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# US ARMY TEST & EVALUATION COMMAND

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DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN GRENADE THROWING

FIFTH PARTIAL REPORT OF
USATECOM PROJECT NO. 8-3-7700-01, PHASE II
DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS

JUNE 1965

## U S ARMY
## GENERAL EQUIPMENT TEST ACTIVITY
## FORT LEE, VIRGINIA

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U. S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

# DEVELOPMENT OF METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN GRENADE THROWING

Fifth Partial Report of
USATECOM PROJECT NO. 8-3-7700-01, Phase II
Development of Methodology for Measuring Effects of
Personal Clothing and Equipment on Combat Effectiveness
of Individual Soldiers


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## FOREWORD

This report reviews a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) and is the fifth of a series of seven reports presenting the results of Phase II of the contract. (See Appendix B.) The project is a three-phase research effort directed toward the development of a field measurement methodology for evaluating the effects of Quartermaster clothing and protective equipment on the combat effectiveness of the individual soldier.

Earlier portions of the work accomplished under this project have indicated that a major constituent of the effectiveness of an individual infantryman in a combat situation is his level of performance in the individual physical tasks which are most important to battlefield success. A meaningful determination of the effect of clothing and personal equipment on the operating efficiency of an infantryman must therefore include objective measurements of his performance in these critical tasks. A survey of 208 highly qualified veterans of the four most recent operating theaters of the U.S. Army indicated that the ability to throw hand grenades from various positions in combat with speed and accuracy was considered an important physical task by combat veterans. This report describes research performed at Fort Lee, Virginia, to establish a reliable and sensitive method for measuring performance in this activity.

The work reported represents a joint effort by Dunlap and Associates, Inc. (D&A) and the Methods Engineering Directorate of the U.S. Army General Equipment Test Activity (GETA). The project team worked together closely throughout all activities but the major effort of D&A was in the development of the measurement scheme, the design of the field trials, interpretation of the data and the preparation of the draft report. GETA prepared the test facilities, planned and conducted the field trials, collected and processed experimental data, and participated in its analysis.

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U. S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

# DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN GRENADE THROWING

FIFTH PARTIAL REPORT OF
USATECOM PROJECT NO 8-3-7700-01, Phase II
Development of Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers

June 1965

## ABSTRACT

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the fifth of a series of seven reports presenting the results of Phase II of the study.

The first partial report in this series reported work performed to identify and rank the relative importance of the physical tasks performed in combat by the individual infantryman. One of the tasks which were considered by a sample of combat veterans to be important to combat success was the ability to throw hand grenades accurately in various battle situations. This report describes the work performed to develop a reliable method for measuring soldier performance in throwing grenades at both horizontal and vertical targets. A proposed test course was established as a temporary facility and tested for reliability and sensitivity to differences in clothing and equipment using USAGETA Troops. It was determined that the tested course provided a practical and useful basis for measuring performance in the task and a modified data collection system was recommended for inclusion in an integrated course to be evaluated as the next step in the research program.

# DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN GRENADE THROWING

## I. Review of Research Objectives

The fundamental objective of the research effort was to develop, try out and evaluate a field performance course which measures an infantry soldier's ability to throw hand grenades as might be required when under enemy fire. The two main requirements which the course had to satisfy were:

- The test situation had to be representative of the combat conditions under which individual infantrymen are required to throw hand grenades;

- The course operating procedures, instrumentation, and measures had to yield data which were sufficiently precise to indicate that the course would be sensitive to the effects of clothing and protective equipment on performance.[1,2]

Other features, deriving in part from the foregoing, which the course was to satisfy included:

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[1] The use of the word "sensitive" refers to the ability to detect small performance differences. A sensitive course presupposes reliability in the collection of measurement data.

[2] The validity of the present test situation and the performance measures to be obtained are logical (not statistical) validities. The validity of the combat task, as an important aspect of the criterion, is considered to be demonstrated by the independent judgments of combat veterans (see results from the Further Refinement of Important Combat Tasks). The validity of the test situation in which task performance is being measured must be either accepted or rejected on logical grounds. Either the test setting does or does not represent the essential features of the conditions under which a man will be required to throw hand grenades. The validity of the measures must also be accepted or rejected on the basis of logic. That is, the measures either are or are not measures which reflect performance associated with throwing hand grenades.

- measurement of performance in a dynamic, movement situation was to be permitted;
- rapid grenade throwing was to be required;
- performance measurement for different throwing distances was to be permitted;
- performance measurement for different types of targets was to be permitted.

The requirement for different types of targets was based on the thinking that the use of hand grenades might vary in the street fighting situation as compared to field combat. Street fighting and "clean-up" operations seem to require the throwing of grenades into buildings and other structures, often from relatively short distances. The field setting, on the other hand, seems to involve throwing from somewhat longer distances at ground positions and emplacements.

## II. Essentials of Test Course as Originally Proposed

The measurement situation originally proposed for research purposes was a course consisting of three target areas. Two of the target areas, which were to be identical, were to simulate the use of grenades against a field emplacement. The third target area was to require that grenades be thrown toward a vertical target area, as in the street fighting situation where grenades must be thrown into doorways and windows.

In the case of the two field-emplacement target areas, a machine gun simulator was to be positioned in the center of each area. This machine gun would appear and "fire" on signal from an observation tower. Individuals were to move along circumscribed paths having radii of 35 and 20 meters, respectively, from the center of each of these areas. When the simulated machine gun appeared and fired, test subjects were to throw a grenade at the objective as rapidly and accurately as possible. Firing would occur randomly three times for each target area. This portion of the test situation would thus provide three measurements of the speed and accuracy of grenade throwing for two distances--20 and 35 meters.

The central target areas for the foregoing simulated field-emplacement situations were each to be measured in circular fashion, starting with a central bull's eye of 5-foot radius and increasing to a radius of 20 feet in 5-foot increments. The scoring rings were not to be visible to test subjects. The latter was to be achieved by slight depressions in the terrain surface which would be marked in a plane visible only to the observers located in the tower.

The vertical target area was to be somewhat analogous to the baseball pitching booth found in amusement parks. From a designated position approximately 15 meters from the objective, test subjects were to throw three grenades into a target area. The target area was to have a rectangular, window-sized bull's-eye. Rectangular areas of increasing size were to surround the bull's-eye area for scoring purposes. The target area was to be constructed to allow for detonation of the grenade charges and still permit performance scores to be recorded.

Procedurally, subjects were to perform in each target area as individuals. A Senior Controller, located in the observation tower, was to schedule the starting of test subjects on the machine gun targets. The Senior Controller was also to control the presentation of the "firing" signals and the movement of subjects through each target area. Observer/Recorders (O/R's) were to be located in the tower and on the ground to record performance.

## III. Description of Actual Test Setting

The test course which was evaluated during Phase II was essentially similar to that described above. The departures worthy of note were:

a) One machine gun target area was used instead of the two originally proposed.

b) At the machine gun target, when the firing signal occurred, subjects first dropped to a prone position. They then quickly took a grenade from the harness of the M 56 combat pack and threw it at the target. (In the case of standing throwing from the 35 meter path, subjects removed a grenade from the harness while prone, and then stood up to make their throw.)

c) The number of range rings surrounding the bull's-eye of the machine gun target was increased from four to fourteen.

d) Subjects threw six grenades at the vertical target, in lieu of the three originally proposed.

