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Report 1855

RAPIDLY EMPLACED ANTIPERSONNEL OBSTACLE

by

Arthur T. Stanley

May 1966

U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

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U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

Report 1855

RAPIDLY EMPLACED ANTIPERSONNEL OBSTACLE

Task 1M543312D46405

May 1966

Distributed by

The Commanding Officer
U. S. Army Engineer Research and Development Laboratories

Prepared by

Arthur T. Stanley
Combat Engineering Division
Military Department

FOREWORD

Authority for the work described in this report is contained in U. S. Army Materiel Command Task 1M543312D46405, "Obstacle, Rapid Emplacement, Antipersonnel." A copy of the Research and Technology Resume is included in the appendix.

Tests covered herein were performed at the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia, during the period from June 1964 through March 1966.

The investigation was under the direction of James A. Dennis, Engineering Technician; Edgar E. Rounds, Senior Project Engineer; and Arthur T. Stanley, Physicist, of the Combat Engineering Division, Military Department. Test men were Joseph W. Latka, George M. D'Orazio, Arthur L. Limerick, and Bert Sheets of the Combat Engineering Division, Military Department. Effectiveness test volunteers were Capt. Stevens and SSG Kadlecik, USMC; and Lt. Crenshaw, SFC Sayers, SFC Basly, SFC Paley, SSG Howell, and SP-5 Cooper of the U. S. Army Engineer School, Fort Belvoir, Virginia. The photographers were Eugene T. Chapman, Charles G. Simmons, Sidney L. Feldman, and Ralph E. Fravel of the Pictorial Sciences Division, Technical Service Department. The experimental program was under the general supervision of B. F. Rinehart, Chief, Demolitions and Fortifications Branch, Combat Engineering Division, Military Department.

SUMMARY

This report covers an investigation of the Rapidly Emplaced Antipersonnel Obstacle. Obstacle effectiveness and design adequacy were primary considerations of the evaluation. Effectiveness was determined by measuring the length of time required for personnel to pass through the obstacle and comparing the data with the time required to pass through triple standard concertina. Design adequacy was examined by observing the effects of a variety of rough handling and environmental conditions on the functioning of several obstacle devices. A statement of reliability was formulated from the data recorded in the design experiments.

The report concludes that:

a. The barbed tape material is more effective as an antipersonnel obstacle than triple standard concertina.

b. The modified obstacle device design provides satisfactory operating reliability within the environmental and rough handling conditions described in this test report.

c. The erected barbed tape pattern is not altered by the environmental conditions described in this test report.

CONTENTS

ILLUSTRATIONS

TABLES

RAPIDLY EMPLACED ANTIPERSONNEL OBSTACLE

I. INTRODUCTION

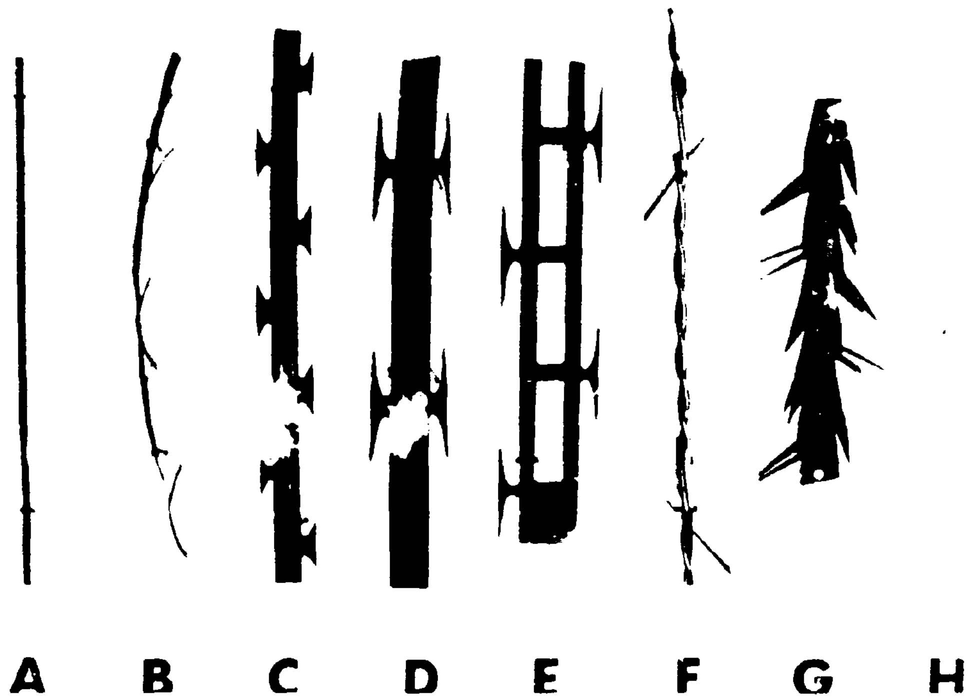
1. Subject. This report covers a series of tests designed to evaluate a mechanically erected barbed steel tape obstacle unit. Obstacle effectiveness and engineering design were primary considerations of the experiments to verify that the developed item provided under contract by Firestone Tire and Rubber Company satisfied the military and technical characteristics.

2. Background and Previous Investigation. A need to improve obstacles formed by wire entanglements, both in terms of effectiveness and emplacement time, has long been recognized. An evaluation performed and reported by Engineer Research and Development Laboratories (ERDL) in 1955 demonstrated that harpoon barbed wire and barbed steel tape (see items F and G of Fig. 1) were superior to standard barbed wire as obstacle materials.[1] Development of the Rapidly Emplaced Antipersonnel Obstacle began with a feasibility study conducted from 1958 to 1960. The purpose of the study was to determine the most effective type of obstacle material compatible with rapid emplacement techniques. This portion of the development cycle was followed by the issuance of three contracts, awarded to Firestone Tire and Rubber Company, for development and production of prototype models. Design effort was oriented toward producing an item which could be handled easily and safely, could be integrated hastily by forward area troops into a defensive perimeter to provide rapid local security, and would be equal in effectiveness to triple standard concertina.

a. Feasibility Study. Requirements of the military characteristics, approved in 1958, were sufficiently broad to accept any type of obstacle, provided that it could be rapidly emplaced and would be as effective as triple standard concertina. Therefore, several forms of obstacle were evaluated, as indicated below.

(1) Sound and Light. Sound waves of proper frequency, intensity, and duration can affect the sense of balance, produce nausea and headaches, and/or damage eardrums. However, the intensity of sound waves propagated in air is diminished so rapidly by

1. Moriarty, Ernest C. Jr., Evaluation of Barbed Materials for Obstacles, USAERDL Report 1427, Fort Belvoir, Virginia: U. S. Army Engineer Research and Development Laboratories, 23 September 1955.



M13203

Fig. 1. Forms of barbed tape: (A) Tape developed by Universal Winding Company. (B) First tape developed by Firestone Tire and Rubber Company. Judged ineffective at 19 October 1961 In-Process Review. (C), (D), and (E) Forms of tape developed by Firestone Tire and Rubber Company under Contract DA-44-009-ENG-5083. Each tape was considered effective at the 12 December 1962 In-Process Review. (F) and (G) Harpoon wire and barbed tape considered in 1955 "Evaluation of Barbed Materials for Obstacles" experiments. Both were considered more effective than barbed wire. (H) German barbed tape.

spherical expansion and attenuation that the power source required to provide an acceptable obstacle device would be too massive to be practical. Light, flickering at appropriate frequencies, can cause headaches, dizziness, nausea, eyestrain, and a sense of unreality. However, the degree of effect of these phenomena is dependent upon individual epileptic weakness, age, physical condition, and mental attitude. Therefore, this type of obstacle could not produce reliable results.

(2) Chemical, Biological, and Radiological Agents. Concepts considered in this area were radioactive bullets shot into the ground, chemicals producing sickening odors and fumes or lung irritants, chemical fogs, and sneezing or itching powder, possibly contained in glass balls. Chemical and biological agents were rejected without detailed investigation because extensive development had already been performed in these areas and because U. S. forces probably would not be permitted to employ these types of agents until chemical and/or biological warfare was initiated by the enemy. Radioactive bullets were rejected because the damaging reaction would be too slow to provide effective local security.

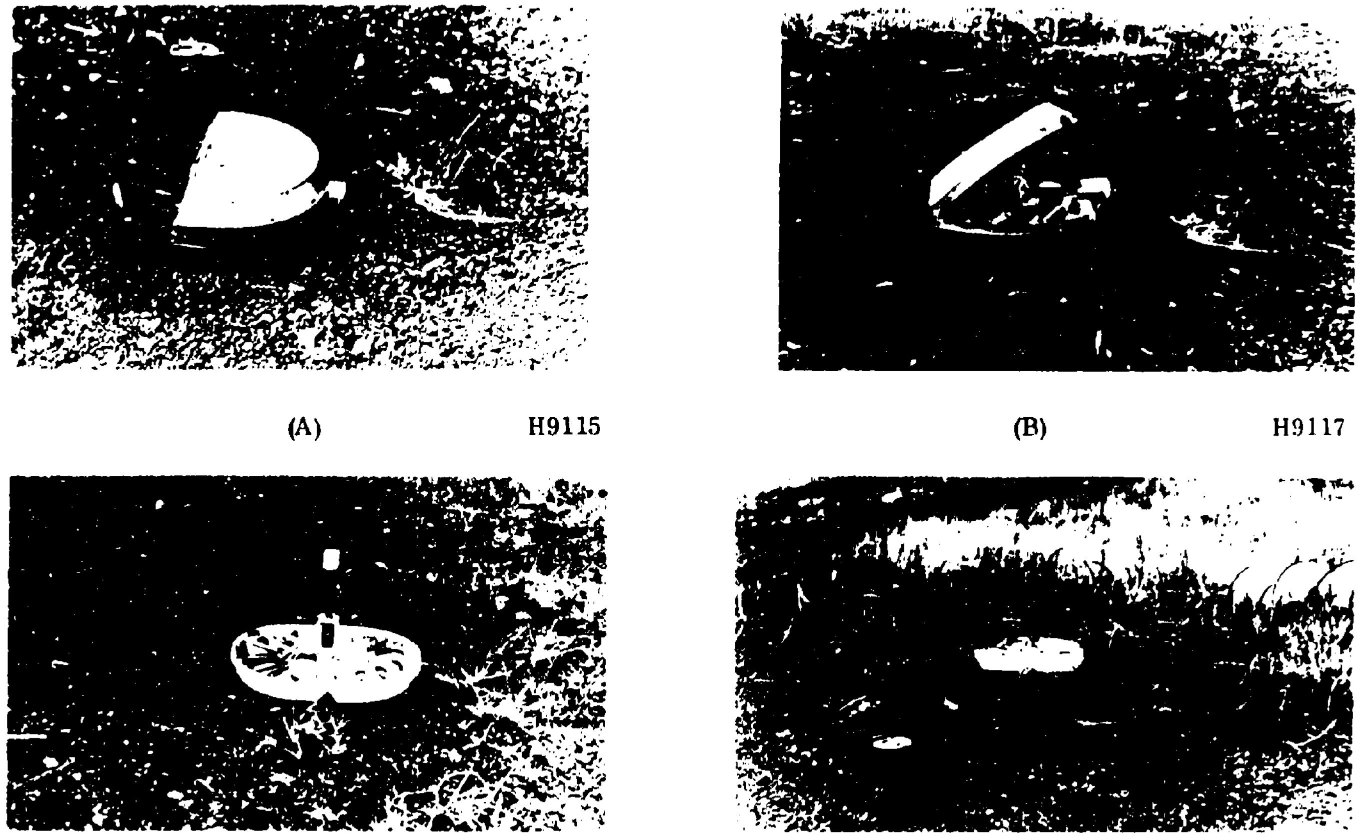
(3) Explosive and Flammable Materials. Application of explosive or flammable materials would not provide the desired results. Although these obstacles would be effective casualty producers, they would be one-shot items and would require replacement after actuation. Replacement would not be practical for units under continuous attack.

