Research Report 1251

LEVEL II (12)

EFFECTS OF DOWN-RANGE FEEDBACK AND THE ARI ZEROING TARGET IN RIFLE MARKSMANSHIP TRAINING

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U. S. Army

Research Institute for the Behavioral and Social Sciences

June 1980

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(18) (11) (K I)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (19) RR— Research Report 1251	2. GOVT ACCESSION NO. AD-A100 958
4. TITLE (and Subtitle) (6) EFFECTS OF DOWN-RANGE FEEDBACK AND THE ARI ZEROING TARGET IN RIFLE MARKSMANSHIP TRAINING	5. TYPE OF REPORT & PERIOD COVERED (9) Research Rept.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Seward Smith, Thomas J. Thompson and Keith Evans (ARI), Arthur D. Osborne, Jeffrey L. Maxey, and John C. Morey (Litton-Mellonics)	8. CONTRACT OR GRANT NUMBER(s) (15) DAHC19-77-C-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS Army Research Institute, Alexandria, VA 22333 Litton-Mellonics Systems Development Division (16) 1001 West Maude Ave, Sunnyvale, CA 94086	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q763743A773
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Infantry School Fort Benning, GA 31905	12. REPORT DATE (11) June 1980
	13. NUMBER OF PAGES 37
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) US Army Research Institute for the Behavioral and Social Sciences (PERI-IJ), 5001 Eisenhower Avenue, Alexandria, VA 22333 (12) 55	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Down-range feedback
Knowledge of results
Zeroing
Rifle marksmanship training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Techniques were developed to provide knowledge of down-range rifle marksmanship results and to improve and simplify the process of zeroing the M16A1 rifle. These techniques were tested in a field experiment utilizing 2,124 basic trainees undergoing basic rifle marksmanship training at Fort Jackson, S.C.

Among male trainees, those who received either the ARI Zeroing Target or Down-range Feedback training were superior in their record fire scores to trainees in the control condition. Those receiving both ARI treatments were the

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best of all, showing a 12.3% performance hit increase over controls. Female trainees did not show these results, but there appear to have been non-comparable samples among the four groups of women. In general, males in all groups had higher record fire scores than females.

Questionnaire data revealed that trainees who received the ARI Zeroing Target training were more knowledgeable about zeroing than were controls. Overall, however, trainees demonstrated poor knowledge of many marksmanship fundamentals.

These findings have been incorporated by the U.S. Army Infantry School and ARI in the development of an improved BRM training program soon to be implemented Army-wide.

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Office, Deputy Chief of Staff for Personnel
Department of the Army

June 1980

Army Project Number
2Q763743A773

Training Effectiveness Analysis
for M16A1 Rifle Marksmanship

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The research reported here was performed by the Army Research Institute (ARI) Field Unit at Fort Benning, in collaboration with the Basic Training Committee Croup, Fort Jackson, S.C. It is part of an ongoing program of research directed toward development of cost effective methods for individual and collective training in M16A1 rifle marksmanship. The overall program addresses M16A1 marksmanship at basic training, advanced individual training and unit training levels. It is concerned with all aspects of training, from problem assessment, through instructional program improvement, to study of training aids and devices. The effort involves close coordination and, in some instances, collaboration with various interested organizations including: The U.S. Army Infantry School (USAIS), U.S. Army Training and Doctrine Command (TRADOC), U.S. Army Forces Command (FORSCOM), U.S. Army Marksmanship Unit, U.S. Army Infantry Board, Army Training Centers, U.S. Marine Corps, and U.S. Navy.

This experiment was concerned with Basic Rifle Marksmanship (BRM) at the Basic Training level. The variables studied were chosen as promising candidate improvements for BRM. Other experiments have been and will be conducted to provide an additional empirical basis for training improvements. The overall goal of the research effort is development of an integrated family of programs to take the firer from BRM through unit level skills in a cost effective manner.

The research was coordinated with the U.S Army Infantry School, the proponent agency for M16A1 rifle marksmanship training program development.

ARI research in marksmanship training systems development is conducted as an inhouse effort augmented by contracts with organizations selected as having unique capabilities for research in the area. In this case Litton Mellonics under contract DAHC19-77-C-0011 provided support. The project was conducted as part of Army RDTE Project 2Q763743A773, FY 78 and FT 79 Work Programs. It was directly responsive to the requirements of FORSCOM, USAIS AND TRADOC.

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Technical Director

EFFECTS OF DOWN-RANGE FEEDBACK AND THE ARI ZEROING TARGET IN RIFLE MARKSMANSHIP TRAINING

BRIEF

Requirement:

Several problems have been noted in current basic rifle marksmanship (BRM) training, some of which have to do with zeroing and with lack of down-range feedback. This experiment was developed to test ways to correct these problems and thereby to improve BRM performance.

Procedure:

A new target, intended to simplify and clarify the zeroing process, was developed by the Army Research Institute (ARI). It provides the firer with information about how much to correct which sight in what direction. ARI also devised a simple procedure for providing down-range feedback which gave the firer precise knowledge of where his hits and misses were located. These two developments were tested in a four group experiment during BRM training. One group took standard BRM training and served as the baseline condition. A second group received training on the ARI Zeroing Target. Another was given the ARI Down-range Feedback exercise. A final group had training including both the ARI Zeroing Target and the Down-range Feedback.

Twelve companies of basic trainees (both male and female) took part in this experiment, during their rifle marksmanship training at Fort Jackson, S.C. The groups were compared on their record fire (qualification) score and questionnaire responses.

Findings:

Among male trainees, those who received either the ARI Zeroing Target or Down-range Feedback training were superior in their record fire scores to the control condition. Those receiving both ARI treatments were the best of all, showing a 12.3% performance hit increase over controls. Female trainees did not show these results, but there appear to have been non-comparable samples among the four groups of women. In general, males in all conditions had higher record fire scores than females.

Questionnaire data revealed that trainees who received the ARI Zeroing Target were more knowledgeable about zeroing than were controls. Oveall, however, trainees demonstrated poor knowledge of many marksmanship fundamentals.

Utilization of Findings:

These findings are being incorporated by the U.S. Army Infantry School and ARI in the development of an improved BRM training program to be fielded in the coming months. Refinements of these zeroing and down-range feedback activities and several other research ideas suggested during this experiment are being studied in other experiments as further candidate training program improvements.

EFFECTS OF DOWN-RANGE FEEDBACK AND THE ARI ZEROING TARGET IN RIFLE MARKSMANSHIP TRAINING

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EFFECTS OF DOWN-RANGE FEEDBACK AND THE ARI ZEROING TARGET IN RIFLE MARKSMANSHIP TRAINING

INTRODUCTION

A perennial problem in the Army is rifle marksmanship training. It has drawn criticism, examination and revision repeatedly across the years (e.g., Conway, 1978; Dees, Magner, & McCluskey, 1971; McFann, Hammes, & Taylor, 1955; Wigger, 1977). In a recent cycle of attention, in 1976 the Army Research Institute (ARI) Field Unit at Fort Benning, Georgia, began studying the Army's rifle marksmanship program. This research, sponsored by the U.S. Army Infantry School (USAIS) and by Forces Command, has stemmed from widespread concern that marksmanship skills are inadequate, standards are too low and training costs are too high. ARI began by participating with USAIS and TRASANA in the Basic Rifle Marksmanship (BRM) Test (TRASANA, 1977) which led to training cost savings through substantial reduction of hours and ammunition used in BRM training at basic training centers. Several reports of the BRM Test and of other ARI marksmanship research have been completed (Evans, Thompson, & Smith, 1979; Hicks & Tierney, 1978; Klein & Tierney, 1978; Maxey & Dempster, 1978; Maxey & George, 1977; Maxey, Klein, & Dempster, 1978; Maxey & Sweezey, 1977; Smillie & Chitwood, 1977; Tierney, Cartner, & Thompson, 1977; Tierney & Cartner, 1978).

Table 1 outlines the four candidate programs compared during the BRM Test. Upon completion of the test, the Fort Benning program of instruction (POI) was adopted on an interim basis pending further research. The Benning program (USAIS, 1977) lists a duration of 37 hours and an ammunition expenditure of 334 rounds per trainee. The program it replaced (ASUBJSCD 23-72), called for 77 hours and 720 rounds. The decision was based not on the superiority of the Fort Benning program, but rather that it was more cost effective and did not result in performance decrements.