The reasons for these changes were as follows. One machine gun target area was used, instead of the two originally proposed, for several reasons. Only one machine gun simulator could be obtained in the needed time period for use with the course. Construction of a second machine gun target area, unless absolutely necessary, would have delayed the start of testing. In addition, there would have been increased costs associated with constructing a second observation tower and installing instrumentation connections. Finally, and most importantly, it became apparent from tryouts with the first machine gun target area that test subjects could be processed through the course with sufficient speed to allow us to evaluate the course concept without the second target area.

The requirement for subjects to first drop to a prone position, when the machine gun simulator opened fire, was introduced for realism. It was our opinion (and confirmed by several combat veterans) that the immediate response of a man walking through enemy territory with his rifle in his hands would be to drop to the ground when fired upon from a concealed enemy position. To require subjects to drop their rifles, take a grenade from their harness, prepare and throw the grenade--all the time standing in view of the supposed enemy--seemed both an ineffective and unrealistic behavior.

The number of range rings surrounding the bull's-eye of the machine gun target was increased in order to increase the precision with which accuracy of throwing was being measured. The results of initial testing indicated that a number of grenades were missing the target area entirely. In order to differentiate among these grenades, and thus increase the precision of our measurements, the additional range rings were added.

Finally, the number of grenades being thrown at the vertical window target was increased in order to give a more stable (reliable) estimate of throwing accuracy in this event. Initial testing indicated that there was extensive variation in accuracy among the three

grenades being thrown by a given person. In order to increase the reliability of our measures in this event, the number of grenades was thus increased.

Figure 1 shows, in plan view, the actual layout of the experimental course. At the machine gun target, subjects threw three grenades from both the 20 meter and the 35 meter paths. Subjects used a prone throwing position from the 20 meter path and a standing throwing position from the 35 meter path.

The vertical window target was positioned 15 meters from the sandbags which marked the throwing point. Subjects first ran a 30-yard dash, which included a change in direction, and then took a prone position at the sandbags. They then quickly prepared a grenade, rose to the kneeling position, and threw the grenade at the window target.

Figures 2 through 6 show the machine gun target area. Figures 2 through 4 show the event as seen from the observation tower. Figure 5 shows a subject throwing from the prone position at the 20 meter distance. Figure 6 shows a subject throwing from the standing position at the 35 meter distance.

Figures 7 through 10 show the vertical target event. Figure 7 shows the target itself with the recessed window. Figures 8 through 10 show a subject performing the event. The sandbags in the foreground of Figure 8 were used to mark the place where the subjects should change direction in running the 30 yards toward the throwing point.

With regard to the vertical window target, the recessed central window was a standard window size, 26 inches tall and 30 inches wide. The four range rings around the window were all 5-3/4 inches wide. The target was fabricated from 3/4" plywood and covered with 1/8" rubber matting to cushion the impact shock of the grenades. While not clearly visible in Figure 7, the entire target was supported at the rear with pipe and angle iron bolted to a concrete foundation.

## IV. Course Operating Procedures

Operation of the course was controlled by a Senior Controller who was stationed in the observation tower for the machine gun