(4) Physical Barriers. Concepts considered in this class of obstacle were spiked objects similar to enlarged children's jacks (caltrops), electrically charged wire fence, hurricane force winds, detergent or plastic foam, and barbed wire or tape erected by either a rocket or jack-in-the-box technique. Spiked objects could be neutralized easily by placing steel inserts in boots. The effects of an electrically charged fence could be countered either through grounding the fence or by employing insulating material. The machine required to produce hurricane force winds would be too massive to be practical. Production of foam in the volume required would involve the use of special equipment operated by skilled personnel. Furthermore, rain and snow would have a destructive effect on a foam barrier. Barbed steel tape or wire was the only concept considered that provided a solution to the military characteristics. During the feasibility study, Universal Winding Company was engaged

to conduct preliminary investigations with 1/8-inch wide, 0.012-inch thick, barbed steel tape (shown as item A of Fig. 1). These investigations terminated with fabrication of a prototype model containing several reels of wound-spring steel-barbed tape. A pair of coil springs was designed to throw the wound reels of tape 3 feet in the air. Upon reaching the proper height, the reels of tape were designed to release and expand from the spring energy stored within the barbed tape. Through this process, it was intended that the tape be distributed uniformly over an area of 10 to 15 feet in diameter. Two prototype models were demonstrated to ERDL personnel on 17 September 1959. The barbed tape did not erect as expected but, rather, became completely tangled and, as a result, covered an area of only about 3 feet (as shown in Fig. 2). Although the device failed, the test established that the barbs and reel assemblies would have to be designed to prevent tangling of the tape during the uncoiling process, that each reel assembly would have to be placed in the obstacle device in a manner that would prevent interference between adjacent reels during erection, and that a supplemental energy source would be required to erect the tape, as the spring energy of the tape itself would be insufficient for this purpose.

b. Contract DA-44-009-ENG-4426. On 31 March 1960, a contract was awarded to Firestone Tire and Rubber Company to design and develop a Rapidly Emplaced Antipersonnel Obstacle. The first item developed was a 1/4-inch wide, 0.030-inch thick, spring steel tape. The tape was cut diagonally from each edge to the center and the resultant triangular sections were bent outward to form barbs (item B of Fig. 1). The tape was wound on reels approximately 6 inches in diameter, and a clam-shell-type shipping container/erection device (Fig. 3) was designed to contain 12 of these reels. Energy for tape erection was delivered by the recoil action of a gun, fabricated to accommodate a standard 7.62-mm NATO cartridge. This gun also drove an anchor into the ground to secure the barbed tape. The unit was equipped with a mechanical timer and a radio receiver so that either manual or remote actuation was possible. The tape was designed to occupy an area of about 20 feet in diameter after expansion. An In-Process Review was conducted on 19 October 1961 to evaluate the prototype models. The user considered the concept desirable but determined that the barbed tape lacked effectiveness and that development effort should be continued in order to arrive at a more effective obstacle material. The military characteristics were amended to include a 24-inch minimum, 36-inch desirable, barbed tape height requirement. Further, the user decided that the presence of battery powered electrical components would reduce reliability. Therefore, the remote control concept was eliminated.

Fig. 2. Tape pattern of prototype model developed during feasibility study by Universal Winding Company.



(A) H9115

(B) H9117

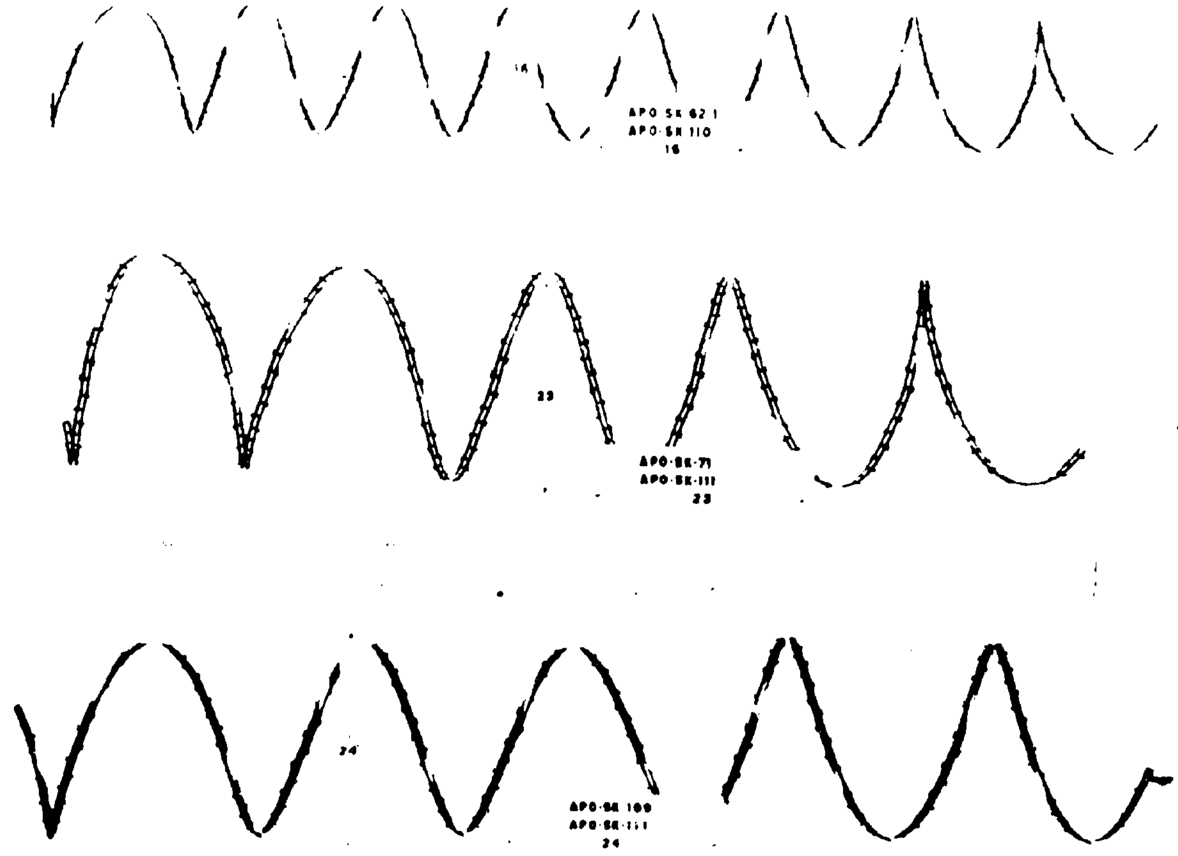
(C) H9116

(D) H9114

Fig. 3. Clam shell prototype: (A) Canister in closed position. (B) Partially open by timer or remote control device. (C) Completely open, gun in firing position. (D) Erected tape.

c. Contract DA-44-009-ENG-5083. On 24 May 1962, a second contract was awarded to Firestone Tire and Rubber Company to develop more effective tape. The new tape had to stand twice as high as the tape developed in the previous contract. The section modulus, therefore, had to be increased by enlarging the width so that the tape would support itself to such a height. Three different tapes, shown in Fig. 4, were developed and presented for approval at an In-Process Review on 12 December 1962. One tape, 3/4 inch wide, was designed to stand 16 inches high. The other tapes, $1\frac{1}{2}$ inches wide, were designed to stand 24 inches high. However, one of the tapes had rectangular sections cut out of the center to reduce weight. As a result, this lighter tape was not stable in the erected position. The user at the In-Process Review decided that all were effective and that the developer should design an obstacle, selecting whichever tape could be most conveniently applied to an erection device. Further, it was decided that height requirements would be eliminated from the military characteristics because the lesser height of barbed tape, compared to that of triple standard concertina, was compensated for by its greater width.

d. Contract DA-44-009-AMC-100(T). On 14 February 1963, a third contract was awarded to Firestone Tire and Rubber Company to produce the selected barbed tape in sufficient quantity to allow performance of effectiveness tests on the material, and to design, develop, and deliver to ERDL prototype models for engineering design tests. Effectiveness tests were conducted from June to September 1964. Results of these tests are included in paragraph 5 of this report. Prototype models, one of which is shown in Fig. 5, were delivered to ERDL for presentation at an In-Process Review conducted on 1 October 1964. It was concluded at the In-Process Review that the effectiveness of the obstacle and the design concepts of the shipping container/erection device were satisfactory. However, it was recommended that changes be made to ruggedize the obstacle, to simplify operation of the device, to increase reliability, and to design the parts so that they could be fabricated by mass production techniques. A major redesign effort was expended to develop the current Rapidly Emplaced Antipersonnel Obstacle. Fifteen obstacle units were delivered to ERDL for engineering design tests in late November 1965. The results of these tests plus those of the effectiveness tests, performed under this contract, form this report.



J12114

Fig. 4. The three tapes presented at 12 December 1962 In-Process Review. Each tape was judged to be effective.

Fig. 5. Prototype evaluated at 1 October 1964 In-Process Review.