The results of the BRM Test were puzzling because, as Table 1 documents, the most significant reductions in hours realized by the Benning program were in fundamentals, zeroing and field firing. The extra practice provided by the 77 hour program in these activities ought to have led to greater measured skill unless the training exercises didn't promote learning

Table 1

Programs, Subjects, Hours and Rounds of the Basic Rifle Marksmanship (BRM) Test

Program of Instruction (POI)	Hours	Rounds per Trainee
ASUBJSCD 23-72 (Baseline)	77	720
Ft Jackson	62	513
Ft Dix	49	262
Ft Benning	35	334

Comparison of BRM POI Alternatives

Subjects Covered and Hours of Instruction

Subject	ASUBJSCD 23-72 (Baseline)	Ft Jackson	Ft Dix	Ft Benning
Mechanical Training	4	4	4	4
Marksmanship Fundamentals and Battle sight zero	22	16	20	8
Known Distance Fire	-	-	4	-
Field Fire	30	24	4	12
Record Fire	10	10	12	5
Automatic Fire	3	3	3	3
Night Fire	8	5	2	3
Total Hours	77	62	49	35

Partly to check the possibility that something was wrong with those exercises, members of the ARI-Benning research team went to Fort Jackson, S.C., in March, 1978 and took BRM training with a basic training company. Many things were learned on that trip, two portions of which led directly to the experiment reported in this paper. First, the zeroing process in the Benning program of instruction (POI) is hurried and confusing to the typical trainee. Second, once the trainee leaves the 25 meter firing line at the end of zeroing (early in training), there is little if any useful or detailed feedback about where his shots go when firing at more distant down-range targets. The trainee knows if (but not where) he hits because the killable pop-up targets fall, but he usually cannot tell where his misses go. Correction of mistakes is thus difficult at best.

It appeared that improvements in the zeroing process and in providing better down-range feedback might lead to improved marksmanship knowledge and skill and would therefore be important areas for experimentation.

METHOD

Following the trip to Fort Jackson in March, 1978, ARI became actively involved with training personnel there in program development and marksmanship research.[1] ARI and Fort Jackson shared ideas about problems and solutions and made plans for experiments that could be run in the course of normal basic training. This experiment is the first product of this cooperative planning.

Zeroing

Once soldiers have learned some of the basics of marksmanship, including practice in how to obtain a tight shot group, they attempt to zero their weapons. This is a process where, by changing sights, the shot group is shifted to hit the intended impact point on the target. For some years the target portrayed in Figure 1 has been standard for zeroing. With the M16A1 rifle the intended impact point on this target is the lower X (for the currently used 250 meter battlesight zero). The firer counts the number of squares away from the X (horizonatally and vertically), multiplies by two, interpolates if between squares and derives the number of clicks to move his front or rear sights to correct the bullet strike. Using this target and procedure causes much confusion, inaction and/or improper adjustment.

To offset these problems, the ARI 25 Meter Zeroing Target, shown in Figure 2, was developed by the authors. To determine how to correct his sights, the firer locates his shot group center, picks the horizontal

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[1]ARI's highly productive and beneficial partnership with COL Anthony Labrozzi, Commander, BT Committee Group, Fort Jackson, S.C., is greatly appreciated and acknowledged.

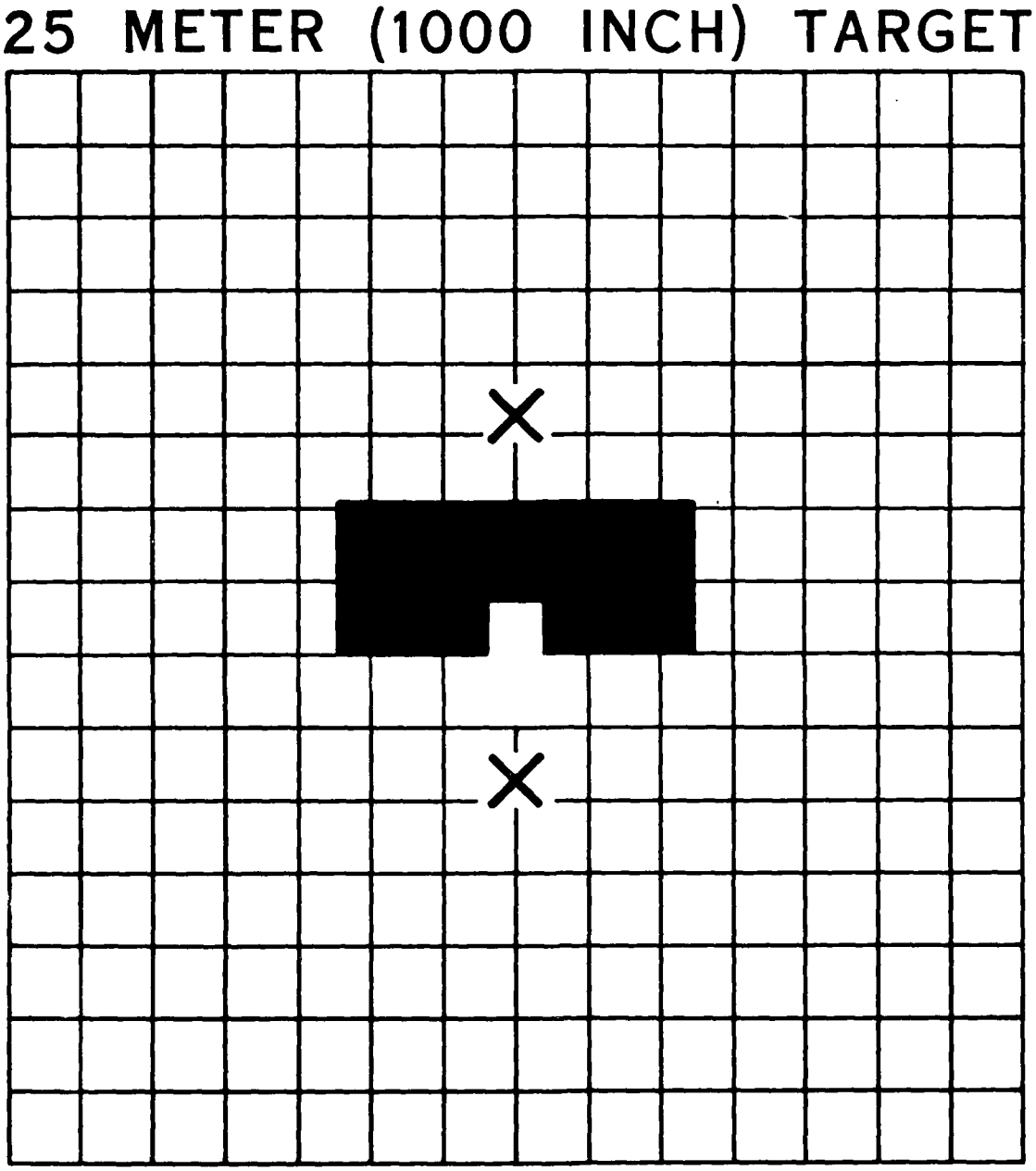

Figure 1. Standard 25 Meter Zeroing Target. Each square represents 2 clicks on the rifle sights. The lower X is the intended impact point for the M16A1 rifle and the upper X is used for the M14.