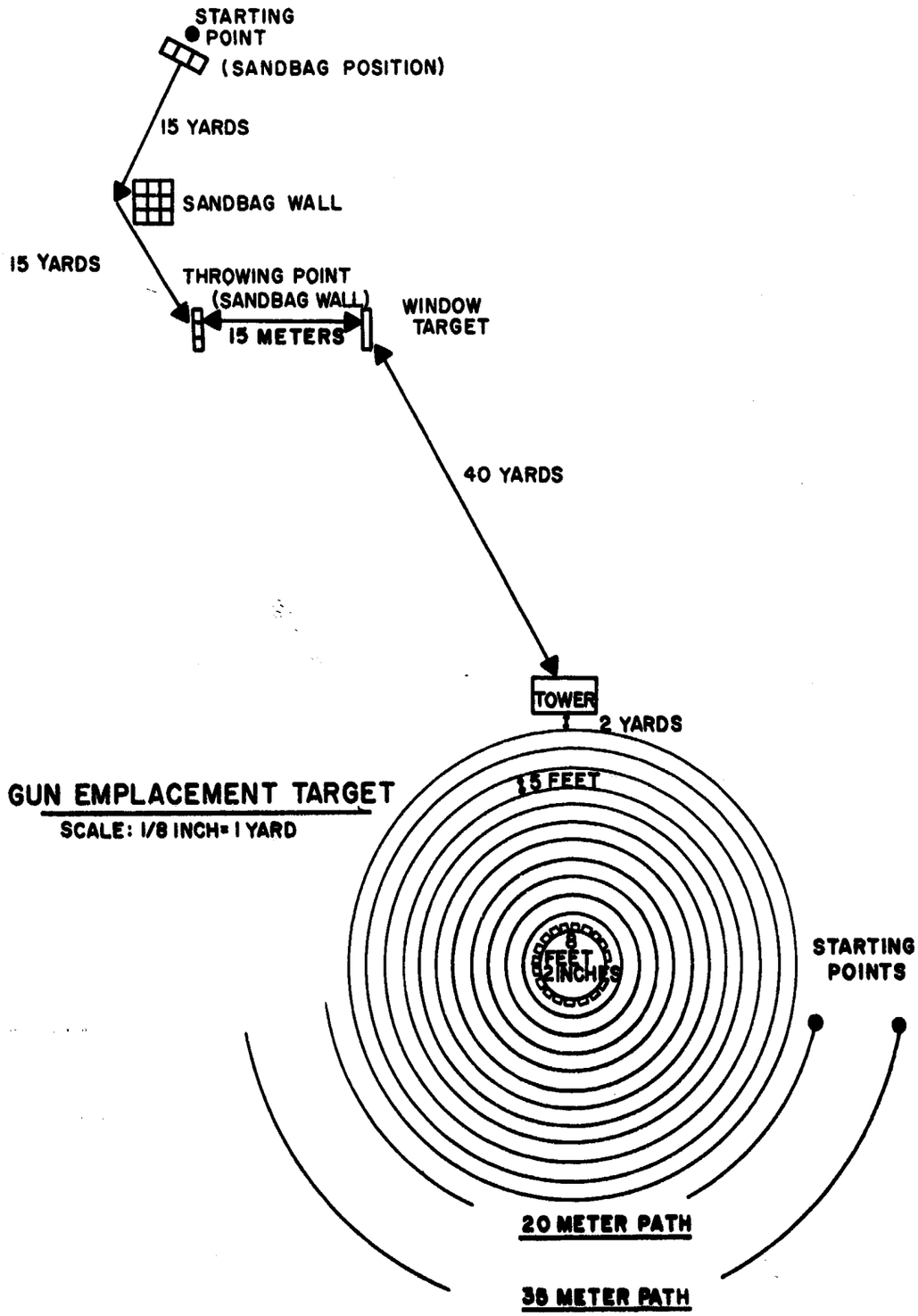


Figure 1. Plan View of Grenade Course

Figure 2. Machine Gun Target

Figure 3. Subject on 20 Meter Path, Machine Gun Target

Figure 4. Subject Throwing Grenade from Prone Position

Figure 5. Close-Up of Subject Throwing from 20 Meter Path

Figure 6. Close-Up of Subject Throwing from 35 Meter Path

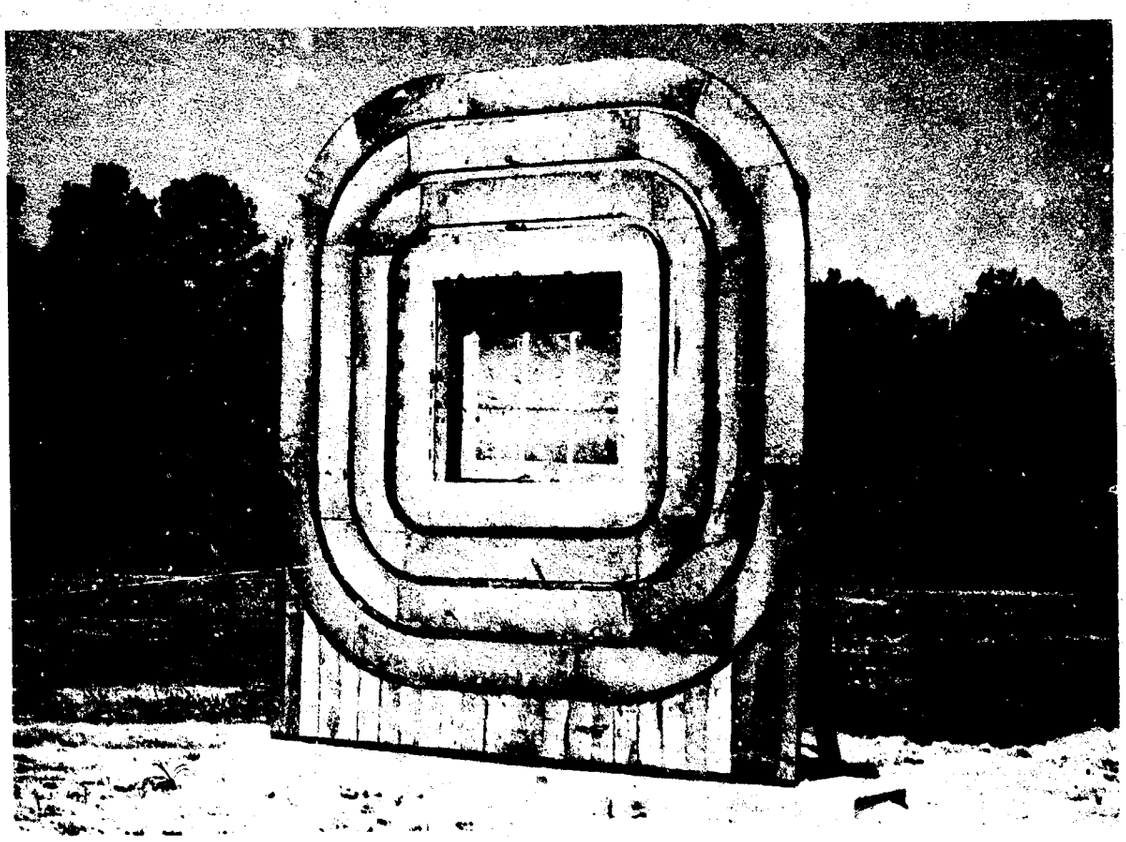

Figure 7. Vertical Window Target.

Figure 8. Subject on 30 Yard Dash Toward Vertical Target.

Figure 9. Subject Arriving at Throwing Position for Vertical Window Target.

**Figure 10. Subject Throwing From Kneeling Position at Vertical Window Target.**

target, and at the start of the event for the vertical window target.[1] The main features of the operating procedure were as follows.

Initially, on their first exposure to the course, test subjects were read a set of standard instructions (see Appendix A). The standard instructions indicated the purpose of the course and how each subject was to proceed. After this briefing and the answering of any questions, the test subjects were walked through the course. While walking through the course, the instructions concerning how subjects were to proceed were reviewed again. The machine gun simulator was fired and demonstration grenades were thrown from a prone position at the 20 meter path, from a standing position at the 35 meter path, and from a kneeling position at the vertical window target.

After the foregoing familiarization, each test subject individually performed on the course. Only one subject was allowed on the course at a time. At the machine gun target, when signalled to START by the Senior Controller, the subject moved out along the indicated path (20 or 35 meters, as pre-scheduled) with his rifle in his hands. The subject was accompanied along the path by two test personnel: an observer who coordinated the commands of the Senior Controller and who also acted as a safety monitor for use of the practice grenades; and an O/R who indicated the occurrence of specific behaviors. As the subject moved along the path, the Senior Controller (or one of the O/R's assisting the Senior Controller) in the tower operated a switch which caused several events to occur simultaneously. The machine gun simulator fired a 3-second burst, and two laboratory stop clocks (.01 second resolution), located in the tower, were simultaneously started. The programming of this initiating signal was essentially random and at the control of the Senior Controller. The only requirement (known also to the test subject) was that the subject would receive three separate signals to throw a single grenade while on that particular path.

The firing of the machine gun simulator was the signal for the subject to drop rapidly to the prone position, remove a grenade from the harness of his combat pack, prepare the grenade by pulling the

[1]During the Phase II research testing of the course, the two events (machine gun target and vertical window target) were not conducted on the same day as would be the case for an integrated course.

pin, and then throw the grenade as accurately as possible at the target. In the case of standing throwing from the 35 meter path, subjects were instructed to prepare their grenade while still prone, and then stand up to make their throw.

After a grenade had been thrown, the subject picked up his rifle and stood ready to move out again when signalled to do so by the Senior Controller. The Senior Controller moved people as quickly as possible through the course, both to keep testing time to a minimum and to provide a degree of control over the elapsed time between throws. Normally, a subject was moved out as soon as the performance times on the clocks in the tower had been recorded and the clocks reset. As already indicated, this procedure was repeated three times on both the 20 and 35 meter paths of the machine gun target.

At the vertical window target, subjects started from a prone position with their rifles at their shoulders behind sandbags which marked the beginning of the event. When signalled to START, they quickly arose and dashed along the indicated 30-yard path and took a prone position behind the sandbags that marked the throwing point. Then, as rapidly as they could, they took a grenade from their harness, pulled the safety pin, rose to a kneeling position (see Figure 10), and threw the grenade as accurately as possible at the target. After throwing the grenade, they again took a prone position behind the sandbags until released by the O/R located at the throwing point. When released, the subject returned to the start of the event and took a position in line awaiting his turn to throw another grenade. This procedure was repeated until each subject had thrown six grenades at the window target.

Duties of test personnel were also explained initially using prepared instructions. Samples of the basic O/R Briefings are given in Appendix A. The duties and assignments were as follows.

The Senior Controller, as already explained, was responsible for overall operation of the course. In particular, he started subjects on the two course events, controlled the movement of subjects on the paths of the machine gun target, and ordered the activation of the machine gun firing signals.