L6643

II. INVESTIGATION

3. Description of Equipment. Eight reels of barbed tape, a release mechanism, and an actuator device, as shown in Fig. 6, are mounted on a base pan and packaged in a sheet metal container 19 inches long, $6\frac{1}{2}$ inches wide, and 10 inches high. The total weight of the obstacle unit is 31 pounds 4 ounces.

a. The barbed tape is fabricated from 1.225-inch wide by 0.025-inch thick spring steel strips. Sections are cut from each side of the tape so that four barbs, 7/8 inch long, are located on 4-inch centers. The tape is coiled under constant tension to form a reel approximately 8 inches in diameter. Each reel is oriented in the unit with its axis in the horizontal plane. Four reels are positioned side by side at each end of the canister. The reels are numbered in a systematic manner for identification throughout the test.

b. The release mechanism is powered by a timer with a 90-degree, zero-torque output, 5-minute, plus or minus 2 minutes, timing cycle. The timing cycle is followed by a 150-degree, 20-ounce-inches torque power stroke. During the power stroke, a follower is rotated by a pin cam attached to the timer shaft. Rotation of the follower frees the top cover release assembly. Once released, the top cover displaces vertically under the power of two leaf springs. Movement of the top cover releases the two end covers. The reel retainer springs, bearing between the end covers and the tape reels, remove the end covers from the canister. Removal of the end covers allows the tape reels to rotate horizontally about the center of the unit, under the power of hinge springs placed between the reels. This motion orients the reels at each end of the canister in a 60-degree fan with 20 degrees between each reel. Reel No. 4 pushes a sear as it rotates. Movement of this sear releases the hammer which, in turn, fires a standard 7.62-mm NATO cartridge.

c. The actuator assembly consists of a gun, fitted within a cylinder, to function as a piston. Approximately 10 percent of the cartridge gases are captured in the cylinder to force the gun upward. Slings, attached to the wire carrier brackets, mounted on top of the gun, eject the reels of tape with a slingshot action. Each reel uncoils to form a helix approximately 12 feet long and 15 inches high.

4. Test Procedures. The tests were conducted in two phases. Effectiveness of the barbed tape was evaluated in the first phase by hand placing the material and determining the delay time, which was defined as

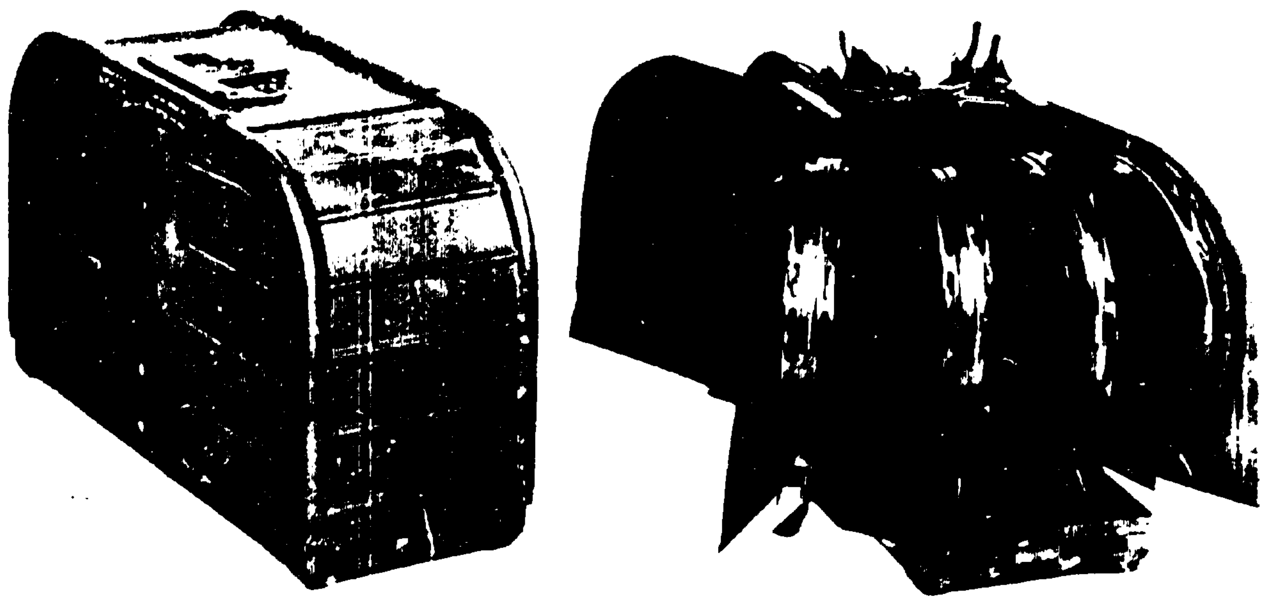


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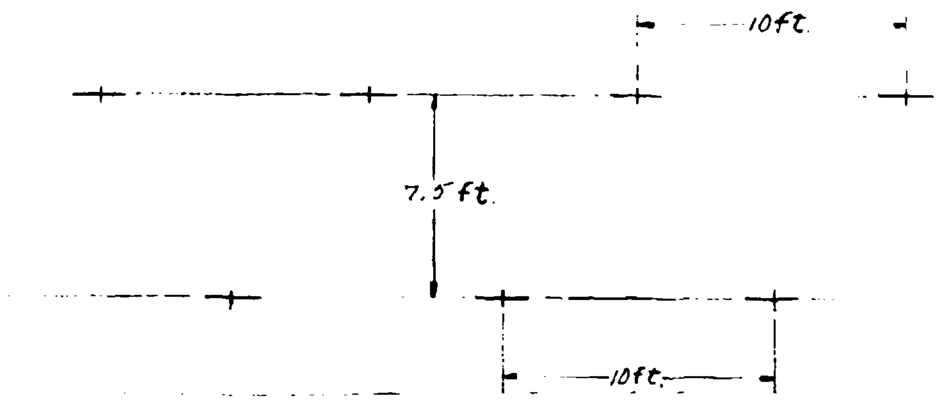
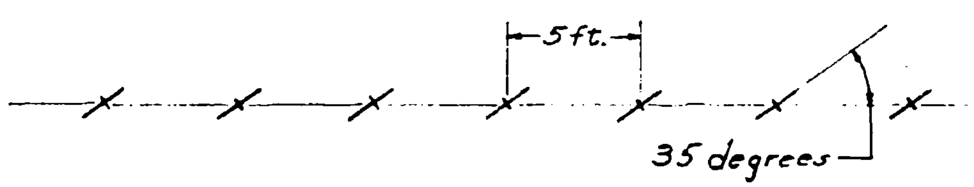
Fig. 6. Rapidly Emplaced Antipersonnel Obstacle completely assembled (left) and with top and end covers removed (right).



—+— Denotes location of obstacle units. Long tick mark indicates direction of long axis (length) and short tick mark indicates direction of short axis (width).

Fig. 7. Obstacle pattern, 10 feet by 7.5 feet, 2 rows.



—+— Denotes location of obstacle units. Long tick mark indicates direction of long axis (length) and short tick mark indicates direction of short axis (width).

Fig. 8. Obstacle pattern, 5 feet at 35 degrees.

the time required for personnel to pass through the obstacle. Engineering design of the obstacle device was evaluated during the second phase by test firing 15 obstacle units after subjecting them to a variety of controlled environmental and rough handling conditions. Operation of the obstacle units was observed and measurements were taken of the actuation time and resultant tape patterns. These data were applied to formulating a statement of reliability and evaluating effects of environmental conditions for temperate and tropic zones, contained in paragraph 7, AR 705-15, to verify satisfaction of the military and technical characteristics.

5. Obstacle Effectiveness Tests. Reels of barbed tape were erected by hand to duplicate theoretical patterns that would be achieved by emplacement from canisters positioned as shown in Figs. 7 and 8. Test personnel volunteers from the Engineer School, Fort Belvoir, Virginia, and a Marine Corps Captain from Quantico, Virginia, were equipped with protective clothing, as shown in Fig. 9. This clothing consisted of modified smoke jumper suits fabricated from heavy canvas of double thickness in the arms and legs, crash helmets with steel mesh face covers, combat boots with arctic overcovers, regular fatigue uniforms, and barbed tape gauntlets. The following tests were conducted, with the results indicated, to determine delay times for personnel crawling, crouching, and running upright with and without breaching aids, and for selected vehicles.

a. Personnel Running Upright. Five trials were conducted with personnel starting from a prone position approximately 5 yards from the forward edge of the obstacle. As time was started, test personnel stood up and attempted to run through the barbed tape. The obstacle pattern for the first two trials was 10 feet by 7.5 feet, 2 rows, and for the last three trials, 5 feet at 35 degrees. The first two trials were conducted in the afternoon, the third at dusk, and the last two at night. During all trials, the weather was clear and the soil was dry. Results are given in Table I and shown in Fig. 10.

b. Personnel Moving in Crouched Position. Three trials were conducted with personnel starting approximately 15 yards from the forward edge of the obstacle. As time was started, test personnel attempted to run through the obstacle in a crouched position. The first two trials were conducted in the afternoon with the 10-foot by 7.5-foot, 2-row pattern, and the last trial was completed at dusk with the 5-foot-at-35-degrees pattern. The weather was clear and the soil was dry during each trial. Results are listed in Table II and shown in Fig. 11.

(A) L3394

(B) L3351

(C) L3350

Fig. 9. Protective clothing worn by volunteers. (A) Personnel wearing protective trousers and fatigue pants. (B) Protective canvas coat. (C) Personnel completely dressed in protective clothing.

Table I. Data for Personnel Running Upright Through Barbed Tape

Trial	Individual	Delay Time (sec)	Remarks
1	1	7	
	2	8	
	3	47	Pants torn in 8 places.
2	1	6.4	
	2	8	
	3	13	
3	1	8	Clothing torn in 2 places.
	2	8	Several snag marks in clothing.
	3	10	Several snag marks in clothing.
4	1	10	Several snag marks in clothing.
	2	9	Several snag marks in clothing.
	3	10	Several snag marks in clothing.
5	1	7.5	Several snag marks in clothing.
	2	8.5	Several snag marks in clothing.
	3	9	Several snag marks in clothing.

c. Personnel Crawling. One trial was conducted with three test men starting from a prone position approximately 5 yards from the forward edge of the obstacle. As time started, test personnel attempted to crawl through the 10-foot by 7.5-foot 2-row pattern (Fig. 12). This test was conducted in the afternoon with clear weather and dry soil. Each man became tangled in the tape coils, and the test was halted after 1 minute. Penetration was equal to body length.

d. Personnel Using Breaching Aids. Five trials were conducted with personnel and breaching material approximately 15 yards from the forward edge of the obstacle. At a given signal, the test men carried

(A) L3372

(B) L8233

Fig. 10. Personnel running upright effectiveness tests. (A) Personnel could pass through obstacle uninjured in upright position only when caution was exercised. (B) Individual passed through obstacle rapidly in upright position. Clothing was torn in several places because appropriate caution was not exercised. Soldier would have received severe wounds if protective clothing had not been worn.