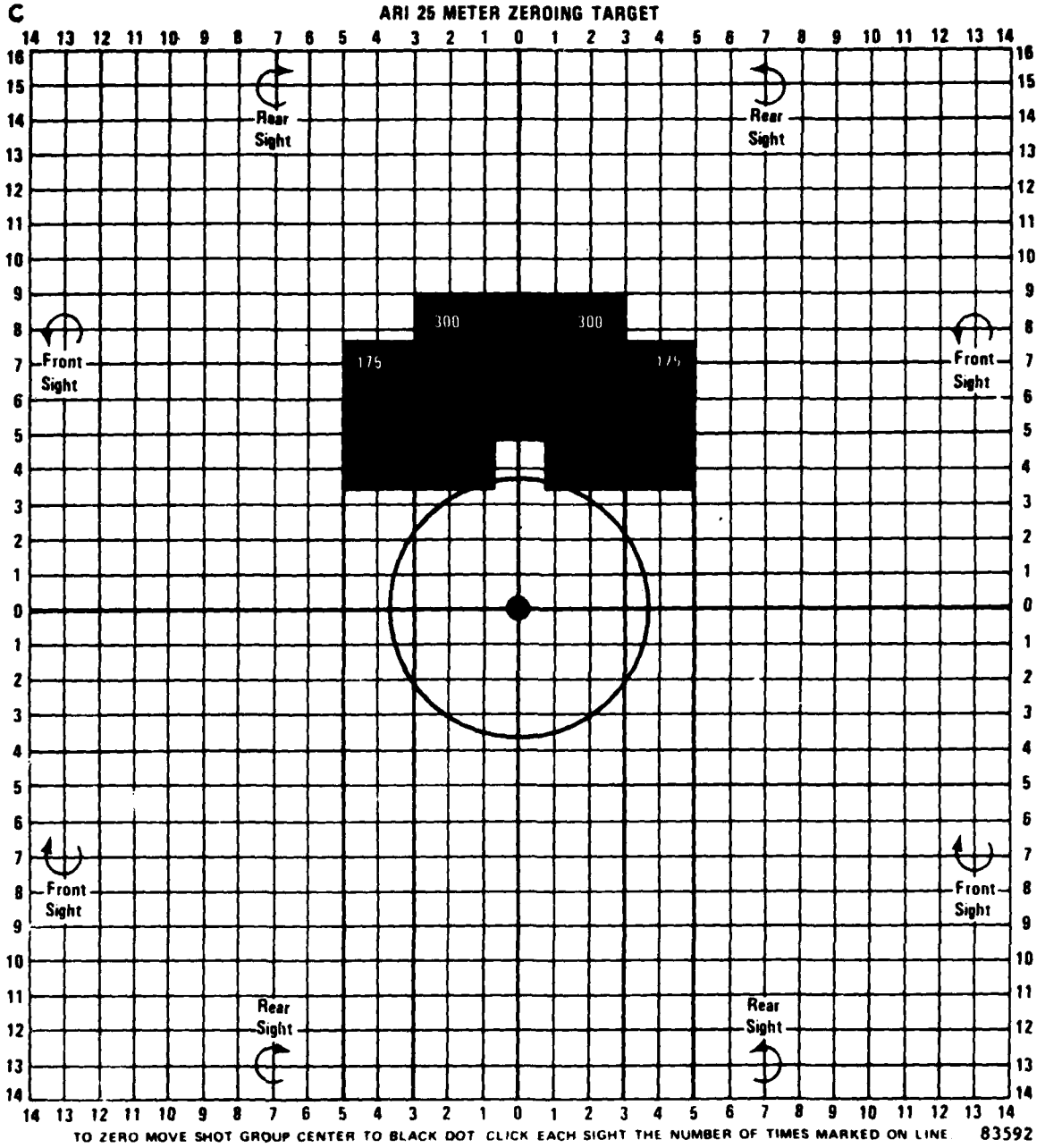

Figure 2. ARI 25 Meter Zeroing Target. Each square is one click of the rifle sights. Information at the margins tells how many clicks to move which sight in what direction.

and vertical lines nearest that point and then finds at the margins - how many clicks to move which sight in what direction. Pilot tests revealed that the ARI Zeroing Target was less confusing, easier to use and resulted in fewer errors, so it was decided to test it more fully. Therefore, the ARI Target (Figure 2) was used for zeroing half of the subjects in the current experiment. The other half used the standard zeroing target (Figure 1).

Down-range Feedback

It is universally accepted that learning occurs best in an environment providing immediate relevant feedback about the adequacy of the learner's response. The "Punchy Pete" killable pop-up targets developed for TRAINFIRE were intended to provide the feedback for field firing - and they did. However, as BRM has evolved in recent years, too much has been asked of the crude feedback - simply "hit" or "miss" - provided by that target. All of the skill sharpening, periodic trips back to the 25 meter line that were included in the original TRAINFIRE program have been gradually eliminated over the years. Now all of the skill improvement depends upon the killable target used at ranges of 75, 175 and 300 meters. This hit/miss feedback, particularly as it lacks detail about misses, is neither effective for problem diagnosis nor for teaching marksmanship fundamentals.

In the current program of marksmanship training, after firing about 36 rounds and spending 10 hours at the 25 meter range, the trainee proceeds to the field fire range, usually never to return to the 25 meter line again. This is insufficient time and practice to acquire shooting fundamentals, but even worse, represents an absence of detailed feedback about shot location for the entire remaining BRM training program.

Two things appear obvious. First, as skills develop, return trips to the 25 meter line to recheck zero and to use shot group exercises for detecting shooting flaws is probably necessary. This will be tested in future experiments. A second point, providing more complete and detailed down-range feedback to prepare firers for field firing, would probably lead to a more successful transition from 25 meter to field firing. It could also aid greatly in diagnosis and in teaching about effects of wind, gravity and other influences on the bullet. For these reasons the authors studied ways to provide down-range feedback on regular field fire ranges and devised the simple process used in the current experiment.

At ARI's recommendation, Fort Jackson modified a standard 300 meter field fire range to accomplish the feedback task on known distance type targets without requiring support personnel down-range.[2] Figure 3 shows a picture of the range looking from the firing line out to targets located at 75 and 175 meters. The targets are mounted

[2] COL Labrozzi and his staff deserve credit for many of the design details of this down-range feedback facility.

on removable wooden frames in sleeves in the ground. The 175 meter target, as shown in Figure 4, consists of a standard thin paper E (kneeling) silhouette pasted in the center of a 6' by 6' sheet of known distance target paper turned backwards. The 75 meter F-type prone target is the "Center, Target Repair Rifle Target "D" Prone (Army)" mounted on a 36" by 38" frame.

The exercise devised for use of this modified range for this experiment involved trainees firing four three-round shot groups at the 175 meter target. They walked down-range after each group to see where their bullets went (for silhouette hits and for misses). Spotters were placed in the bullet holes (see Figure 4) so that Drill Sergeants could see who needed correction and to assist in problem diagnosis. Sight corrections were permitted because many firers had not yet achieved an acceptable weapon zero. After the fourth shot group, the trainees also fired a three-round shot group at the 75 meter target and then checked both targets. This portion of the exercise is helpful in teaching wind and trajectory effects and for boosting confidence in where bullets strike for a given aiming point.

In the experiment, half of the trainees used this down-range feedback exercise for one of their two field fire training periods. The other half had the standard two periods of field fire instruction.

Design of the Experiment

The experiment employed a factorial design, varying zeroing procedure (ARI Zeroing Target vs. Standard Zeroing Target) and down-range feedback (ARI Down-range Feedback vs. Standard Field Fire). Three companies of basic trainees were assigned to each treatment condition.

	Standard Field Fire	ARI Down-range Feedback
Standard Target	3 Companies	3 Companies
ARI Zeroing Target	3 Companies	3 Companies

In the current BRM training program, Period 4 is the zeroing exercise, using the standard zeroing target. This period, unaltered, was the baseline (Standard Zeroing Target) condition. The ARI Zeroing Target condition consisted of Period 4, modified only as required to instruct trainees in the use of the ARI target. Trainees from one condition were not taught how to use the target employed by the other.


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Periods 5 and 6 are the standard periods of BRM instruction in field firing techniques. Period 5 teaches firing at pop-up targets appearing singly at 75, 175 and 300 meters. During Period 6 these same targets appear sometimes singly and sometimes in multiples. Periods 5 and 6, in unaltered form, were employed for the Standard Field Fire condition of the experiment. The ARI Down-range Feedback condition used the previously described exercise in place of regular Period 5. Period 6 was then modified for these trainees to combine the training exercises of both Periods 5 and 6 of the standard training program. The similarities and differences between the standard and modified Periods 5 and 6 are shown in Table 2.

Table 2

Composition for the Standard and the ARI Down-range Feedback (Modified) Field Fire Experimental Conditions

Instructional Periods	Standard Field Fire (Regular Periods 5 & 6)	ARI Down-range Feedback (Modified Periods 5 & 6)
BRM Period 5	42 Total Rounds 42 single fire shots at 75, 175 and 300 meter pop-up targets	15 Total Rounds* 4 3-round shot groups at 175 meter stationary target 1 3-round shot group at 75 meter stationary target
BRM Period 6	36 Total Rounds 8 single fire shots at 75, 175 or 300 meter pop-up targets 28 shots fired at 14 different-range pairs of pop-up targets	56 Total Rounds 20 single fire shots at 75, 175 or 300 meter pop-up targets 36 shots fired at 18 different-range pairs of pop-up targets
	78 Total Rounds (Per 5 & 6)	71 Total Rounds (Per 5 & 6)

*Time constraints prevented firing more rounds per trainee in this exercise.

Data collection for the experiment was carried out between October 16, 1978 and November 17, 1978 at Fort Jackson, South Carolina by Basic Training Committee Group personnel of that installation. ARI staff members frequently monitored training and data collection. The experimental procedures kept pace with the normal flow of basic training so no disruptions occurred.