Operation of the machine gun target required five O/R's; two in the observation tower, two on the path with the test subject, and one at the start of the course. On the tower, one O/R served as a spotter. He noted the number of the range ring within which each grenade detonated and gave this information to the second O/R. The second O/R in the tower recorded the elapsed times indicated on the two stop clocks, reset the stop clocks, and also recorded the accuracy of throwing as reported by the first O/R. It should be mentioned that, when the spotter was unsure of the range ring in which a grenade had detonated, he asked for verification from the ground O/R located at the start of the course. The latter O/R had the responsibility for insuring that each test subject was properly wearing the prescribed clothing and equipment in accordance with the test design and instructions from the Senior Controller. This O/R (usually the NCOIC)[1] also knew that it was his responsibility to assist the grenade spotter in the tower on throws that were difficult to score.

The two O/R's on the path with the test subject have already been mentioned. One served to coordinate the commands of the Senior Controller--when the subject should move out again, etc. This O/R also acted as a safety monitor for use of the practice grenades. (While the powder charge in the practice grenades is very small, injury could occur if a subject continued to hold the grenade after the handle had been released.) The second O/R on the path was the primary data observer. He carried two portable hand switches, one in each hand. It was his responsibility to observe and indicate (by depressing the appropriate switch): 1) when the subject was prone--following the initiation signal from the machine gun simulator; and 2) when the grenade left the hand of the subject (as it was thrown at the target).

Four O/R's were required to support the operation of the vertical window target. Two O/R's served functions identical to those of the O/R's in the tower for the machine gun target event. One O/R observed the accuracy of throwing. He gave this datum to the second O/R who recorded this information and the elapsed time from two laboratory clocks, and then reset the clocks.

[1] Non-Commissioned Officer In Charge.

A third O/R, who was located at the sandbag throwing point, made observations identical to those of the O/R on the path for the machine gun target event. He held two switches, one in each hand, and indicated: 1) when the subject was prone at the throwing point (following the 30-yard dash); and 2) when the grenade left the subject's hand (the subject having taken a kneeling throwing position).

The fourth O/R was positioned at the start of the event. Again, as in the case of the machine gun target, this O/R was usually the NCOIC. It was his responsibility to coordinate the movement of test subjects as directed by the Senior Controller and also to insure that each subject was properly wearing the prescribed clothing and equipment.

## V. Instrumentation

The instrumentation used in measuring performance consisted of: two A. W. Haydon K15120 laboratory stop clocks; a box containing a three-second delay interval timer, two latching relays, and receptacles which provided power to and control of the clocks; two microswitches, positioned in aluminum tubular stock which served as remote control switches for the clocks; and wiring to connect the remote control switches to their respective clocks and to provide power to the relay box. (Since the machine gun target and the vertical window target were not operated simultaneously, the same instrumentation served both events.)

The Haydon clock displayed time to within 10 milliseconds (1/100 of a second). It had a clock face dial with two hands (see Figure 11). The smaller or inner hand accumulated in seconds up to a total of 60 seconds. In addition to an electric reset capability, the clock could be operated by either remote controls or by the two pushbutton switches on the top of the clock housing.

The latching relay associated with each clock caused a clock, once started, to continue to run until a signal de-energized the relay by breaking the "latch." It was thus possible for the O/R on the path with the test subject (or at the throwing point for the vertical window target) to stop each of the clocks remotely.

The use of the clocks and control box was analogous to that developed for the research trials of the Maneuver Course. The

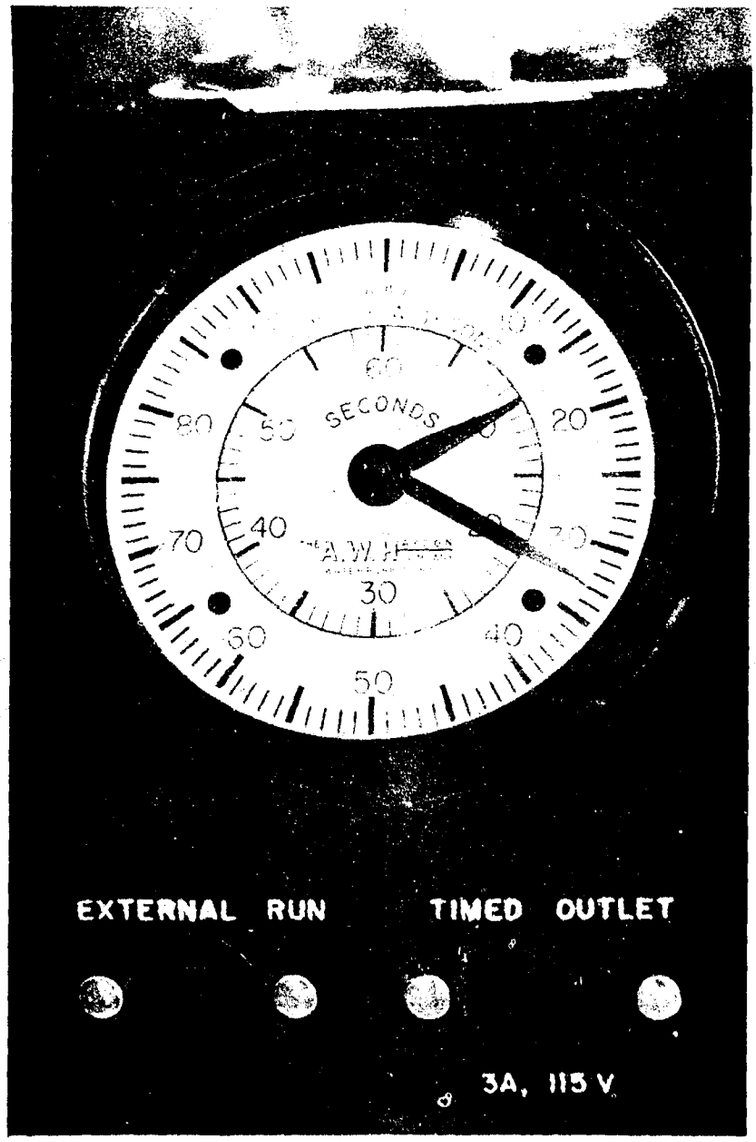


Figure 11. Instrumentation: A. W. Haydon Stop Clock

detailed description of the instrumentation with wiring and pictorial diagrams as presented in Appendix B of the report of the Phase II testing of the Maneuver Course[1] pertains also to the instrumentation used for the experimental trials of the Grenade Course. The only exception was the addition of a 3-second delay interval timer. This timer was connected to the machine gun simulator and, when energized, it caused the simulator to fire a 3-second burst. Thus, when the Senior Controller in the tower closed his "operate" switch, the two time clocks started simultaneously with the burst of simulated firing.

## VI. Measures and Test Design

### A. Measures

With the instrumentation described in the preceding section, data were collected on the following basic measures:

- Throwing response time (measured to .01 second) for each grenade.
- Total time (measured to .01 second) from gun fire to release of grenade for the machine gun target event.
- Dash time (measured to .01 second) for the vertical window target event.
- Accuracy of throwing at the machine gun target and at the vertical window target.

For the accuracy measure, a score of 14 for the machine gun target is equivalent to a direct hit--the grenade detonated within the bull's-eye of the target area. The range rings were numbered in decreasing order as the distance from the bull's-eye increased. Thus a score of 11 corresponds to the third range ring around the bull's-eye. Accuracy scoring was similar for the vertical window target except that there were only four range rings. Thus a score of 4 for the vertical window target indicates a direct hit.