Table II. Data for Personnel Moving in Crouched Position Through Barbed Tape

Trial	Individual	Delay Time (sec)	Remarks
1	1	10	Individual stood upright several times. Clothing torn in 15 places.
	2	--	Entangled after 15 sec. Test terminated after additional 45 sec of struggle. Puncture received in hand, and uniform torn in 10 places.
	3	--	Entangled after 5.8 sec. Test terminated as above. Uniform torn in 23 places.
2	1	28	Passed through obstacle in upright position. Uniform received large tear.
	2	51	Received 1.5-cm-long puncture in foot through combat boot with arctic overcover.
	3	--	Entangled after 20 sec. Test terminated after additional 23 sec of struggle. Uniform torn in several places.
3	1	10	Each man passed in upright position. The three men received a total of seven tears in clothing.
	2	9	
	3	10	

(A) L3375

(B) L3376

Fig. 11. Injury received by second individual to pass through obstacle during trial 2 of crouched position tests. (A) Barbed tape punctured both the arctic overcover and the combat boot. (B) Injury required medical attention.

L3373

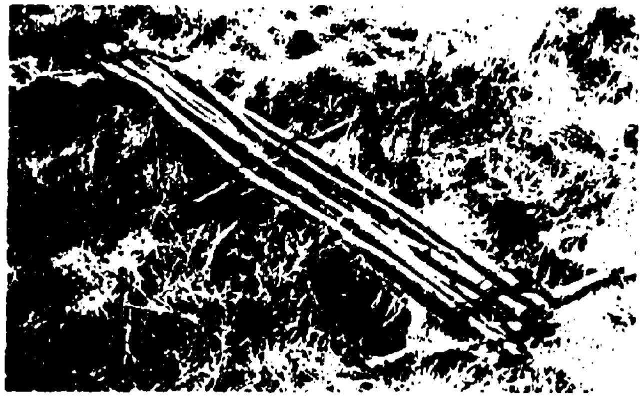
L10110

Fig. 12. Individuals attempting to crawl through obstacle. Both were immobilized by the tape and both required assistance to be freed. Each would have been severely wounded if protective clothing had not been used.

the material to the obstacle and worked as a team to emplace the breaching aids. The following materials were used for the trials indicated: Trial 1, frame mats of 6-foot-long, 1-inch-diameter poles; trial 2, frame mats of 6-foot-long, 3-inch-diameter poles; trial 3, 6-foot tall evergreen trees; trial 4, shelter half canvas; trial 5, wool blankets. Each trial was conducted in the afternoon with clear weather and dry soil. Results are given in Table III and shown in Figs. 13 and 14.

Table III. Data for Personnel Using Breaching Aids

Trial	Individual	Delay Time (sec)	Remarks
1	1	24.2	Required 20 sec to emplace breaching aid.
	2	24.2	Required 20 sec to emplace breaching aid.
	3	37.2	Fell down after 18 sec. Trousers torn in several places.
2	1	25	All men crossed together with no injury.
	2	25	
	3	25	
3	1	18	All men crossed together with no injury.
	2	18	
	3	18	
4	1	42	Required 28 sec to position canvas. Each man's clothing snagged on the tape.
	2	42	
	3	42	
5	1	35.8	Required 23 sec to position blankets. One man fell after 33 sec and sustained cuts in trouser legs.
	2	35.8	
	3	35.8	



(A) L3377

(B) L3384

(C) L3387

Fig. 13. Breaching aids used to cross obstacle. (A) Frame mat of 1-inch-diameter poles. Three-inch-diameter poles were also used. (B) Evergreen trees. (C) Wool blankets. Shelter half canvas was also used.

(A) L3383

(B) L3382

Fig. 14. Crossing obstacle with breaching aids. (A) Arctic overcover snagged by barbed tape. Individual had to remove barb before proceeding. (B) Individual tangled by tape receiving assistance to cross obstacle.

e. Personnel Mounted in Vehicles. Three trials were conducted, each with a different type vehicle. The tape was emplaced on 6-inch grass in the 10-foot by 7.5-foot, 2-row pattern. The weather was clear and the soil was dry during each trial. The results were as follows:

(1) A 1/4-ton truck with four-wheel drive engaged passed through the obstacle. Tape caught on the left rear tire and locked the wheel after the vehicle traveled 20 yards beyond the obstacle. A large path was cleared through the obstacle. No permanent damage was done to the vehicle although one hour was required for three men to free the left rear wheel.

(2) A $2\frac{1}{2}$-ton truck with six-wheel drive engaged passed through the obstacle. The tape caught on the undercarriage of the truck and a large path was cleared through the obstacle. No damage was done to the vehicle.

(3) An M-48 tank crossed over the obstacle without difficulty. The tape did not catch on the tank and no path was cleared for dismounted troops.

6. Engineering Design. Two series of experiments composed this portion of the test. The first series was conducted with obstacle devices, as delivered by the contractor, to determine adequacy of the design to survive environmental and rough handling conditions. The second experimental series was conducted with obstacle units containing all the modifications required to eliminate the failures evidenced in the first series.

a. First Series of Design Tests. In response to design requirements, the following tests were conducted with the results indicated.

(1) Control Test. A firing site, used for all tested units, was prepared by marking a 100-foot line, over which the obstacles were centered, with standard 2-inch-wide white tracing tape. The control unit was selected at random, positioned upright on the center line, and oriented with the longitudinal axis of the unit 35 degrees from the center line. A NATO cartridge was inserted in the chamber, and both the escapement and automatic actuator pins were removed. The release mechanism operated in 4 minutes 15 seconds. However, the unit failed to operate because the reel holders did not fan out with sufficient force to displace the hammer sear and release the hammer. The reel holders were forced into position by test personnel. The NATO round was detonated. However, the slings that

M10625

Fig. 15. Results of first control experiment.

expel the reels of wound tape became unhooked from the wire carrier brackets attached to the top of the gun. The tape remained coiled as shown in Fig. 15, while the gun, brackets, and cylinder flew 50 feet into the air.

(2) Second Control Test. The first control test was repeated with another unit because of failures noted. Actuation time was 4 minutes 37 seconds. Results are given in Table IV.

Table IV. Data for Second Control Test

Reel	θ	L (ft)	H (in.)	Remarks
1	15	10.0	13.0	
2	-10	10.1	15.5	
3	20	10.2	14.75	
4	30	19.0	14.5	
5		1.8	14.75	Tape tangled.
6	-2	12.4	14.0	
7	22	18.5	14.5	
8	33	8.9	14.75	

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

(3) Salt Spray Test. One obstacle device was placed in a salt chamber for 50 hours in accordance with method 6061 of Federal Test Method 141. A 20-percent NaCl brine was used. Following exposure in the salt chamber, the unit was placed on level ground in an open field of 6-inch grass to weather for one week. The canister was then placed on the center line, 5 feet from the previously tested unit, and oriented with the longitudinal axis 35 degrees from the center line. A NATO cartridge was inserted into the chamber, and both pins were pulled for automatic operation. The unit did not function because the timer failed to complete the timing cycle. The timer was reset and the unit was disarmed and removed for examination. The release mechanism was found to operate satisfactorily without application of corrective action. The unit was replaced in the test site and

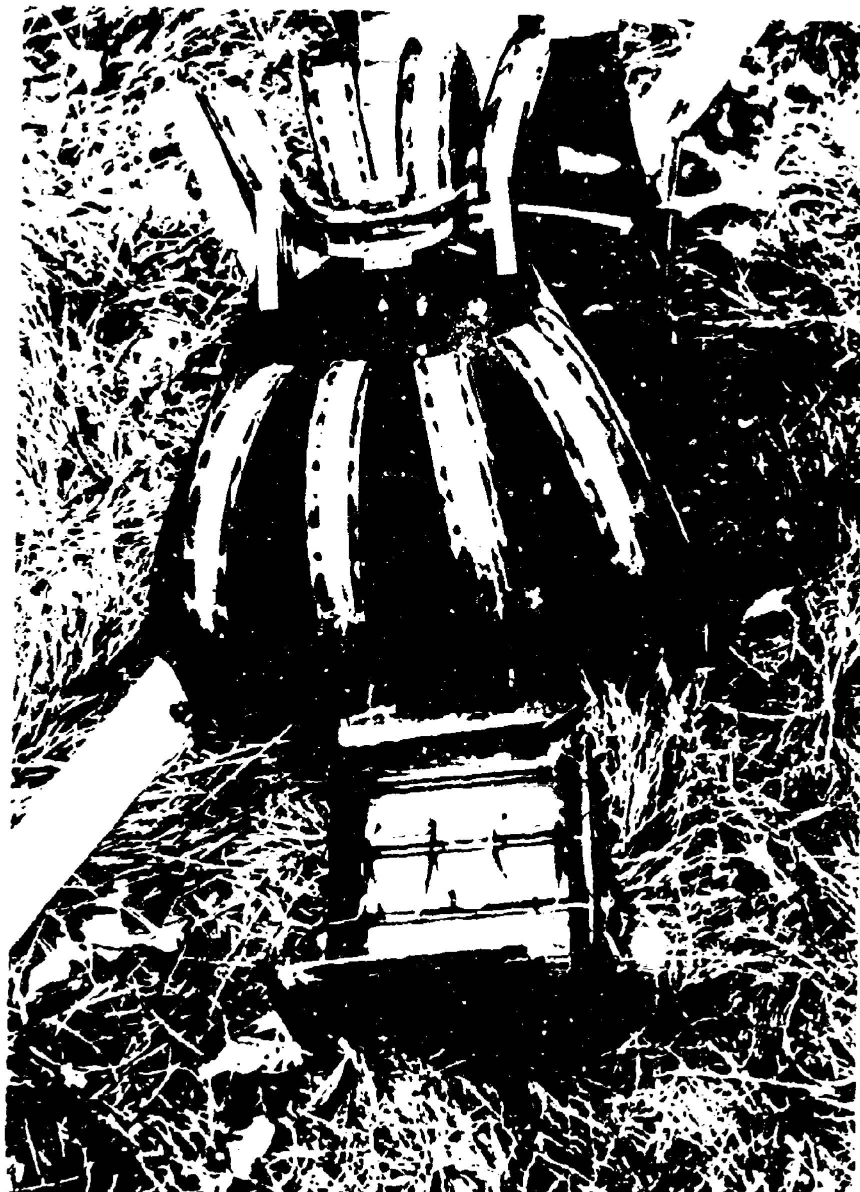
the experiment was repeated satisfactorily. Results are given in Table V and shown in Fig. 16.