Subjects

The 2,124 participants in the experiment were members of 12 basic training companies undergoing their entry level training at Fort Jackson, South Carolina. In order to avoid interrupting the normal flow of training and to prevent division of already insufficient cadre and BRM committee group personnel resources, the experimental limitation of assigning an entire company to the same treatment condition had to be accepted. Thus, three companies were randomly assigned to each of the four cells of the experimental design. All basic training companies at Fort Jackson currently contain both male and female trainees, usually two-thirds to three-quarters males. Sizes of these training companies vary. The total numbers of trainees assigned to each experimental condition, reflecting that variability, are given in Table 3.

Table 3

Males and Females Assigned to Each Experimental Condition

	Standard Field Fire	ARI Down-range Feedback	
Standard Zeroing Target	Males = 352 Females = 160 Total Ss = 512	Males = 401 Females = 183 Total Ss = 584	Males = 753 Females = 343 Total Ss = 1096
ARI Zeroing Target	Males = 399 Females = 113 Total Ss = 512	Males = 349 Females = 167 Total Ss = 516	Males = 748 Females = 280 Total Ss = 1028
	Total Males = 751 Total Females = 273 Total Ss = 1024	750 350 1100	1501 623 2124

Data Collection

Record Fire. The prime data gathered were qualification scores (record fire) at the end of BRM training. The qualification exercise at Fort Jackson utilized the record fire range with automatically scored pop-up targets at ranges of 50 to 300 meters in increments of 50 meters. Forty target exposures (singly or in multiples) constitute the test, permitting scores of 0 to 40 points (one point per hit). Current standards require 17 hits to qualify (Marksman = 17-23, Sharpshooter = 24-27, Expert = 28-40). The total number of hits per trainee printed out by the computer was the qualification score utilized for analyses.

Questionnaire. A questionnaire was prepared to measure marksmanship experience and knowledge (e.g., understanding of the zeroing process, awareness of required aiming points). Its major purposes were to add understanding to the results of record fire, to confirm whether intended training occurred or was understood and to assess the value of the new ARI 25 Meter Zeroing Target. See Appendix A for questionnaire details.

RESULTS

Analyses of variance were calculated to compare performances of the various treatment groups. Sex of trainee was also included in analyses because male trainees typically fire higher qualification scores at the end of BRM training than do females.

Record Qualification Performance

The prime data for comparing BRM performances were record fire (qualification) scores. These scores were compared using an unweighted means, three factor factorial analysis of variance, as summarized in Table 4. Trainees who experienced the ARI Down-range Feedback condition out-performed those who did not. Similarly, those using the ARI Zeroing Target were better than those using the regular target. As expected, males qualified higher than females (24.1 vs. 20.4 hits). There was a significant interaction, however, which reflected a large difference between field fire programs for males but not for females. For this reason record fire performances of males and females were examined separately using two factor factorial analyses of variance.

The analysis for males showed highly significant main effects favoring both the ARI Zeroing Target and ARI Down-range Feedback conditions. Table 5 summarizes the mean performance for the four treatment conditions. Overall, trainees in the ARI Down-range Feedback conditions qualified higher ($p<.001$) than those undergoing Standard Field Fire (25.0 vs. 23.2 hits). Although no record fire differences as a result of type of zeroing target had been predicted, the ARI target groups significantly ($p<.005$) out-shot those using the standard zeroing target

Table 4

Analysis of Variance of Qualification Scores at the End of Basic Rifle Marksmanship Training

SOURCE	df	MS	F	p
Male vs. Female (A)	1	6489.07	137.06	.001
Down-range Feedback vs. Standard Field Fire (B)	1	718.11	15.17	.001
ARI vs. Standard Zeroing Target (C)	1	377.40	7.97	.005
AB	1	492.23	10.40	.001
AC	1	5.65	.12	
BC	1	15.18	.32	
ABC	1	37.92	.80	
Residual	2116	47.35		

Table 5

Mean Record Qualification Scores for Male Trainees as a Function of Zeroing Target and Field Fire Conditions

	Standard Field Fire	ARI Down-range Feedback	Totals
Standard Zeroing Target	22.7	24.5	23.6
ARI Zeroing Target	23.7	25.5	24.6
Totals	23.2	25.0	

(24.6 vs. 23.6 hits). Trainees who received both the ARI Zeroing Target and Down-range Feedback training averaged 25.5 hits, nearly a 3 point (12 percent) improvement compared to those given standard zero and field fire training (22.7 hits).

The analysis for women did not reveal any significant differences in record fire scores for the experimental conditions tested (see Table 6). These results will be discussed later in the report.

Table 6

Mean Record Qualification Scores for Female Trainees as a Function of Zeroing Target and Field Fire Conditions

	Standard Field Fire	ARI Down-range Feedback	Totals
Standard Zeroing Target	19.9	20.1	20.0
ARI Zeroing Target	21.3	20.3	20.8
Totals	20.6	20.2	

Questionnaire Data

Several items in the questionnaire were written to find out what trainees knew about marksmanship fundamentals at the end of BRM training.

How to Change Sights. It was expected that trainees' knowledge of how to zero the rifle would be the main advantage afforded by use of the ARI Zeroing Target (Figure 2). Question 9 of the questionnaire (see Appendix A for all questions) pictured a shot group high and left of the intended impact point on a replica of the specific zeroing target used by the trainee. The question asked how many clicks to move the group to correct the zero. There was a highly significant difference in answering as a function of type of zeroing target used ($F = 101.03$, $df = 1, 1,507$, $p<.001$). Almost half of the trainees (47.9 percent) who used the ARI target gave fully correct answers compared with only 25.4 percent of those trained with the standard zeroing target. The ARI target thus produced nearly twice as many correct answers. Males and females generally did not differ in the zeroing knowledge sampled by this question.

Sighting Knowledge. Questions 1 to 3 showed correct and incorrect drawings of sight alignment, sight picture, or a combination of sight alignment and sight picture. Most persons appeared to know sighting fundamentals, accurately identifying as correct or incorrect an average of 10.7 of the 12 pictures.

Wind and Trajectory Knowledge. Eight questions (15-22) checked knowledge of where to aim for specific target ranges or in the wind, or where bullets should strike for various aiming points. Males knew the correct answer somewhat more often than females ($F = 9.47$, $df = 1, 1,572$, $p < .002$). However, they averaged only 3.64 of the possible 8 correct compared to 3.41 for females. These were fundamental and important questions about aiming. Lack of this knowledge suggests a clear deficiency for both groups.

Will Shot Group Hit? In question 10 a shot group was located somewhat to the left on the appropriate 25 meter target replica and the trainee was asked whether the bullets would have been likely to hit 175 meter or 300 meter targets. Information permitting a full and accurate answer is contained on the ARI target but not the standard zeroing target. The two groups were not significantly different. Only 43.9 percent of those trained on the ARI target were correct compared with 37.2 percent for those who used the standard target. It appears likely that this information was not taught since as many as 25 percent of either group could have gotten the question correct by guessing alone.

Rifle Experience. One other question (27) was examined to determine prior rifle experience: 57.1 percent of male trainees and 89.3 percent of the females had no prior experience (hunting). Actually, only 27.4 percent of the males compared with 3.8 percent of the females had "many" prior hunting experiences with rifles. The male-female differences were highly different statistically ($F = 175.61$, $df = 1, 1,555$, $p < .001$). As is usual in the Army today, however, the overall prior weapons experience of the entry level soldier is low.

Correlations of Questionnaire Items with Record Fire Scores

Table 7 gives the Pearson correlation coefficients between record fire scores and various questionnaire measures for male and female trainees. Each of the questionnaire measures was found to have a small but significant ($p < .05$) positive relationship with record fire performance.

Possible Sample Biases

In general, assigning entire companies as a group to a condition is not a particularly satisfactory randomization procedure, though necessary in this experiment. For this reason it seemed wise to examine the various measures to see if any biases could be detected that might affect conclusions. These examinations are summarized in the next three sections.

Table 7

Pearson Correlation Coefficients Between Record Fire Scores and Questionnaire Measures

Measure	Record Fire Score (r for Males)*	Record Fire Score (r for Females)*
How to Change Sights	.16	22
Sighting Knowledge	.09	.14
Wind and Trajectory Knowledge	09	.22
Will Shot Group Hit?	.10	.08
Rifle Experience	.17	.12

*All $p < .05$ or better.

Standard Field Fire vs. ARI Down-range Feedback

Table 8 summarizes comparisons of the two field fire conditions for the data collected. The record fire scores shown are for males and females combined. From the earlier indicated analysis of variance of record fire scores, however, males showed about a two point difference while females showed none (see Tables 4-6). All of the questionnaire measures favored the Standard Field Fire condition, though only two were significant. In general, the trainees in the Standard Field Fire condition were more knowledgeable at the end of training then those in the ARI Down-range Feedback condition. There were no treatment related reasons to expect these knowledge differences. However, they could have caused partial masking of the value of the ARI Down-range Feedback.