[1] Development of a Methodology for Measuring Infantry Performance in Maneuverability. Report on Results of Research Testing and Evaluation During Phase II. U.S. Army General Equipment Test Activity, Ft. Lee, Virginia, 1965.

Throwing response time refers to the elapsed time from when a subject was prone until the prepared hand grenade left his hand. In other words, it was the difference in time between the two clock readings. (One clock was stopped when the subject was prone--on either the paths of the machine gun target, or at the throwing point for the vertical window target; the second clock was stopped when the grenade left the subject's hand.) Originally, it had been our intention to use detonation of the grenade itself as the signal to stop the second clock. However, tests of the fuses initially supplied with the practice grenades resulted in a range of fuse times from 4.27 seconds to 4.90 seconds. This range provided too large an unwanted source of variation for our data, and we thus decided to use release of the grenade itself as the event to stop the record clock.[1]

B. Test Design

The experimental testing was designed to provide information on the following points of interest:

- The feasibility and suitability of the course concept and operating procedures;
- The suitability of the instrumentation concept and equipment;
- The reliability and potential sensitivity of the course.

The reliability of a given test course refers to the precision and accuracy of measurement which the course provides. It can be evaluated in terms of the consistency (i.e., repeatability) of the experimental results obtained from the course over some time period. A measure of reliability, of course, will be obtained from the Phase III testing. However, it appears possible to infer something about course reliability from Phase II results. If a statistically significant difference (at, say, the 5% level of confidence) is obtained between performance measures for a treatment condition (e.g., Gloves vs.

[1]Subsequent tests of the replacement fuses for the practice grenades resulted in a range of fuse times from 4.50 to 4.60 seconds. Hence, if replacement fuses are used, detonation could probably be used as the event to stop the second clock--if this seems a desirable change.

No Gloves), one infers that the obtained difference is not likely to occur by chance. A significant performance difference suggests that, if the test were to be repeated under the same conditions (e.g., with the same treatment conditions, the same procedures, and the same subject population), one might expect to obtain similar results. Thus one can estimate that a course is reasonably reliable if statistically significant performance differences occur. This is the best estimate that can be made on the basis of Phase II results.

The sensitivity of a test course is evaluated in terms of whether the course is able to detect a real performance difference if one exists. If a test course reveals statistically significant differences between performance measures for a treatment condition, then the course can be considered sensitive. Sensitivity and reliability of a test course are interrelated. Accurate and precise measurement will lead to a small within treatment (error) variance. The smaller the within treatment variance, the smaller are the performance differences between treatments that are needed to produce statistical significance. Thus if a test course produces statistically significant performance differences for a treatment condition, it can be assumed to be sensitive and at least minimally reliable.

The Hand Grenade Course was evaluated in two repeated measurement test designs in which various weights distributed about the M56 combat pack and harness and the standard leather shell glove with knitted insert were the independent variables or treatment conditions. The designs are illustrated in Figure 12.

The rationale underlying the use of these test designs was as follows. If the course is composed of the same hand grenade throwing activities as are required in combat, and if the conditions under which these activities are performed are representative of the combat setting, then the performance data obtained from the course are a valid indication of performance to be expected under combat conditions. Thus, if one finds no significant differences among the performance measures, one might conclude that no differences will exist among the particular clothing and/or equipment items studied in the actual combat setting. It is possible, of course, that uncontrollable sources of variation may be masking small but real performance differences which will become apparent only with a more refined Phase III version of the course. However, the development

Machine Gun Target

| | 15# Pack | | 30# Pack | | 45# Pack | |
|---|---|---|---|---|---|---|
| | 20 Meter Path Prone Throwing | 35 Meter Path Standing Throwing | 20 Meter Path Prone Throwing | 35 Meter Path Standing Throwing | 20 Meter Path Prone Throwing | 35 Meter Path Standing Throwing |
| Subject 1 | | | | | | |
| Subject 2 | | | | | | |
| . | | | | | | |
| . | | | | | | |
| . | | | | | | |
| . | | | | | | |
| Subject n | | | | | | |

| | WITH GLOVES | | WITHOUT GLOVES | |
|---|---|---|---|---|
| | 20 Meter Path Prone Throwing | 35 Meter Path Standing Throwing | 20 Meter Path Prone Throwing | 35 Meter Path Standing Throwing |
| Subject 1 | | | | |
| Subject 2 | | | | |
| . | | | | |
| . | | | | |
| . | | | | |
| . | | | | |
| Subject n | | | | |

Figure 12. Test Designs.

Vertical Window Target

| | 15# Pack | 30# Pack | 45# Pack |
|---|---|---|---|
| Subject 1 | | | |
| Subject 2 | | | |
| . | | | |
| . | | | |
| . | | | |
| . | | | |
| Subject n | | | |

| | WITH GLOVES | WITHOUT GLOVES |
|---|---|---|
| Subject 1 | | |
| Subject 2 | | |
| . | | |
| . | | |
| . | | |
| . | | |
| Subject n | | |

Figure 12. Test Designs (continued).

of this Phase III course is better justified if it can be shown in Phase II that the course will detect real differences if they exist. It is obvious, of course, that a field performance course which fails to differentiate between the clothing and equipment which it was designed to evaluate is of little potential utility to the Army. It was our hope in selecting treatment conditions (Gloves vs. No Gloves and different combat pack weights) for this Phase II course that some performance differences would occur. It was also our hope in designing the measurement system that the data obtained would be sufficiently accurate and precise to detect real performance differences if they exist.

Several other points should be mentioned with regard to the foregoing test designs. First, the repeated measurements were used in order to provide sensitivity with respect to the primary independent variables. Second, in implementing the designs, the order in which subjects performed under the various treatment conditions was counterbalanced. The counterbalancing was used to offset any effects that might attend the order of testing. In implementing the counterbalancing, subjects were tested on the same day under the appropriate conditions. Thus, while more than one day was frequently needed to obtain the scheduled sample size, complete data were obtained from each subject on the day that the given subject appeared for testing.

## VII. Results

The data to be presented cover testing sessions which span the period of 28 April 1964 through 4 June 1964. All of the data pertain to Quartermaster test subjects. The data are broken out into two sets of results: 1) testing with a machine gun target; and 2) testing with the vertical window target.

### A. Machine Gun Target

The experimental data from the testing of the machine gun target event were collected on 28 April, 5 May, and 4 June 1964. Table 1 presents the results obtained with the weighted combat packs and under the Gloves vs. No Gloves comparison for both the 20 meter and 35 meter paths. Presented in the table are the size of the sample, the average performance under the indicated conditions, and the results of statistical tests for differences between conditions. In making the statistical tests, the analysis of variance was used. If the F value for

Table 1. Comparison of Weighted Packs and Gloves vs. No Gloves

Machine Gun Target
Data of 28 April, 5 May, & 4 June 1964

| Measure | Path | Pack Comparison (23 Men) | | | | Glove Comparison (17 Men) | | |
|---|---|---|---|---|---|---|---|---|
| | | Average Measurement | | | Result of Significance Tests[1] | Average Measurement | | Result of Significance Tests[1] |
| | | 15# | 30# | 45# | | Gloves | No Gloves | |
| Total Time from Gunfire to Release of Grenade (Seconds) | 20 Meter Prone | 7.51 | 6.91 | 7.82 | Significantly longer time with the 45# pack than with the 30# pack | 8.86 | 6.74 | Significantly longer time with gloves than without |
| | 35 Meter Stand | 7.81 | 7.99 | 8.42 | No significant difference | 7.99 | 7.31 | No significant difference |
| Accuracy Score | 20 Meter Prone | 10.87 | 10.84 | 10.38 | No significant difference | 11.28 | 11.20 | No significant difference |
| | 35 Meter Stand | 11.29 | 11.01 | 10.42 | No significant difference | 11.71 | 11.92 | No significant difference |

[1]At the 1 per cent level of significance

testing the pack mean square was significant, Tukey's[1] procedure was used to determine which pack means differed.