Table V. Data for Salt Spray Test

Reel	θ	L (ft)	H (in.)	Remarks
1	15	13.8	14.0	Coil axis curved 270 degrees.
2	5	15.0	13.0	Coil axis curved 30 degrees.
3	20	18.3	12.0	Coil axis curved 100 degrees.
4	35	15.5	12.5	Coil axis curved 60 degrees.
5	5	15.3	12.0	Coil axis curved [illegible]0 degrees.
6	-2	15.3	12.25	Coil axis curved 90 degrees.
7	20	15.4	11.0	Coil axis curved 90 degrees.
8	35	21.1	12.0	Coil axis curved 70 degrees.

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

(4) Humidity Test. One obstacle device was placed in an environmental chamber in which a dry bulb temperature was 100° F and a wet bulb temperature was 99° F. The unit remained in this 96-percent relative humidity condition for 49 hours and was then placed upright on level ground in an open field of 6-inch grass to weather for one week. After the weathering period, the unit was positioned on the center line, 5 feet from the previously tested unit, and oriented with the longitudinal axis 35 degrees from the center line. A NATO cartridge was loaded in the chamber, and both the escapement and automatic pins were pulled. The timer failed to start. The NATO cartridge was removed from the chamber and the timer was reset and actuated in the automatic mode. The release mechanism operated properly in 5 minutes 54 seconds. The NATO cartridge was reloaded in the chamber, the timer was reset, and the original experiment was repeated. The release mechanism failed to operate although the timer, still in the timing cycle, had rotated more than 90 degrees.



M12410

Fig. 16. Obstacle unit after salt spray and one week of weathering. Accumulation of salt on the reels had no effect on tape expansion.

(5) Low Temperature Test. One obstacle device with one NATO round was placed in an environmental chamber in which the dry bulb temperature was -65° F and the wet bulb temperature was -100° F. After 48 hours, the dry bulb temperature was raised to -25° F. This temperature was maintained for only 24 hours because of environmental chamber failure. The temperature reached 50° F. The unit was again subjected to a dry bulb temperature of -25° F for 24 hours. The obstacle and NATO cartridge were transported to the test site in an insulated container, removed from the insulated container, oriented as in previous tests, and set for lanyard operation. The insulated container was replaced, and 5 minutes were allowed to elapse to provide for completion of the timing cycle. The insulated container was removed by a cord through a pulley and the lanyard was pulled. When the release mechanism failed to operate, the unit was disarmed and inspected. The timing cycle was completed in the release mechanism. However, the follower was binding on the sheet metal container and required a 40-pound lanyard pull to be rotated. This condition still existed 1 hour later when the temperature of the obstacle had risen to atmospheric temperature, 60° F.

(6) Humidity Plus Freeze Test. One obstacle device was placed in an environmental chamber in which the dry bulb temperature was 100° F and the wet bulb temperature was 99° F. The unit remained in this 96-percent relative humidity atmosphere for 49 hours. The canister was removed from the chamber, wrapped in two waterproof bags, and transported to another environmental chamber in which the dry bulb temperature was -25° F and the wet bulb temperature was -100° F. This portion of the experiment was conducted simultaneously with the similar portion of the low temperature test described in the previous paragraph, and the same chamber failure and schedule were experienced. This unit was transported to the test site and set for operation immediately after the failure of, and in an identical manner with, the obstacle device ...tioned in paragraph (5) above, except that the unit was set for automatic operation and the insulated cover was removed 3 minutes after the actuator pins were pulled. The release mechanism failed to complete the timing cycle. Replacement of the automatic actuator pin started the timer; the timer was rewound and set for lanyard operation. The release mechanism operated properly; however, the reel holders failed to fan out with sufficient force to displace the hammer sear and release the hammer.

(7) Rain Test. One obstacle device was placed upright on level ground in the center of four spray nozzles. Each spray nozzle was affixed to the top of a 3-foot stake and each stake was positioned vertically at a 2-foot horizontal distance from the center of the canister. Water, piped to the nozzles, fell on the canister for 30 minutes. Two minutes prior to water shutoff, a test man entered the spray area, turned the canister upside down, and opened the breach to allow any water that might have accumulated to drain out of the gun. With one hand placed over the breach, the test man returned the unit to its original position, loaded a NATO cartridge, and closed the breach. This operation required 1 minute. After the water flow was stopped, the unit was placed on the center line, 5 feet from the previously fired canister, and was oriented with the longitudinal axis 35 degrees from the center line. Both pins were pulled for automatic operation, and the canister functioned properly in 5 minutes 23 seconds. Results are given in Table VI and shown in Fig. 17.

Table VI. Data for Rain Test

Reel	θ	L (ft)	H (in.)	Remarks
1	35	6.7	13	Tape tangled.
2	18	14.3	15	Coil axis curved 90 degrees.
3	0	9.2	15	Coil axis curved 90 degrees.
4	35	12.3	13	Coil axis curved 120 degrees.
5				Coil completely tangled on No. 6 sling and No. 8 reel retainer spring.
6	5	9.9	13	Coil axis curved 90 degrees.
7	20	9.8	13	Coil axis curved 90 degrees.
8	35	7.6	12	Coil axis curved 90 degrees.

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

(8) Drop Test. The test area was fabricated by placing a 2-foot square, 5/8-inch thick, steel plate on level ground in a field of 6-inch grass. A 1/2-inch-thick sheet of "Celotex" was placed on top of the steel plate.

Fig. 17. Rain test conducted on obstacle unit. M12416

(a) One unit was dropped on a top corner from a height of 1 foot. The angle of incidence of the canister edges with the horizontal was approximately 30 degrees. No damage to the obstacle was evidenced. The unit was then dropped on a bottom corner from a height of 1.5 feet, with the same angle of incidence. The end cover at the end of fall became detached at the bottom. The end cover opposite the end of fall became completely detached. These covers were replaced, and the obstacle was placed over the center line, 5 feet from the previously fired unit and oriented with the longitudinal axis 35 degrees from the center line. A NATO round was inserted in the chamber and the unit functioned normally in the automatic mode. Results are given in Table VII.

Table VII. Data for First Drop Test

Reel	θ	L (ft)	H (in.)	Remarks
1	16	14.0	13.0	Coil axis curved 90 degrees.
2	7	7.8	12.0	Coil axis curved 270 degrees.
3	25	15.5	14.0	Coil axis curved 90 degrees.
4				Sling broke at top of bracket.
5	20	14.7	13.0	Coil axis curved 150 degrees.
6	0	13.5	15.0	Coil axis curved 270 degrees.
7	18	14.0	14.0	Coil axis curved 100 degrees.
8	30	17.8	14.0	Coil axis curved 90 degrees.

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

(b) Modified end covers and cover release plates were fabricated to preclude end cover detachment. One unit was reassembled to contain these modified parts. This unit was dropped on a bottom corner from a height of 1.5 feet with a 30-degree angle of incidence. Both end covers remained in place. The end cover at the end of fall, however, was bent outward at the end-cover arch, and one side plate was released. The unit was reassembled and dropped from a height of 3 feet with the same angle of incidence. Both end covers remained in place. The end cover at the end of fall, however, was bent outward at the end-cover arch, and both side plates were released. The obstacle was reassembled and dropped from a height of 2 feet on a top corner with the same angle of incidence. All elements remained in place; however, the end cover at the end of fall twisted at the top cover latch. On the side opposite the fall, the end cover was pushed 1/4 inch into the top cover, and on the side of the fall, the end cover pulled out of the top cover. The obstacle was placed over the center line, 5 feet from the previously fired unit and oriented with the longitudinal axis 35 degrees from the center line. A NATO round was inserted into the chamber, and the canister functioned properly in the automatic mode. Results are given in Table VIII.

Table VIII. Results of Second Drop Test

Reel	θ	L (ft)	H (in.)	Remarks
1	15	18.7	12.0	Coil axis curved 90 degrees.
2	5	11.7	14.0	Coil axis curved 120 degrees.
3	15	13.6	13.25	Coil axis curved 90 degrees.
4	28	18.8	13.0	
5	10	15.4	13.0	Coil axis curved 60 degrees.
6	0	15.6	11.5	Coil axis curved 60 degrees.
7	11	13.7	13.75	Coil axis curved 60 degrees.
8	22	16.8	13.0	Coil axis curved 270 degrees.

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

(9) Vibration Test. One obstacle device was vibrated in two planes: The horizontal plane in the direction of its length, x-axis, and in the direction of its width, y-axis; and the vertical plane in the direction of its height, z-axis. The vibration transmitted to the test sample was designed to simulate transportation both by air and by surface, as extracted from MIL-STD-810A, Method 514.1, with 30 minutes dwell at each resonant frequency. The desired

vibration curves, shown in Fig. 18, could not be achieved because of the limitations of the vibration apparatus. The unit was actuated after the vibration was completed.

(a) X-Axis. The vibration achieved is shown in Fig. 19. No resonant frequency was detected, and no damage to the unit was evidenced.

(b) Y-Axis. The vibration achieved is shown in Fig. 20. Five resonant frequencies were detected. The results of 30 minutes dwell at each of these frequencies were as follows:

1. At 13 cycles per second at 0.07-inch double amplitude; no evidence of damage.

2. At 23 cycles per second at 0.07-inch double amplitude; one end cover would not release because a barb of tape was stuck on the end cover channel at the top cover latch. The loops of tape in each coil began to slip horizontally over each other.