Standard Zeroing Target vs. ARI Zeroing Target

Table 9 presents the same data comparisons (males and females combined) as a function of type of zeroing target used. Analysis of variance (see Table 4) showed improved record fire performance for trainees using the ARI Zeroing Target, with a one point superiority over the Standard Target for males and a .8 point increase (not significant) for females (see Tables 5 and 6). The use of the ARI Zeroing

Table 8

Mean Record Fire and Questionnaire Measure Scores for Standard Field Fire and ARI Down-range Feedback Conditions

Measure	Standard Field Fire	ARI Down-range Feedback	F	p
Record Fire	21.9	22.6	15.17	.001
How to Change Sights	1.11	1.00		--
Sighting Knowledge	10.80	10.56		--
Wind and Trajectory Knowledge	3.77	3.28	31.13	.001
Will Shot Group Hit?	1.32	1.24	4.15	.042
Rifle Experience	.46	.40		--

Table 9

Mean Record Fire and Questionnaire Measure Scores for Standard Zeroing Target and ARI Zeroing Target Conditions

Measure	Standard Zeroing Target	ARI Zeroing Target	F	p
Record Fire	21.8	22.7	7.97	.005
How to Change Sights	.84	1.27	101.03	.001
Sighting Knowledge	11.28	10.08	95.27	.001
Wind and Trajectory Knowledge	3.55	3.50		--
Will Shot Group Hit?	1.24	1.32		--
Rifle Experience	.38	.47	6.45	.011

Target also led to significantly greater knowledge of how to change sights to zero the rifle. The other questionnaire data showed two significant group differences, one favoring the ARI Zeroing Target condition, and one favoring the standard condition.

Males vs. Females

Males and females are compared on the various measures in Table 10. Major differences existed in rifle experience and in record fire scores. These results are typical and were expected. Males were also found to know more about wind and trajectory effects on the bullet. However, in other knowledge areas the two groups were similar. Why males should so consistently outshoot females is not clear and is no better explained by this experiment than by prior findings.

Table 10

Mean Record Fire and Questionnaire Measure Scores for Males and Females

Measure	Male	Female	F	p
Record Fire	24.1	20.4	137.06	.001
How to Change Sights	1.07	1.04		--
Sighting Knowledge	10.80	10.56		--
Wind and Trajectory Knowledge	3.64	3.41	9.47	.002
Will Shot Group Hit?	1.30	1.25		--
Rifle Experience	.70	.16	175.61	.001

DISCUSSION AND CONCLUSIONS

ARI Zeroing Target and Down-range Feedback

Evidence has been presented showing that improved zeroing and down-range feedback both improve record fire performance for males. The ARI Zeroing Target presumably increases understanding of the zeroing process, reduces sight adjustment errors and, overall, is easier to use. The down-range feedback exercise has the advantage of providing specific knowledge of where hits and misses go, thus assisting with problem diagnosis and providing information about down-range effects on the bullet. It also can serve to prolong the zeroing process so that firers can become somewhat more proficient prior to final zero confirmation. One current problem is that trainees zero very early in the program, before acquiring much knowledge or skill. Their zeros in many cases are inadequate. The use of more feedback later in the program should result in gradual skill sharpening and a more certain zero. These, in turn, ought to increase firer performance and confidence.

Experimental Results for Female Trainees

The results of this experiment were different between men and women. The process of assigning men to conditions does not appear to have biased any cell of the design favorably or unfavorably. In contrast, for females there appear to have been unintended differences suggesting that accidental sampling biases may have contributed to reducing the effects of the experimental variables. In general, the women assigned to the ARI Down-range Feedback condition had less prior weapons experience and were less knowledgeable about BRM than those in the Standard Field Fire condition. Any advantage of the Down-range Feedback could have thus been negated for those women.

Those females assigned to use the ARI Zeroing Target tended to fire better in qualification and tended to know more about how to zero their rifles. They were weaker on general marksmanship knowledge, however, so the results of the zeroing target comparison may also have been minimized. Further data collection may clarify these findings.

Another possibility needs to be considered. Female trainees typically fire lower scores than do male trainees. The current very short BRM program may yield a less satisfactory basis for learning among females who enter far less experienced than males in marksmanship fundamentals. There are likely to be many reasons to increase certain portions of BRM training for all trainees, but it may be even more necessary for the females than for the males.

Trainee Knowledge and Instructor Limitations

The data reported for this experiment only somewhat address how knowledgeable trainees were by the end of BRM. It seems clear, however, that their average awareness of important riflery fundamentals was considerably limited. Failure to know how to zero, where to aim, and how to allow for effects of gravity and wind certainly translate directly into missed distant targets.

Trainees receive considerable training on sight alignment and aiming point (for 25 meter targets). Based upon this experiment they appear to know this information. In most other marksmanship content areas the knowledge is probably inadequate. Trainees do not know effects of wind and gravity at various ranges and thus do not know where to aim for higher probability of hit. From observations it is also clear that many trainees do not know rapid reloading procedure, immediate action to clear malfunctions, and proper care of the weapon.

The committee group instructors appear to be generally quite skilled, but the majority of the instruction at the firing line must be carried out by drill sergeants who arrive at the range with the basic training company. These persons by and large have had little training beyond their own BRM training. They very likely learned little there and hence have little to impart now that they are instructors. Few drill sergeants appear to be good at diagnosis and/or remediation of shooters' problems. In many cases they have been observed giving incorrect information or failing to correct an obvious firer defect. One problem, perhaps, is that most of them have never seen in detail where bullets go beyond 25 meters.

In the current experiment, questionnaire results clearly show that instructors did not give trainees much of the information or guidance that would have helped to improve performances on the down-range feedback exercise (e.g., what are the effects of wind and gravity?). They also failed to convey the information about where shots were likely to go when shooting at more distant targets, based upon where the firer had hit the 25 meter target.

In short, much instruction, diagnosis and remediation has been observed to be inadequate, with the result that trainees' knowledge is seriously limited. Almost certainly this in turn has a negative effect upon shooting performance.

Even if the instructor performance were of uniformly high quality, one additional problem is high ratios of trainees to instructors throughout training. During marksmanship fundamentals (e.g., time to correct prime mistakes before bad habits become set) it is not uncommon to observe 15 or even 20 trainees to one drill sergeant at the firing line. The typical firing exercise ends with most trainees receiving no correction or assistance at all.

Implications of This Experiment

The data suggest that improved zeroing and more detailed feedback from down range will boost record fire performance. Improvements of these manipulations will be tried in further experiments designed to develop a more effective program of instruction. It is clear that proper and complete instruction needs to be given so that these and other parts of BRM training can have their intended effect. The performance of female trainees will again be studied to determine whether the POI improvements will also improve their firing ability.

The most promising additional variables for further study and inclusion are: lower trainee to instructor ratios, returns to the 25 meter line later on in training to examine zero and shot groups, and use of printed guide materials to aid instructors and trainees in mastery of fundamentals.

Improved ARI 25 Meter Zeroing Target

Figure 5 shows an improved version of the ARI 25 Meter Zeroing Target recently developed for further experimentation. The same procedure for correcting rifle zero is utilized. For example, information is found at the margins to tell the firer how many clicks to move which sight in what direction. The two silhouette outlines portray 175 and 300 meter targets appropriately scaled when seen at 25 meters. They are intended to show the firer what his 25 meter bullets would have hit down range at 175 or 300 meters (assuming proper aiming point for targets at those ranges). Trainees can be shown that a tight shot group located on the intersection of the two "0" lines at the center of the circle is the desired zero. They can see that the nearer to the dot and the tighter the shot group, the more likely they would be to hit 175 meter and 300 meter field fire targets. It is expected that this feature will assist drill sergeants and trainees to be more aware of the need for a well zeroed rifle and will lead to more care in obtaining a proper zero.

The circle beneath the black bullseye rectangle is the allowable shot group size for proper zeroing. A rifle that shoots all three shots inside the circle is considered to be zeroed. One change in target design is to reduce the diameter of the circle to be equivalent to the 19" width of the pop-up field fire target when represented at 25 meters. This change from 5.2 cm (the current requirement) to 4 cm provides a more stringent but more face-valid criterion of zeroing adequacy.