As may be seen in Table 1, significant differences were obtained for the total time from gunfire to release of the grenade when subjects threw from the 20 meter prone position path. Significantly longer time was required with the 45 pound pack than with the 30 pound pack, and significantly longer time was required with gloves than without gloves. Although results were in the expected direction, no significant differences were obtained when the subjects threw from the 35 meter standing position path. No significant differences were obtained for the accuracy scores for either path.

B. Vertical Window Target

The data from testing of the vertical window target event were collected on 4 and 7 May 1964. The results are presented in Table 2. Shown in the table are the size of the sample, the average performance under the indicated conditions, and the results of statistical tests for differences between conditions. Each throw at the vertical window target event was preceded by a 30-yard dash; results of this activity are also shown in Table 2. As with the machine gun target, statistical tests used were the analysis of variance and Tukey's test.

As may be seen in Table 2, significant differences were obtained for the dash event when subjects wore combat packs of different weights. Significantly longer time was required with the 45 pound pack than with the 30 pound and 15 pound packs. In addition, significantly longer time was required with the 30 pound pack than with the 15 pound pack. As would be expected, there were no differences in dash time for the Gloves vs. No Gloves comparison.

Although throwing response time and accuracy data were generally in the expected direction (with the exception that less time was required with the 30 pound pack than with the 15 pound pack) no significant performance differences were obtained for these measures.

## VIII. Interpretation of Results

The following conclusion is made in reference to the results presented in the preceding section:

[1]Bowker, A. H. and Lieberman, G. J. Engineering Statistics. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1959, p. 295.

Table 2. Comparison of Weighted Packs and Gloves vs. No Gloves

Vertical Window Target
Data of 4 & 7 May 1964

| Measure | Pack Comparison (14 Men) | | | | Glove Comparison (14 Men) | | |
|---|---|---|---|---|---|---|---|
| | Average Measurement | | | Result of Significance Tests[1] | Average Measurement | | Result of Significance Tests[1] |
| | 15# | 30# | 45# | | Gloves | No Gloves | |
| Time for 30-Yard Dash (Seconds) | 7.58 | 7.98 | 8.70 | Significantly longer time with the 45# pack than with 30# or 15# packs; significantly longer time with 30# than with 15# pack | 7.89 | 7.89 | No significant difference |
| Throwing Response Time (Seconds) | 6.13 | 5.86 | 6.47 | No significant difference | 6.24 | 5.72 | No significant difference |
| Accuracy Score | 2.68 | 2.36 | 2.10 | No significant difference | 2.57 | 2.08 | No significant difference |

[1] At the 5 per cent level of significance

- The magnitude of the differences detected as significant with the weighted combat packs and under the Gloves vs. No Gloves conditions for the 20-meter prone position path and the machine gun target is interpreted to indicate that the Grenade Course will be sensitive to a practically useful extent.

## IX. Recommendations for Final Test Course

Based upon all of the experiences gained in the tryout of the Phase II course, the following recommendations have merit for the design and operation of the Phase III Hand Grenade Course. The recommendations presuppose that the test setting will be essentially similar to the Phase II course except where changes are specifically stated.

- Consideration should be given to replacing the A. W. Haydon stop clocks as the primary data collection instrumentation. The nature of the problem lies in the fact that test personnel, despite practice, still made occasional errors in reading the clock dials. A safer alternative would be to use a timing instrument which displays elapsed time via a numeric or digital readout. (The instrumentation under consideration for the Phase III Fire and Reload Weapon and Maneuver Courses would certainly be suitable here also. While the Grenade Course does not require as sophisticated an instrumentation setup as these other courses, there is no reason why the instrumentation could not be shared--provided that it is not necessary to operate the courses simultaneously.)

- It is recommended that consideration be given to automating the indication of arrival at the throwing points (following the 30 yard dashes) of the vertical window target. The indication of when a subject has arrived at a position and is prone--while definite, overt behaviors--does permit for intra and inter- O/R variation. The location of an automatic sensor, such as a pressure-sensitive switch in a pneumatic mat, at the sandbags marking the throwing points could possibly improve the precision of performance measurement.

- If feasible, the movement of subjects through the machine gun target event can be improved by using two target areas--one

for the prone throwing from 20 meters, and one for the standing throwing from 35 meters. Additional O/R personnel and instrumentation would be required.

- Similarly, the operation of the vertical window target event can be improved through the use of six separate targets. Possibly, a six-sided structure (simulating a building) could be erected with each wall containing a vertical target as used in Phase II. Subjects could first dash 15 yards away from the building and then 15 yards toward the building in arriving at the throwing point for each side.

- Finally, consideration should be given to adding one or two additional range rings to the vertical window target. It is possible that additional range rings will improve the precision with which accuracy of throwing is measured in this event. As may be seen in the Phase II results (Table 2), the average accuracy of throwing was not particularly high (in terms of the scoring procedure). The additional range rings may help to better differentiate among those grenades which are presently scored as a "zero" because they missed the target entirely.

## APPENDIX A

Machine Gun Target

O/R Briefing
Troop Briefing

Vertical Window Target

O/R Briefing
Troop Briefing

A-1

## Grenade Course Machine Gun Target

O/R Briefing

### I. Purpose of the Course

The purpose of the grenade course is to study the effects of Quartermaster clothing and protective equipment on the infantry soldier's ability to quickly and accurately throw grenades from different positions at a ground emplacement target.

In this grenade course we are interested primarily in how quickly and accurately a soldier can throw a grenade at a simulated machine gun emplacement target.

### II. Course Description and Use

The present course is a preliminary one and is located adjacent to the Hasty Fighting Positions Course. The course is made up of a simulated machine gun emplacement target marked with range rings in the ground at five-foot intervals. Two throwing paths are located 20 and 35 meters from the target. A control tower is located adjacent to the target area.

The course will be operated as follows. Each test subject will perform on the course individually and will be accompanied by an O/R and a safety man. The basic uniform will be fatigue jacket and trousers, combat boots and fatigue hat. All subjects will carry the M-1 rifle. Subjects may be issued additional clothing and/or equipment as directed by the Senior Controller prior to starting. The subject, when told to "START" by the Senior Controller, will start down a predetermined path. He will be accompanied by an O/R and a safety man. The safety man will be in command of the group and will be totally responsible for all actions. The subject will carry his M-1 rifle in his hands. As the subject is progressing down the path, the OIC located in the tower, will press a button causing the machine gun simulator to fire. When the simulator fires, the subject is to drop to the ground, remove a grenade from his belt, pull the pin, and throw the grenade at the target as quickly and as accurately as possible.