3. At 54 cycles per second at 0.036-inch double amplitude; loops of tape in each coil continued to slide horizontally.

4. At 195 cycles per second with 10-g force; sling No. 1 was binding in tape coil.

5. At 255 cycles per second with 10-g force; no evidence of damage.

(c) Z-Axis. The vibration achieved is shown in Fig. 21. Five resonant frequencies were detected. The results of 30 minutes dwell at each of these frequencies were as follows:

1. At 53 cycles per second with 0.1-inch double amplitude; no additional damage to the unit was evidenced.

2. At 61 cycles per second with 0.036-inch double amplitude; no additional damage to the unit was evidenced.

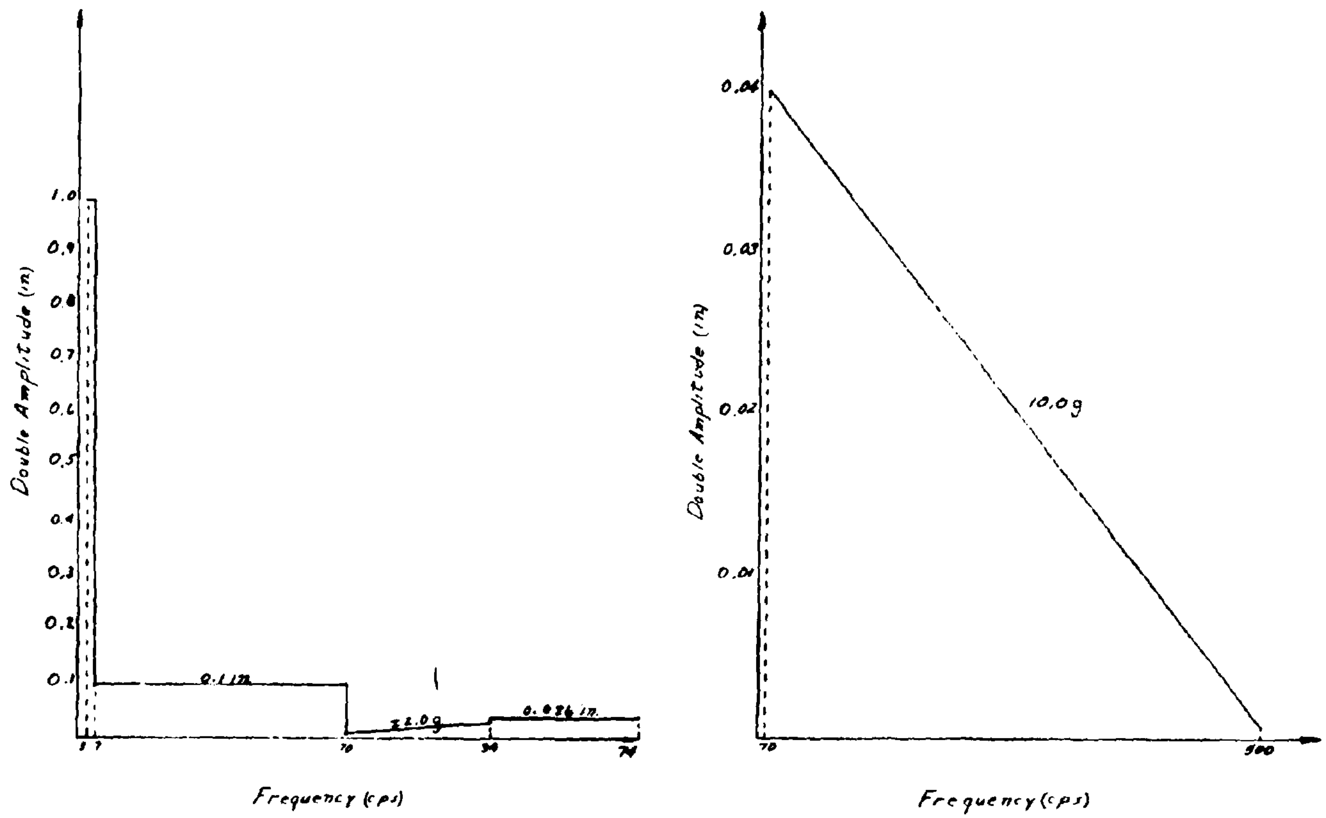


Fig. 18. Desired vibration curves.

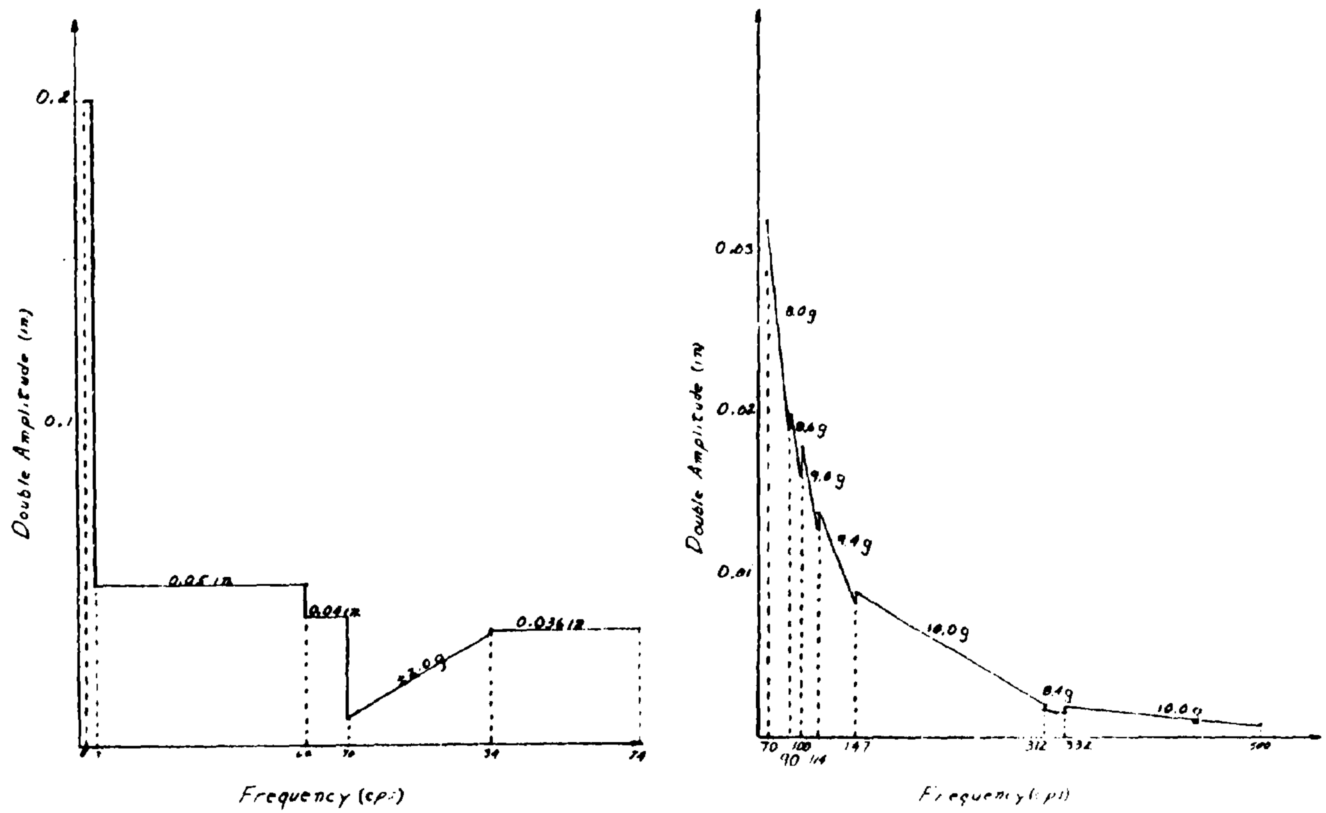


Fig. 19. Vibration achieved along x-axis.

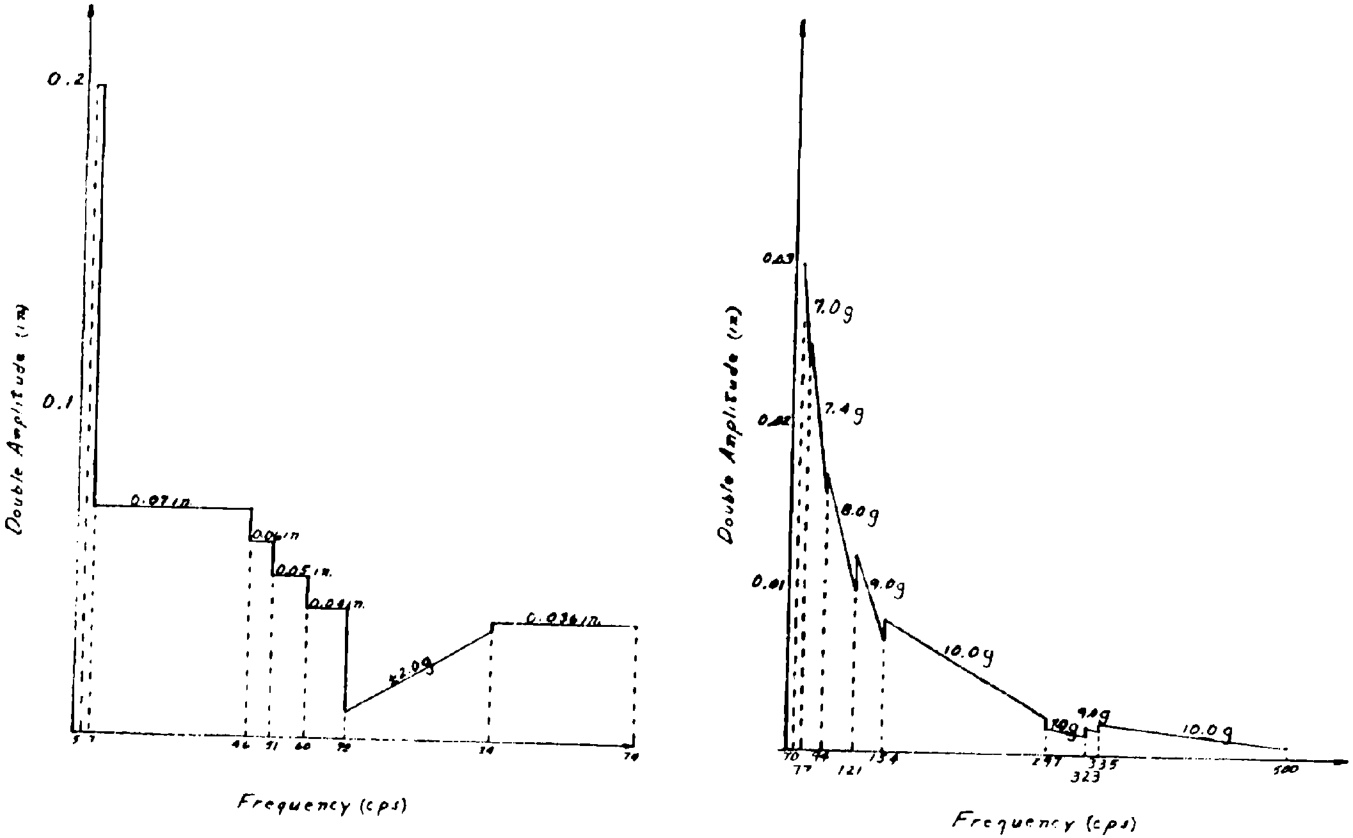


Fig. 20. Vibration achieved along y-axis.

