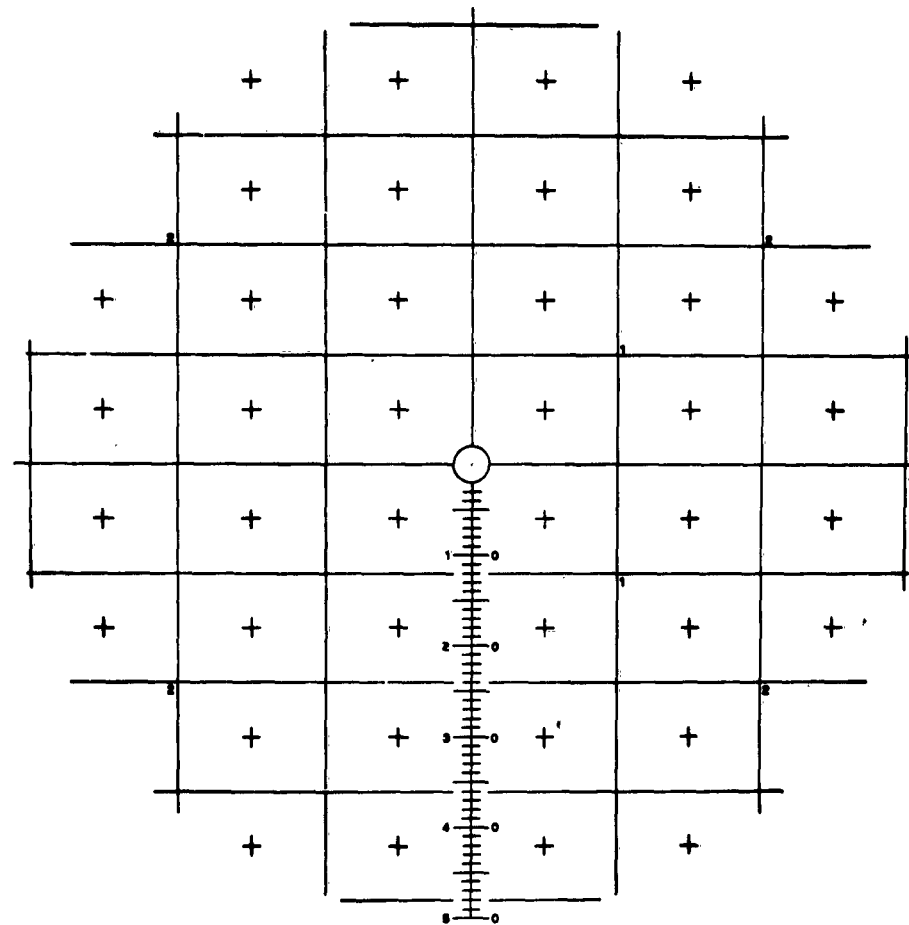


Figure 4

positions had been chosen by random sampling. The Ss were run in groups of three. After localizing six flashes, these Ss received a break while another group of three Ss received the next six flashes—and so on, until all Ss had received 18 flashes. The M48A2 tank with the M4A1 gun-flash simulator remained stationary. Each of the M60 fire control systems was zeroed in on the gun-flash simulator. Before each flash, each of the experimenters in the tanks adjusted the gunlaying controls to establish a

predetermined offset from the flash, and thereby to position the flash in each tank on the chosen spot in the field of view. When all tanks were ready, a signal was given to the gun-flash simulator crew, and within seconds a flash was fired. The gunner called out his reading of the position of the flash and then moved the gun controls a corresponding amount. The position of his lay was determined by the experimenter by means of the azimuth indicator and the M1 gunner's quadrant, and was then recorded.

Results

Shown in Table 2 are the mean errors in reading and gunlaying for each S for the 18 flash positions. These data reveal that mean error was considerably greater in the field situation than it was in the laboratory situation. Mean reading errors which were larger than mean lay error are designated by an asterisk in the table. Such a finding may have been the result of several circumstances. There may have been errors in

Table 2
Mean Reading and Lay Errors in Mils
(Field Study)

SUBJECT		Azimuth		Elevation	
		Reading	Lay	Reading	Lay
Trained Group	1	2.06	2.56	5.75*	3.39
	2	11.89	12.17	18.78	21.17
	3	11.17*	10.39	16.33	16.36
	4	5.56	5.67	3.61*	3.38
	5	2.65	3.06	4.18*	2.94
Untrained Group	6	6.35	9.76	6.35	7.14
	7	14.35	18.76	11.71	13.49
	8	1.89*	1.61	4.06*	1.74
	9	18.44	19.11	20.61*	18.05
	10	27.61*	20.50	15.39	18.24
	11	5.56	5.67	6.56*	6.48
	12	11.94	12.29	23.61*	15.24

* Reading error is larger than lay error.

recording due either to instrument variance or to experimenter variance. Or the gunners may have utilized references other than the reticle, or additional cues, in making their lays. Although the mean errors made by some of the untrained gunners were the largest made, not all the trained gunners performed better than the untrained gunners.

DISCUSSION

Although the findings of the first study were not significant, they suggested that a small gain in accuracy occurred when the new reticle was employed. The decrement in performance that occurred in the field situation might have been expected. No filters were employed which would reduce the size of the flash, and the measurement of performance was not as precise as that used in the simulated situation. It might be anticipated that at least as much decrement would occur if the old reticle were similarly employed.

Although large variability in performance between gunners was expected with the old reticle, it was not predicted with the new one, for the new reticle supplied a greater field of reference. Such a wide variation in performance might occur when training was not effective or when motivation was low. Although both factors may have contributed to the variance, it is more likely that other factors are responsible. The optics of the periscope causes an aberration of the image of the flash when it occurs beyond the limits of the exit pupil; under such circumstances, precise localization of the center of the flash is difficult. Moreover, there is a

certain amount of play in the hand cranks themselves this play further decreases the accuracy of the lays. For these reasons, any fire control system which incorporates only an improved reticle design will produce gains in accuracy which are both small and unstable.

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