Grenades will be thrown from a prone position from the 20 meter path and from a standing position at the 35 meter path. (Subjects will always drop to a prone position upon hearing the gun fire regardless of the final throwing position to be used.) The O/R accompanying the subject down the path will record the exact moment he hits the prone position and exact moment the grenade leaves the subject's hand on the throw toward the target. The OIC, located in the tower, will score the throw based on the proximity of the grenade detonation to the target. After the clocks in the tower have been recorded and reset, the Senior Controller will indicate to the safety man that the group may resume movement down the pathway. This procedure will be repeated twice more or until the subject has thrown three grenades on each path.

III. Observer/Recorder Procedures

The OIC will be stationed on the tower and will be responsible for the over-all conduct of the course. The starter (NCOIC) will be located on the ground and will insure that subjects perform on the course according to the predetermined schedule and that subjects wear the proper uniform and any special clothing and/or equipment required. The starter will also be responsible for the scheduling of O/R's and safety men to be utilized on the course as well as the over-all conduct of all men employed.

Subjects will perform the course individually and will be accompanied by an O/R and a safety man (the safety man is in command). Subjects will start down the path designated by the starter when given the command "START." The safety man will precede the subject along the path with the O/R following. The O/R will have two O/R buttons which are linked with the clock timers located in the tower. At the sound of the machine gun fire (started by the OIC in the tower), the subject will drop as rapidly as possible to a prone position, pull a grenade from his belt, pull the pin, and throw the grenade at the target. After throwing the grenade, the subject will again drop to the prone position. The O/R accompanying the subject will depress O/R button No. 1 when the subject assumes the prone position and O/R button No. 2 when the grenade leaves the hand of the subject toward the target.

The O/R located in the bottom of the tower will record (a) the time taken to hit the prone position (clock #1) and (b) the time taken

to throw the grenade (clock #2) on the appropriate line of the data sheet. The OIC, located on the tower, will score the grenade accuracy based on its proximity to the target at time of detonation. (Grenades settling in a depressed ring will be scored as the next higher range ring score.) These scores will be relayed to the O/R in the bottom of the tower who will record them on the data sheet.

The OIC, after insuring that both clocks have been reset, will instruct the starter to have the subject continue along the path. This sequence will be repeated until the subject has thrown three grenades from both the 20 and 35 meter lines.

IV. Preliminary Checks

Starter (NCOIC): Prior to starting subjects through the course, the starter (NCOIC) will insure that:

a) Subjects are sequenced according to the predetermined schedule provided by the OIC

b) Subjects are in the proper basic uniform (fatigue jacket and trousers, combat boots and fatigue hat)

c) Subjects are properly wearing and/or using the special clothing and/or equipment required by the schedule

d) O/R's and safety men are properly scheduled and completely familiar with their duties.

O/R (bottom of tower)

a) Insure that clock timers are in proper working condition

b) Insure that data sheet is available and properly used

c) Insure that clocks are reset (following each run) prior to approving additional runs.

V. O/R Data Recording Form

(Review use of form with O/R stationed in bottom of tower.)

A-4

## Grenade Course Machine Gun Emplacement Target

Troop Briefing

### I. Purpose of the Course

You are serving in research experiments that will eventually lead to a standard course on which to evaluate the effects of Quartermaster clothing and equipment on a soldier's ability to perform important combat tasks. This is a serious and expensive undertaking. Everyone wants the American soldier to have the best clothing and equipment. The best clothing and equipment may save lives.

Today, and for the next few days, we will be evaluating our preliminary concepts for a course designed to reveal the effects of Quartermaster clothing and equipment on the infantry soldier's ability to throw a hand grenade with speed and accuracy.

### II. Course Procedures

The course is made up of a machine gun emplacement target with two throwing paths. The target represents an enemy gun position. Your task is to destroy this position by the use of hand grenades. The course is run as follows.

You will each be accompanied through the course by an Observer/Recorder and a safety man. The safety man is in command while you are running the course. The uniform is fatigue jacket and trousers, combat boots and fatigue hat. You will also carry the M-1 rifle. Prior to starting, you will be told that you are to throw your grenades from either a prone or standing position. You will start when signalled by the Senior Controller. You will be carrying your rifle in your hands. You are to move slowly down the path looking to both sides as though on a patrol behind enemy lines. As you are moving, the machine gun will suddenly open fire. When the gun fires, you are to DROP TO THE GROUND as quickly as possible. You will then rapidly remove a grenade from your belt, pull the pin, and throw the grenade as accurately as you can at the machine gun. If you have been instructed to throw from a standing position, you will still DROP TO THE GROUND when the machine gun opens fire. Still on the ground, you will prepare your grenade and pull the pin. Then, you will stand up and throw the grenade as accurately as you can at the machine gun.

The O/R accompanying you will inform you when to resume movement along the path. This procedure will be repeated until you have thrown three grenades.

Remember that we are interested in speed and accuracy on this "machine gun" target event.

Are there any questions?

A-6

## Grenade Course Vertical Window Target

O/R Briefing

### I. Purpose of the Course

The purpose of the grenade course is to study the effects of Quartermaster clothing and protective equipment on the infantry soldier's ability to quickly and accurately throw grenades at a vertical window type target.

In this course, we are interested primarily in how quickly and accurately a soldier can throw a grenade at a vertical window type target.

### II. Course Description and Use

The present course is a preliminary one and is located adjacent to the machine gun target grenade course area. The course is made up of a vertical window type target and a sandbag protective wall, located 15 meters from the window target, from which position the subject will throw his grenades. In addition, a 30-yard pathway has been designated along which the subject will run from the starting position to the throwing wall.

The course will be operated as follows. Subjects will perform on the course individually. The basic uniform will be fatigue jacket and trousers, combat boots and fatigue hat. All subjects will carry the M-1 rifle. Subjects may be issued special clothing and/or equipment by the starter (NCOIC) prior to running the course. The subject will start from a prone position with his weapon at his shoulder on command of the starter (NCOIC). When told to "START" he will rise and run the 30-yard pathway as rapidly as possible and assume a prone position behind the sandbag wall. He will then quickly remove a grenade from his belt, pull the pin, take a kneeling position and throw the grenade as accurately as possible at the window target. Upon throwing the grenade, the subject will again drop to a prone position where he will remain until the O/R stationed at the sandbag wall tells him to move back to the starting point. This procedure will be repeated until the subject has thrown six grenades.

The O/R stationed at the sandbag wall position will have two O/R buttons with which to record time measures. He will depress O/R button No. 1 when the subject hits the prone position at the finish of the 30-yard dash. He will depress O/R button No. 2 when the grenade leaves the subject's hand on its way toward the window target.

## III. Observer/Recorder Procedures

The starter (NCOIC) will be located at the start of the event and will be responsible for the efficient operation of the course. He will insure that subjects are run according to the predetermined schedule furnished by the OIC and that all subjects wear the proper uniform and special clothing or equipment as provided by the schedule. He will also start the subjects through the course and simultaneously with the given command of "START" he will depress the start button causing the two clock timers located in the bottom of the tower to start accumulating time.