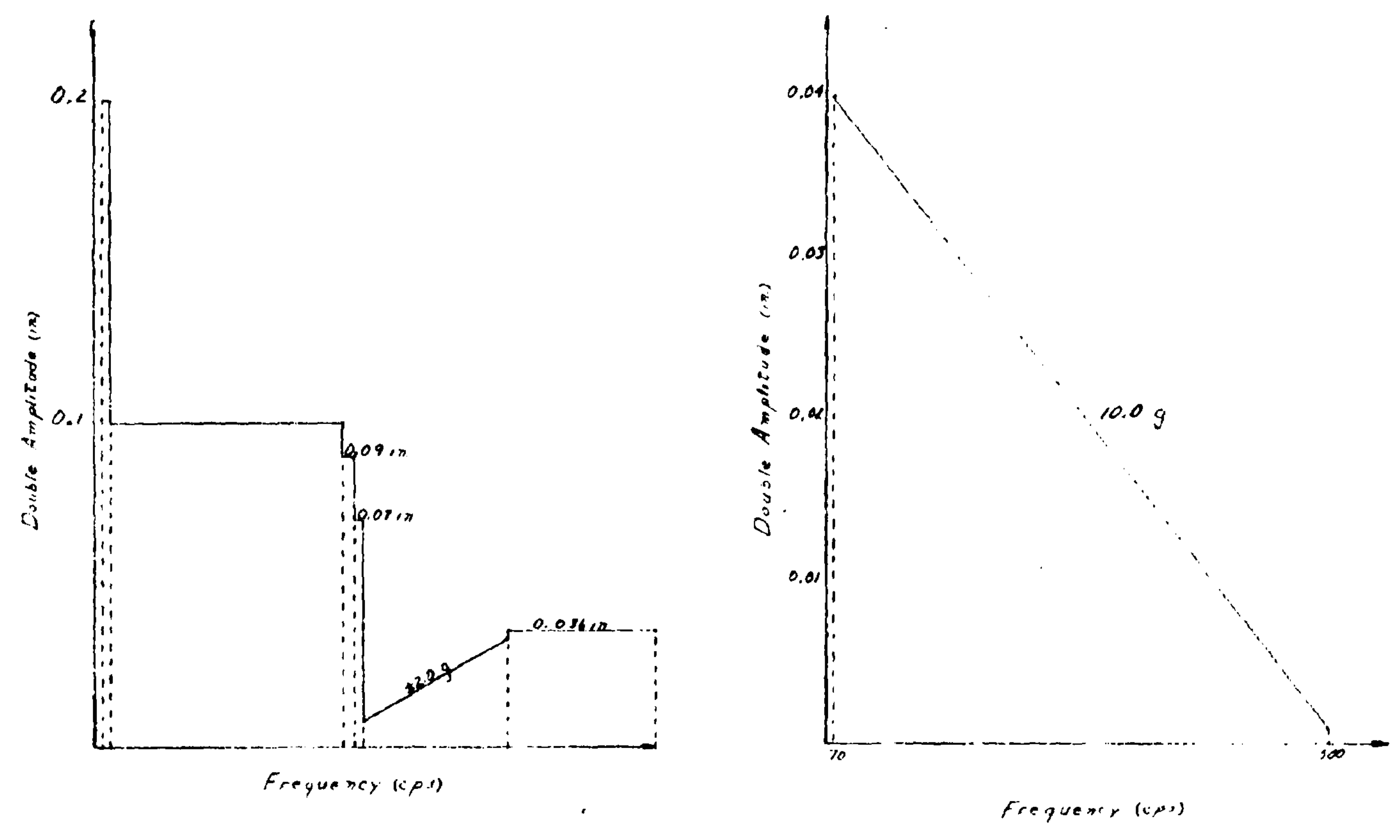


Fig. 21. Vibration achieved along z-axis.

3. At 275 cycles per second at 10-g force; no additional damage to the unit was evidenced.

4. At 317 cycles per second at 10-g force; no additional damage to the unit was evidenced.

5. At 346 cycles per second with 10-g force; no additional damage to the unit was evidenced.

(d) Test Firing. The vibrated canister was placed over the center line, 5 feet from the previously tested unit and oriented with the longitudinal axis 35 degrees from the center line. A NATO cartridge was placed in the chamber and both the escapement and automatic pins were pulled from the timer. The unit failed to operate because the timing cycle in the release mechanism was not completed. The screws attaching the adapter plate to the timer were loose. The timer was rewound and reset for the automatic mode of operation. The unit failed again because the top cover did not release, although the timing cycle had been completed. The unit was forced to function by test personnel to determine the effects of vibration upon coil erection. Results are given in Table IX.

Table IX. Data from Vibration Test

Reel	θ	L (ft)	H (in.)	Remarks
1	15	10.7	12.0	Coil axis curved 90 degrees.
2	10	9.0	12.0	Coil axis curved 90 degrees.
3	20	16.0	14.0	Coil axis curved 90 degrees.
4	40	16.5	14.0	Coil axis curved 90 degrees.
5	15	10.5	12.0	
6	5	13.3	11.0	
7	18	14.3	13.0	Coil axis curved 90 degrees.
8	38	19.3	13.0	Coil axis curved 90 degrees.

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

(10) Railroad Impact Test. One obstacle device was placed in a weather-resistant grade V3c corrugated fiberboard box with inside dimensions of 19-1/2 inches by 6-7/8 inches by 10-1/2 inches. This unit was placed in the bottom corner of a cleated plywood box, fabricated from 3/8-inch-thick plywood in accordance with Federal Specification PPP-V-601. The box construction was modified from the specification by the addition of two wooden bottom skids. Additional obstacle units were simulated by wooden mock-ups filled with sand to achieve the appropriate weight. The simulated obstacles were placed in the plywood box, with the packaged obstacle device, in three layers. Each layer consisted of two rows, each of which contained seven units. Each unit was oriented upright with the longitudinal axis parallel to the width of the plywood box. The plywood box was banded girth-wise in three places with 3/4-inch-wide flat steel strappings. The gross load of the plywood box was 1,475 pounds. The box was placed on a flat railroad car with its longitudinal axis parallel to the direction of travel and the end containing the obstacle device forward. The loaded railroad car collided with two stationary railroad cars at a velocity of 9.8 miles per hour. The front end of the box was broken from the impact. The obstacle device was unpackaged and inspected. No damage was revealed. The unit was activated without a NATO cartridge. The release mechanism functioned properly. Because of the absence of noticeable damage, this canister was not test fired in order to preserve it for future experimentation in the areas of poor performance that had been evidenced during the tests described in the preceding paragraphs.

(11) Jumble Plus Rain Test. One obstacle device was placed loose, upright, and unpackaged in the bed of a 3/4-ton truck. The truck was driven around a course consisting of the following surfaces: rough dirt road, 0.4 mile; cross-country, 0.? mile; gravel road, 0.6 mile; and black-top, 0.3 mile. The unit was inspected for damage at the point of each transition from one surface to another. One end cover became detached at the bottom after 39.8 miles of travel while the vehicle was on the gravel road. This end cover became completely disconnected after 61.1 miles of travel while the vehicle was on the gravel road. The canister was reassembled after 76.9 miles were recorded. The course was completed 86 times for a total distance of 153.7 miles. No additional damage was observed. The obstacle was then subjected to rainfall and was test fired in a fashion identical to that described in paragraph (7). The release mechanism functioned properly. However, slings 1, 2, 3, 4, 5, and 7 released at the bracket. Sling 6 broke at the bottom where it was

connected to the reel holder, and sling 8 broke at the top where it was connected to the bracket. Tape reels 5 and 6 erected, while the others remained coiled in the reel holders.

(12) High Temperature Test. One obstacle device with a NATO cartridge was placed in an environmental chamber with an ambient temperature of 165° F for 48 hours. The temperature was then reduced to 125° F for an additional 47 hours. The canister was removed from the chamber, transported to the test site, and actuated in a manner identical to that described in paragraph (5). The unit functioned properly, and results are listed in Table X.

Table X. Data from High Temperature Test

Reel	θ	L (ft)	H (in.)	Remarks
1	13	9.0	16.0	Coil axis curved [illegible] degrees.
2	5	15.7	14.0	Coil axis curved 90 degrees.
3	15	12.8	13.0	
4	36	16.9	12.0	
5	15	16.2	12.0	Coil axis curved 90 degrees.
6	3	9.8	13.0	Coil axis curved 100 degrees.
7	14	19.8	12.0	Coil axis curved 90 degrees.
8	30	18.9	14.0	Coil axis curved 60 degrees.

Legend: θ - angle between axis of coil and longitudinal axis of canister in degrees.
L - length of coil.
H - average height of coil.

b. Design Modification Tests. Analysis of the failures experienced during the first series of design tests as just described revealed the need for several design modifications. Details of this analysis are presented later in paragraph 9. The design changes included reducing the sling hardness to prevent yielding or fracture at the wire carrier bracket, doubling the number of reel holder hinge springs between the appropriate reel holders to guarantee displacement of the hammer sear, shortening the top cover release plates and altering the end cover base pan insert to prevent end cover detachment, increasing the length of the end cover sides to avoid premature release of the side plates, placing one unpunched coil of tape around each barbed tape reel assembly to eliminate binding between tape barbs and end covers, and redesigning the release mechanism/timer. Two obstacle devices were reassembled to contain each of the above modifications, and the following experiments were conducted.

(1) Low Temperature. One obstacle unit was placed in an environmental chamber with a dry bulb temperature of -25° F and a wet bulb temperature of -100° F. The unit was removed from the chamber after 24 hours, transported to the test site, and set for automatic operation in a manner identical to that described in paragraph 6a(5). The timer operated properly. However, the unit failed to function because of improper orientation of the automatic safety pin retainer. The retainer in this case served the same function as the automatic safety pin would have if it had not been removed, i.e., stopping the timer after the timing cycle so that the release mechanism was set for lanyard operation. The timer was rewound, and the unit was set for lanyard operation. The obstacle device functioned properly in this mode.

(2) Drop Test. The test site described in paragraph 6a(8) was used. One obstacle device was dropped on a top corner from a height of 2 feet with a 30-degree angle of incidence. No damage was detected. The obstacle was then dropped on a bottom corner from a 3-foot height with a 30-degree angle of incidence. The end cover base pan insert, adjacent to the insert above the corner of fall, released from the base pan. However, no functional damage was observed and no safety hazard existed as the end covers and side plates remained in place. The end cover base pan insert was replaced without disassembly of the obstacle, and the 3-foot bottom drop test was repeated with impact on the opposite end of the canister. The results were identical to those of the previous drop except that the base pan and base pan lid were crushed upward 3/4 inch by the impact. The unit was set for automatic operation and functioned properly 5 minutes and 5 seconds after removal of the safety pins.

(3) Release Mechanism. The obstacle devices, tested as described previously in paragraphs (1) and (2), were recovered for release mechanism testing. The units were completely reassembled with the exception of the barbed tape and top covers. The timers were cycled with the results indicated in Table XI. Trials 1, 15, and 27 were conducted at -25° F. Prior to trial 38, water, at the rate of 30 milliliters per second, was poured through timer 1 for 2 minutes and through timer 2 for 5 minutes.