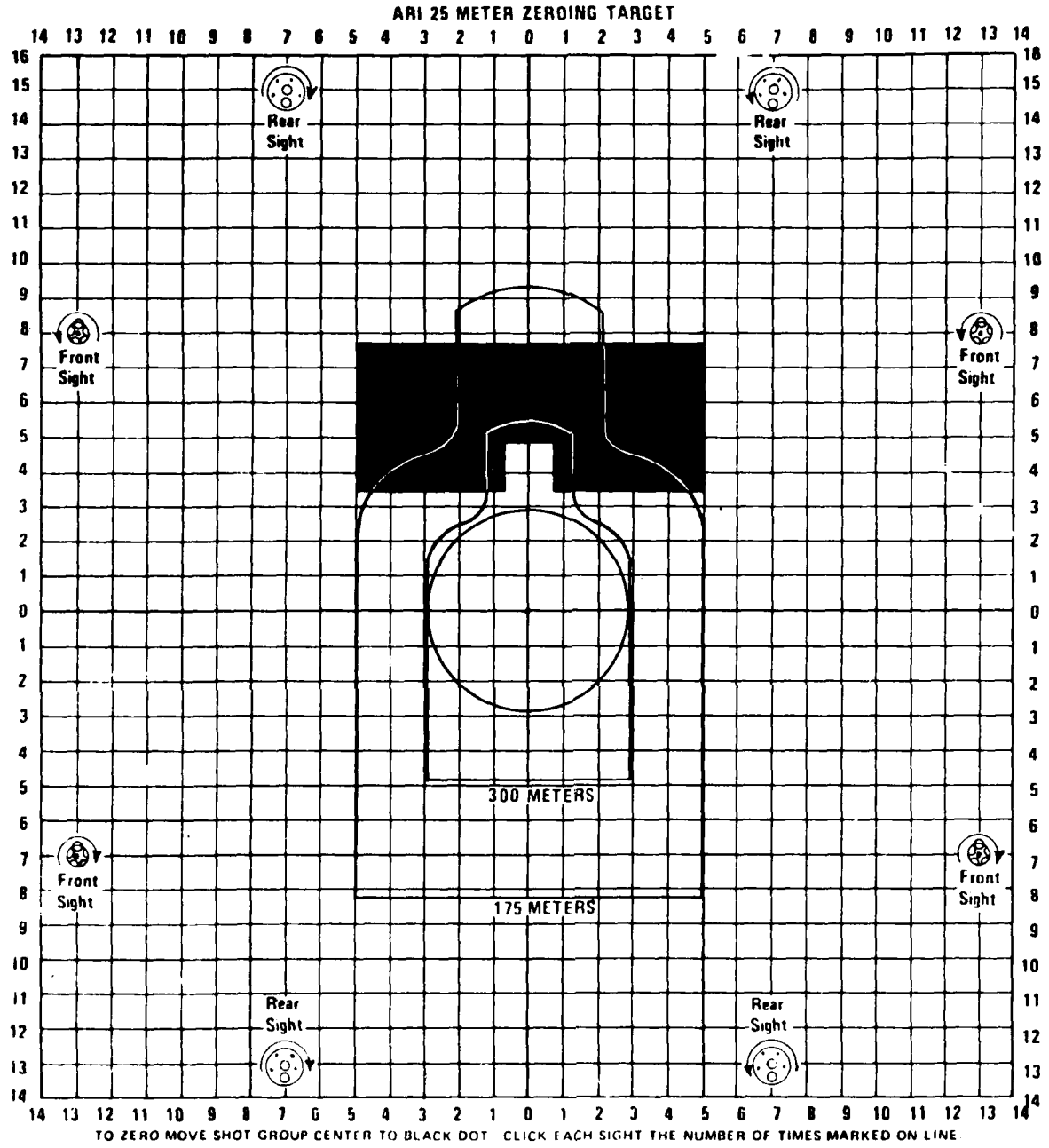

Figure 5. Modified form of the ARI 25 Meter Zeroing Target currently undergoing test for possible adoption.

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APPENDIX A

BASIC RIFLE MARKSMANSHIP

QUESTIONNAIRE

DATA REQUIRED BY THE PRIVACY ACT OF 1974

TITLE: BRM Training Questionnaire

PRESCRIBING DIRECTIVE: AR 70-1

AUTHORITY: 10 USC Sec 4503

PURPOSE(S): The data collected with the attached form are to be used for research purposes only.

This is an experimental personnel data collection form developed by the U. S. Army Research Institute for the Behavioral and Social Sciences pursuant to its research mission as prescribed in AR 70-1. When identifiers (name or Social Security Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of the research, but there will be no effect on individuals for not providing all or any part of the information.

MARKSMANSHIP FUNDAMENTAL - TEST

Last Name	FI	MI	AI-FF
Unit	SSAN		Date

1. For each picture below are the front and rear sight [illegible] (Gil

[ ] Yes
[ ] No

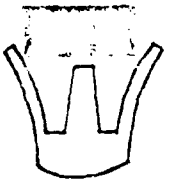
[ ] Yes
[ ] No

[ ] Yes
[ ] No

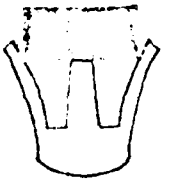
[ ] Yes
[ ] No

2. For each picture below is the [illegible] up (aligned) with the front [illegible]

[ ] Yes
[ ] No



[ ] Yes
[ ] No

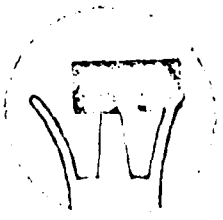


[ ] Yes
[ ] No

[ ] Yes
[ ] No

3. For each picture below [illegible] picture [illegible]

[ ] Yes
[ ] No



[ ] Yes
[ ] No

[ ] Yes
[ ] No

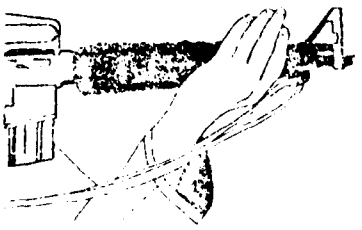
[ ] Yes
[ ] No

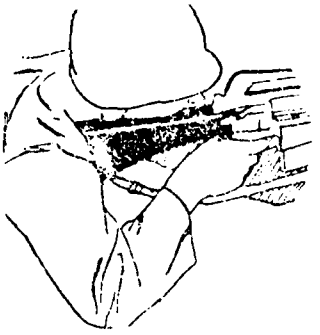
4. With an "X" mark the statement that best describes where the trigger finger should be placed on the rifle trigger.

- ☐ Wrapped completely around the trigger.
- ☐ Tip of the finger on the trigger.
- ☐ Middle of the finger on the trigger.
- ☐ Wrapped around the trigger touching the receiver of the rifle.

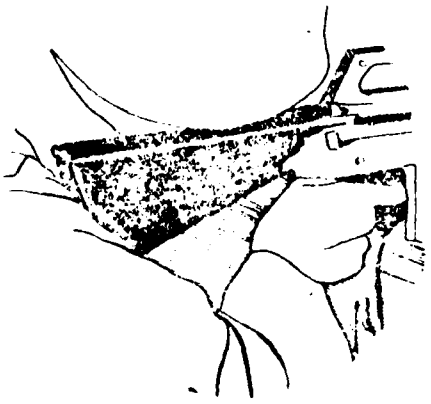
5. Match the steady hold factors listed below with the correct picture. There is only one correct matching for each picture. Write your answer in the space below the picture.

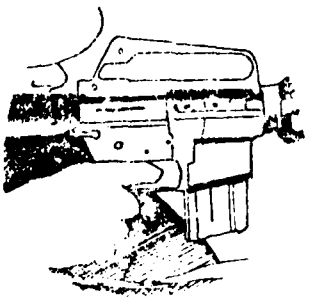
a. Grip of non-firing hand
b. Rifle butt in shoulder
c. Relaxation
d. Grip of firing hand
e. Firing elbow placement
f. Stock weld
g. Breathing
h. Trigger finger placement.