The O/R located at the sandbag wall position will have two O/R buttons which are linked to the previously mentioned clock timers. O/R button No. 1 will be depressed when the subject assumes the prone position after completing the 30-yard run. O/R button No. 2 will be depressed when the grenade leaves the subject's hand on its way toward the target. After the subject has thrown his grenade (from the kneeling position) he will again hit the prone position and remain there until the O/R tells him to move back to the starting line.

The O/R located in the bottom of the tower will record, in the appropriate spaces on the data sheet, (a) the time the subject takes to run the 30-yard path and hit the prone position at the sandbag wall (clock No. 1), and (b) the time the subject takes to throw the grenade toward the window (clock No 2). He will also record the accuracy score as shown by the electronic scoring panel located in the tower. After recording all required data and resetting both clock timers, he will inform the starter that he is ready for another subject. The starter will then repeat the sequence as outlined above until each subject has thrown six grenades at the target.

## IV. Preliminary Checks

The starter (NCOIC), prior to starting the course, will insure that:

a) Subjects are sequenced according to the predetermined schedule.

b) Subjects are in the proper uniform and carrying the M-1 rifle.

c) Subjects are wearing the required special clothing and equipment as specified by the schedule.

d) O/R's are assigned and thoroughly familiar with their duties.

e) O/R clock timers and buttons are functioning properly.

f) Subjects start from a prone position with the rifle at their shoulder.

O/R (located in tower) will insure that:

a) Data sheet is available and properly used.

b) Clock timers are functioning properly.

c) Clock timers are reset prior to approving subsequent trials.

V. <u>O/R Data Recording Sheet</u>

(Review with O/R stationed in tower).

A-9

## Grenade Course Vertical Window Target

Troop Briefing

### I. Purpose of the Course

You are serving in research experiments that will eventually lead to a standard course on which to evaluate the effects of Quartermaster clothing and equipment on a soldier's ability to perform important combat tasks. This is a serious and expensive undertaking. Everyone wants the American soldier to have the best clothing and equipment. The best clothing and equipment may save lives.

Today, and for the next few days, we will be evaluating our preliminary concepts for a course designed to reveal the effects of Quartermaster clothing and equipment on the infantry soldier's ability to throw a hand grenade with speed and accuracy.

### II. Course Procedures

The course is made up of a vertical window target, a running path, and a grenade throwing position. The window target represents a building in which enemy snipers are located. Your task is to move as quickly as possible from the starting point to the protective wall, take cover behind the wall and throw a grenade through the window to destroy the enemy.

You will perform the course individually. The uniform will be fatigue jacket and trousers, combat boots and fatigue hat. You will carry the M-1 rifle. Prior to starting you will be told that you are to throw your grenades from either a kneeling or prone position. Your starting position will be the prone position with the M-1 rifle at your shoulder. When told to "START," by the Senior Controller, you are to quickly get up off the ground, run the path as rapidly as possible and hit the prone position behind the sandbag wall throwing point. Do not put your weapon to your shoulder when assuming this prone position. You will then quickly remove a grenade from your belt, pull the pin, rise to a kneeling position and throw the grenade as accurately as you can at the window target.

After you have thrown the grenade, drop back down to the prone position and remain there until the Observer/Recorder located at the throwing position tells you to get up and move back to the starting position. This entire procedure will be repeated until you have thrown six grenades.

Remember that we are interested in:

a) How quickly you can run from the starting position and take a prone position at the throwing wall.

b) How quickly you can remove a grenade from your belt, pull the pin, rise to a kneeling position, and throw it at the target.

c) How accurately you can throw the grenade at the target.

Are there any questions?

# APPENDIX B

## Project Reports

B-1

## PROJECT REPORTS

I. Report of Phase I, USATECOM Project No. 8-3-7700-01, Development of a Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of the Individual Field Soldier, U. S. Army QM R&E Field Evaluation Agency (now U. S. Army General Equipment Test Activity), February 1964.

II. Reports of Phase II, USATECOM Project No. 8-3-7700-01, Development of Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers, (U. S. Army General Equipment Test Activity):

1. Identification of Important Tasks of Combat Infantry - Report of Results from a Further Refinement, November 1964.

2. Development of a Methodology for Measuring Infantry Performance in Rifle Firing and Reloading, June 1965.

3. Development of a Methodology for Measuring Infantry Performance in Maneuverability, June 1965.

4. Development of a Methodology for Measuring Infantry Performance in Marching and Moving, June 1965.

5. Development of a Methodology for Measuring Infantry Performance in Grenade Throwing, June 1965.

6. Development of a Methodology for Measuring Infantry Performance in Digging Hasty Fighting Positions, June 1965.

7. Final Report, Phase II, December 1965.

AD Accession No.

U.S. Army General Equipment Test Activity, Fort Lee, Virginia

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN GRENADE THROWING, FIFTH PARTIAL REPORT OF USATECOM PROJECT NO. 8-3-7700-01, PHASE II, DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS, by A. Gruber, J. Wm. Dunlap, G. DeNittis, Dunlap and Associates, Inc., Darien, Connecticut, and J. L. Sanders, V. W. Perry, B. D. Dixon, U. S. A. General Equipment Test Activity, Fort Lee, Virginia, June 1965, 49 p., 2 Tables, 12 Figures. (TECOM 8-3-7700-01) Unclassified Report

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the fifth of a series of seven reports presenting the results of Phase II of the study.

The first partial report in this series reported work performed to identify and rank the relative importance of the physical tasks performed in combat by the individual infantryman. One of

UNCLASSIFIED

1. Infantry combat tasks
2. Combat effectiveness
3. Clothing--Effects
4. Protective equipment--Effects
5. Human engineering
6. Measurement methodology
I. Gruber, A.
II. Dunlap, J. Wm.
III. DeNittis, G.
IV. Sanders, J. L.
V. Perry, V. W.
VI. Dixon, B. D.
VII. Title
VIII. TECOM Project No. 8-3-7700-01 (Contract DA 19-129-QM-2068)

AD Accession No.

U.S. Army General Equipment Test Activity, Fort Lee, Virginia

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN GRENADE THROWING, FIFTH PARTIAL REPORT OF USATECOM PROJECT NO. 8-3-7700-01, PHASE II, DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS, by A. Gruber, J. Wm. Dunlap, G. DeNittis, Dunlap and Associates, Inc., Darien, Connecticut, and J. L. Sanders, V. W. Perry, B. D. Dixon, U. S. A. General Equipment Test Activity, Fort Lee, Virginia, June 1965, 49 p., 2 Tables, 12 Figures. (TECOM 8-3-7700-01) Unclassified Report

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V. Perry, V. W.
VI. Dixon, B. D.
VII. Title
VIII. TECOM Project No. 8-3-7700-01 (Contract DA 19-129-QM-2068)

the tasks which were considered by a sample of combat veterans to be important to combat success was the ability to throw hand grenades accurately in various battle situations. This report describes the work performed to develop a reliable method for measuring soldier performance in throwing grenades at both horizontal and vertical targets. A proposed test course was established as a temporary facility and tested for reliability and sensitivity to differences in clothing and equipment using USAGETA Troops. It was determined that the tested course provided a practical and useful basis for measuring performance in the task and a modified data collection system was recommended for inclusion in an integrated course to be evaluated as the next step in the research program.

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# APPENDIX C

## Distribution List