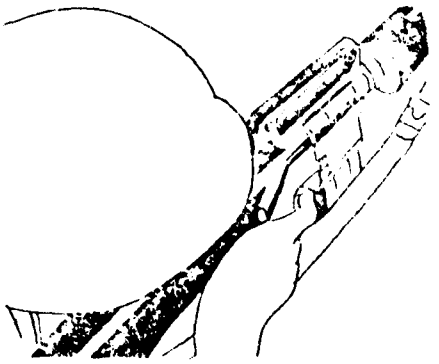




_____ _____ _____





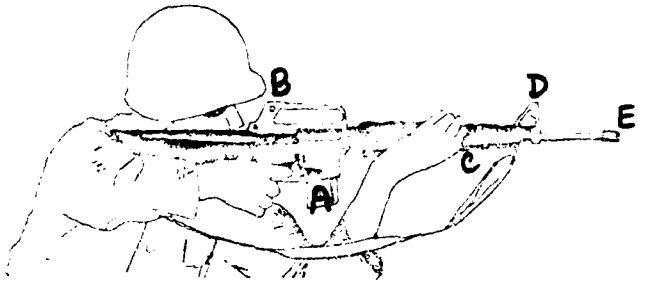


_____ _____ _____

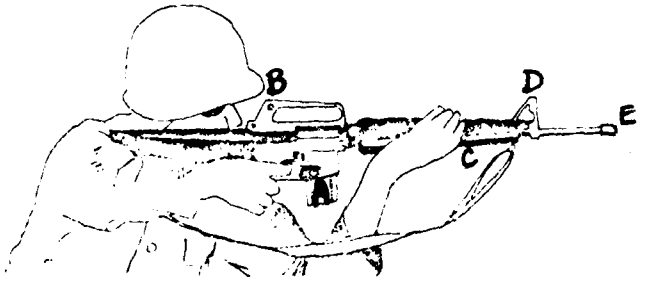
6. Before sight changes can be made to zero a rifle, the firer must be able to:

- ☐ hit the top of the target.
- ☐ hit the bottom of the target.
- ☐ hit the aiming point two out of three times.
- ☐ fire a tight shot group.

7. In the picture shown below, circle the letter that labels the part of the rifle used to make adjustments in windage.

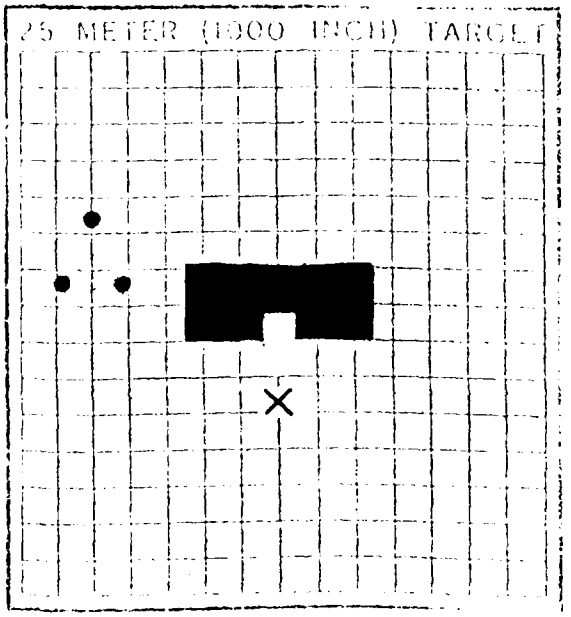


8. In the picture shown below, circle the letter that labels the part of the rifle used to make adjustments in elevation.



THIS PAGE USED FOR THOSE TRAINED WITH THE STANDARD ZEROING TARGET

9. Pictured below is a three (3) round shot group fired at a 25 meter zero target. What changes in elevation and windage should be made to zero the rifle?



ANSWER: _____ clicks of windage right _____ left _____
(fill in) (mark with an "X")

_____ clicks of elevation up _____ down _____
(fill in) (mark with an "X")

THIS PAGE USED FOR THOSE TRAINED WITH THE STANDARD ZEROING TARGET

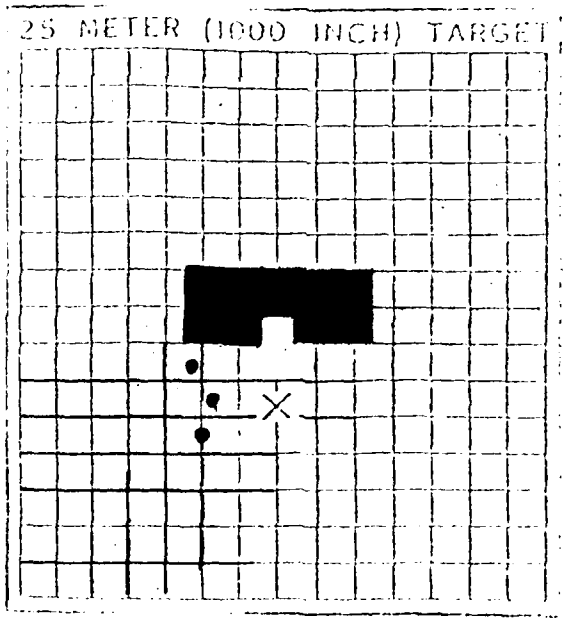
10. Pictured below is a three (3) round shot group fired by a trainee.

a. If the trainee fired his rifle at a 175 meter target would the rounds be likely to hit the target?

- ☐ Yes
- ☐ No
- ☐ I don't know

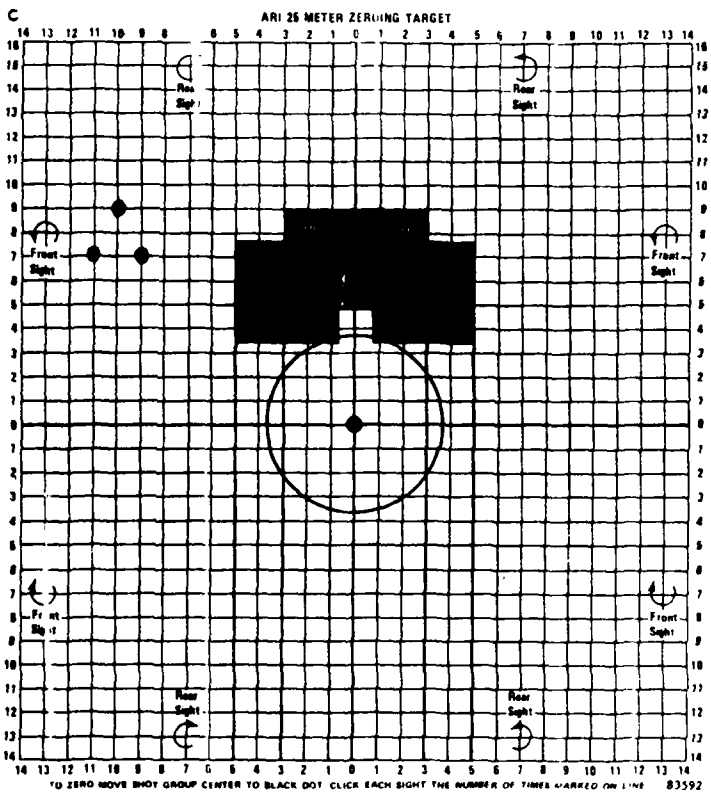
b. If the trainee fired his rifle at a 300 meter target would the rounds be likely to hit the target?

- ☐ Yes
- ☐ No
- ☐ I don't know



THIS PAGE USED FOR THOSE TRAINED WITH THE ARI ZEROING TARGET

9. Pictured below is a three (3) round shot group fired at a 25 meter zero target. What changes in elevation and windage should be made to zero the rifle?



ANSWER: _____ clicks of windage
(fill in)

_____ (mark with an "X")

_____ clicks of elevation
(fill in)

_____ (mark with an "X")

THIS PAGE USED FOR THOSE TRAINED WITH THE ARI ZEROING TARGET

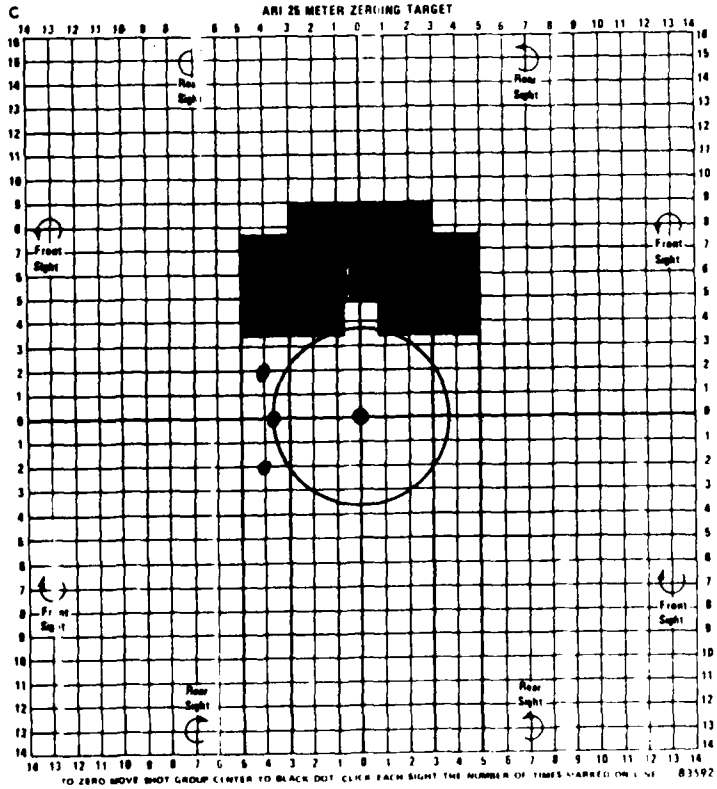
10. Pictured below is a three (3) round shot group fired by a trainee.

a. If the trainee fired his rifle at a 175 meter target would the rounds be likely to hit the target?

- ☐ Yes
- ☐ No
- ☐ I don't know

b. If the trainee fired his rifle at a 300 meter target would the rounds be likely to hit the target?

- ☐ Yes
- ☐ No
- ☐ I don't know



11. With an "X" mark the word that best completes the following sentences.

    a. If I move the front sight ☐ clockwise ☐ counterclockwise, the strike of the round will move up.

    b. If I move the rear sight ☐ clockwise ☐ counterclockwise, the strike of the round will move left.

12. In your own words tell how to zero your rifle.

_____

_____

_____

13. In your own words tell why it is necessary to zero your rifle.

_____

_____

_____

14. Did you have any problems zeroing your rifle? ☐ Yes ☐ No
    If "Yes", what was the problem?

_____

_____

_____

15. If there was a wind blowing across the range from the right side, where would you aim on your target? (Choose the best answer)

    ☐ A bit to the right
    ☐ A bit to the left
    ☐ Dead center
    ☐ I don't know

16. If you aimed at the center of a target and your round fell short, where would you aim the next time you fired at the target? (Choose the best answer)

- ☐ Bottom of the target
- ☐ Dead center
- ☐ Top of the target
- ☐ I don't know

17. Using a well zeroed rifle, where will the rounds impact on a 75 meter target if the rifle is aimed center of target mass?

- ☐ Above center of target mass
- ☐ Dead center
- ☐ Below center of target mass
- ☐ I don't know

18. Using a well zeroed rifle, where will the rounds impact on a 175 meter target if the rifle is aimed center of target mass?

- ☐ Above center of target mass
- ☐ Dead center
- ☐ Below center of target mass
- ☐ I don't know

19. Using a well zeroed rifle, where will the rounds impact on a 300 meter target if the rifle is aimed center of target mass?

- ☐ Above the center of target mass
- ☐ Dead center
- ☐ Below center of target mass
- ☐ I don't know

20. What is the point of aim for the F-type (prone) silhouette target at 75 meters?

- ☐ Bottom of target
- ☐ Dead center
- ☐ Top of target
- ☐ I don't know

21. What is the point of aim for the E-type (kneeling) silhouette target at 175 meters?

- ☐ Bottom of target
- ☐ Dead center
- ☐ Center of shoulders
- ☐ I don't know

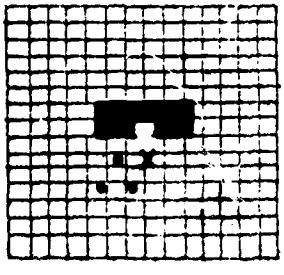
THIS PAGE USED FOR THOSE TRAINED WITH THE STANDARD ZEROING TARGET

22. What is the point of aim for the E-type (kneeling) silhouette target at 300 meters?

- ☐ Bottom of the target
- ☐ Dead center
- ☐ Center of shoulders
- ☐ I don't know

23. Pictured below are two, three (3) round shot groups. Both were fired from zeroed weapons. Which group was fired from the more accurately zeroed weapon?

- ☐ A
- ☐ B
- ☐ Both equally good



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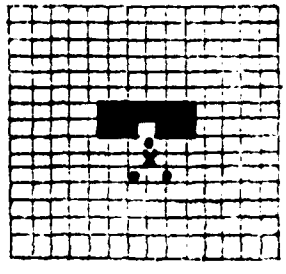


B

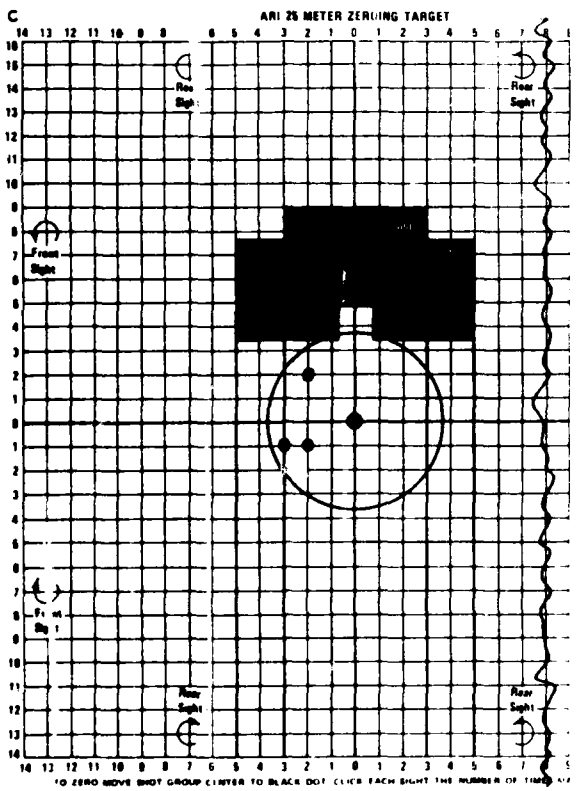
THIS PAGE USED FOR THOSE TRAINED WITH THE ARI ZEROING TARGET

22. What is the point of aim for the E-type (kneeling) silhouette target at 300 meters?

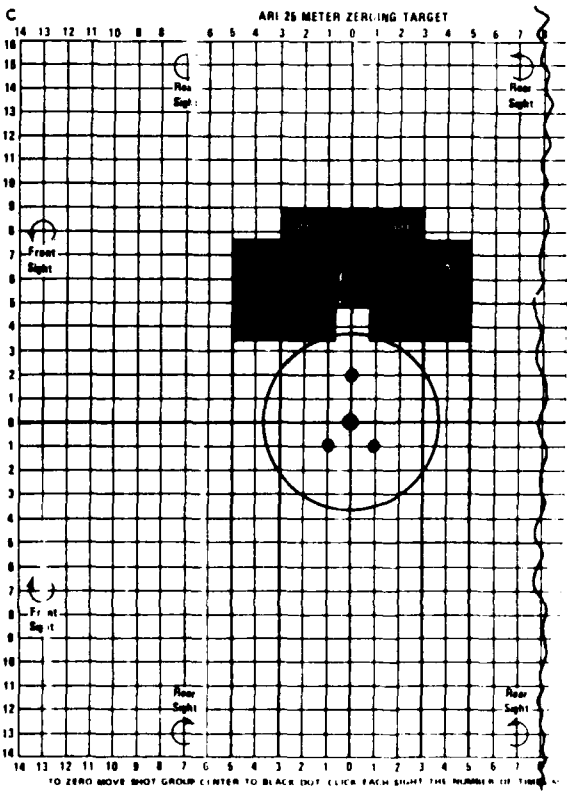
- ☐ Bottom of the target
- ☐ Dead center
- ☐ Center of shoulders
- ☐ I don't know

23. Pictured below are twoo, three (3) round shot groups. Both were fired from zeroed weapons. Which group was fired from the more accurately zeroed weapon?

- ☐ A
- ☐ B
- ☐ Both equally good



A



B

PART II

The purpose of this part of the test is to obtain your opinions about marksmanship training. Answer each question by placing an "X" in the box before the word or statement that best describes your answer to the question. You must choose only one answer for each question. Since there are no right or wrong answers, place an "X" before the word or statement that best describes your feelings about the question.

24. Before marksmanship training, did you have any previous experience in firing a rifle or a shotgun?

- ☐ No
- ☐ Yes

If "Yes", how much experience do you have? (One answer only)

- ☐ One time
- ☐ A few times (15 experiences or less)
- ☐ Many times (more than 15 experiences)

25. Have you ever fired on a small bore (.22 caliber) rifle team?

- ☐ No
- ☐ Yes

26. Have you ever shot skeet?

- ☐ No
- ☐ Yes

27. Are you a hunter?

- ☐ No
- ☐ Yes

If "Yes", how much hunting experience do you have? (One answer)

- ☐ One time
- ☐ A few times (15 experiences or less)
- ☐ Many times (more than 15 experiences)

If "Yes", what type weapon did you hunt with most of the time? (One answer only)

- ☐ Air rifle
- ☐ .22 caliber rifle
- ☐ Rifle larger than .22 caliber
- ☐ Shotgun
- ☐ Other

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