Table XI. Data from Modified Release Mechanism Test

Trial	Actuation Time			
	Timer 1		Timer 2	
	Min	Sec	Min	Sec
1	5	10	5	30
2	5	10	5	30
3	5	10	Not tested	
4	4	45	5	5
5	5	3	5	3
6	5	31	6	10
7	5	1	5	1
8	5	1	5	3
9	5	1	5	3
10	4	26	5	3
11	4	58	6	3
12	4	42	4	55
13	5	4	5	4
14	5	[illegible]	5	4
15	5	15	4	50
16	5	43	5	31
17	5	27	5	12
18	5	17	5	5
19	5	10	5	8
20	5	11	5	3
21	5	0	5	1
22	5	13	5	12
23	5	16	5	6
24	5	10	5	5
25	5	21	5	6
26	5	19	5	4
27	5	5	4	57
28	5	39	5	29
29	5	24	5	14
30	5	7	5	11
31	5	30	5	10
32	5	24	5	9
33	5	23	5	10
34	5	23	5	10
35	5	24	5	10
36	5	21	5	11
37	5	24	5	10

Table XI (cont'd)

Trial	Actuation Time			
	Timer 1		Timer 2	
	Min	Sec	Min	Sec
38	5	31	6	41
39	5	37	7	0
40	5	39	5	49
41	5	34	5	44
42	5	29	5	46
43	5	34	5	40
44	5	36	5	38
45	5	33	5	37
46	5	26	5	36
47	5	31	5	36
48	5	30	5	35
49	5	31	5	33

III. DISCUSSION

7. Examination of Test Method. Unavoidable bias and limited sample size restricted the amount of information that could be derived from the tests. However, valid conclusions could be drawn, which satisfied the purposes of this study, when the following were recognized.

a. During the first phase of testing, delay times were recorded for the obstacle under a variety of conditions. Effectiveness, discussed in paragraph 8, was then evaluated by comparing the delay times for the obstacle to the delay times for triple standard concertina, determined from experiments completed and reported by ERDL in 1955. In several cases, during the barbed tape tests, personnel ripped themselves loose from entanglements without injury and thereby reduced delay times. This, however, would have been impossible if they had been without protective clothing. Furthermore, test personnel stated that they were willing to pass through the barbed tape much more quickly because they knew that the protective clothing would prevent injury. During the 1955 experiments, test personnel were not equipped with protective clothing. Therefore, the results of the comparisons were biased unfavorably against the obstacle device because of the reduction in the barbed tape delay times caused by neutralizing the casualty producing effect.

b. During the second phase of testing, 15 obstacle devices were available for evaluation. Because of the number of different tests scheduled, only limited repetition was accomplished. Therefore, positive identification of failures with specific environmental or rough handling conditions was not possible. However, detection of failures and application of corrective action was achieved.

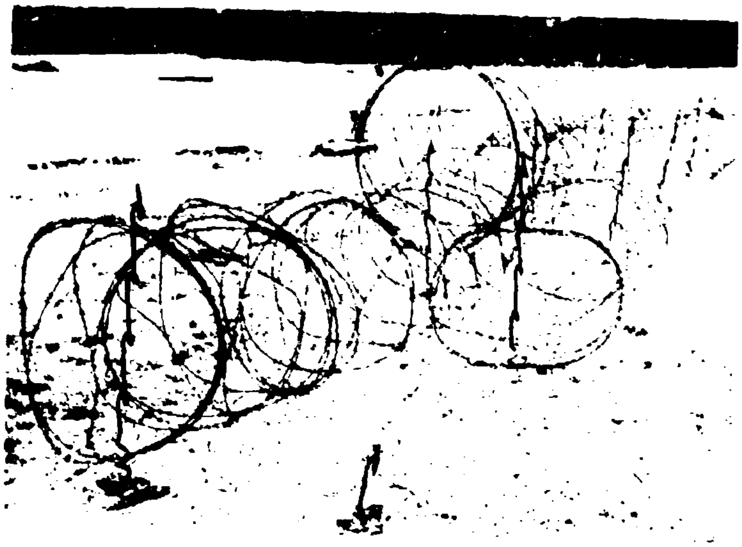
8. Obstacle Effectiveness. The barbed tape obstacle material, hand placed in the theoretical configuration that would be achieved by the obstacle erection device, was compared with triple standard concertina. Typical triple standard concertina and barbed tape obstacles are shown in Fig. 22. Experiments with concertina, completed in 1955, provided the following minimum delay time standards: Running upright, 11.8 seconds; crawling, 41 seconds; using breaching aid, 9 seconds. The breaching aid considered was a plank of wood placed under the concertina and raised up to facilitate crawling. Other breaching aids evaluated in the 1955 experiments made it possible for personnel to walk over the concertina. However, the delay times were so short that they were not recorded. No delay time standard could be located for concertina for the crouched position. Comparison of the test data with the accepted standards provided the following results.

a. Running Upright. The average delay time for barbed tape while personnel were running upright was 11.3 seconds. Although the results were slightly less than the minimum standard, 11.8 seconds, elimination of the bias (paragraph 7a) would have provided an acceptable delay time.

b. Crouching. Only one of the four men who remained in the crouched position passed through the barbed tape. The delay time in this case was 51 seconds. Although no crouch standard could be located, 51 seconds exceeded the greatest minimum standard used.

c. Crawling. None of the test personnel was able to penetrate the barbed tape to a depth greater than his body length. As the width of the obstacle was approximately 20 feet, pass-through in this mode was considered improbable. These results were more desirable than the minimum standard of 41 seconds.

d. Breaching Aids. The breaching aid material that was most successful in reducing the effectiveness of the barbed tape was the evergreen tree. The delay time in this case was 18 seconds. This time compared favorably with the 9-second minimum standard.



(A) F6234

(B) M12422

Fig. 22. Typical obstacles. (A) Triple standard concertina. (B) Rapidly Emplaced Antipersonnel Obstacle.

9. Analysis of Design. The first series of engineering design tests revealed several areas that required design modifications. As stated in paragraph 7b, it was not possible to identify the failures with specific environmental or rough handling conditions. Therefore, at the conclusion of the first series of engineering design tests, possible causes for each failure were examined. All possible corrections were reviewed, and modifications were economically performed by selecting the solutions that both applied to the greatest number of deficiencies and caused the smallest amount of change. The following are the subjects of failure, cause thereof, and corrective action taken.

a. Slings. Failure was experienced during the first control test, the drop test, and the jumble plus rain test. In all but one case, yielding or fracture occurred at the sharp bend in the sling where it was supported by the wire carrier bracket. Each failure could have been a result of fatigue experienced in the forming and assembling processes or caused by impact received during shipment and testing. A production error of not placing the end of the sling through the bracket hole properly could have allowed yielding, but not fracture. A satisfactory sling was arrived at by employing a softer steel wire of sufficient strength to endure the high stress concentration at the point of failure and ductile enough to relieve fatigue and simplify assembly.

b. Reel Holder Hinge Spring. The reel holder hinge springs failed to rotate reel holder No. 4 with sufficient force to displace the hammer sear and release the hammer during the first control test and the humidity plus freeze test. The cause of failure was not well defined as this component operated properly during the second control test, the humidity test, and the freeze test. Satisfactory performance was guaranteed by placing two springs between reel holders 3 and 4.

c. End Covers. The three problems encountered with the end covers were solved with four modifications:

(1) Detachment. End covers popped off the canister during the drop test and the jumble plus rain test. The end cover joints had not been designed with sufficient strength to retain this component upon application of impact to the canister. The following alterations were made:

(a) A right-angle section was added to the base pan insert at the bottom of the end cover.

(b) The top cover release plates were shortened to tighten the top cover latch with the end cover.

(2) Tape Barb Binding. During the vibration test, coils of tape on each reel slid over one another. This forced the barbs on the outside coils to catch on the end cover channel at the top cover latch and prevented release of the end cover. This deficiency was corrected by placing one coil of unpunched tape around the outside of each reel to prevent contact between the barbs and the end covers.

(3) Side Plate Release. During the drop test, the end covers bowed out and released the side plates. Recurrence was prevented by enlarging the sides of the end covers. This made the length of surface contact between the side plates and the end covers greater than the amount of end cover displacement caused by impact.

d. Packaging. The plywood box failure during the railroad impact test was caused by exceeding the 1000-pound load specification of the shipping container. Packaging will be accomplished with only two layers of obstacle devices for a total of 28 units per plywood box. The gross load will be approximately 950 pounds.

e. Release Mechanism. Failures were experienced in the release mechanism during the salt spray test, humidity test, low temperature test, humidity plus freeze test, and vibration test.

(1) Causes. Several deficiencies were detected. Failures could have been caused by any one, or a combination of any of the following:

(a) The timer lubricant employed was rated for satisfactory performance only above -10° F.

(b) The average timer output torque was 12.2 ounce-inches as determined by testing four timers. The output torque specified for the mechanism was 20 ounce-inches.

(c) Contact between the trip cam and either the release trigger or the release mechanism support plate and between the release cam and the intermediate plate may have produced sufficient frictional forces to stall the release mechanism during the timing cycle. No exterior force should have been applied to the timer during this cycle, as all of the output torque was required, by design, to drive the escapement mechanism. These frictional forces could have been caused either by misorientation of the timer shaft or by excessive design tolerances of the release mechanism components.

(2) Corrective Action. Both the release mechanism and the timer were redesigned.

(a) The intermediate plate, support plate, trip cam, and release cam were replaced by a bracket and a pin cam. This portion of the release mechanism was redesigned so that no exterior load would be placed on the timer during the timing cycle.

(b) New timers, designed to provide 20 ounce-inches of output torque under the required environmental conditions, were developed.

f. Carrying Handle. The carrying handle bail came loose from the retainer clip during normal handling of the obstacle. The handle bail was lengthened and a right angle turn was formed on each end to prevent the bail from slipping out of the handle retainer clip.

10. Reliability. Failure, for the purpose of this analysis, was defined as incomplete cycling of either the release mechanism or actuator assembly so that the reels of barbed tape were not ejected from the canister.

a. Obstacle Without Design Modifications. Twenty functional experiments were conducted on obstacle devices as delivered by the contractor. These tests resulted in 10 failures:

mission time = $t = 1$

failures = $r = 10$

confidence = $c = 90\%$

$\alpha = 1 - c = 10\%$

cumulative test time = $T = 20$

mean firings between failures = θ

reliability = R

$$\theta = \frac{2T}{\chi^2_{\alpha,\ 2(r+1)}}$$

$$= \frac{2\ (20)}{30.8}$$

θ = 1.3 mean firings between failures

$$R = e^{-t/\theta}$$

$$= e^{-1/1.3}$$

R = 46% (with 90% confidence)

b. Modified Obstacle Units. Two completely modified obstacle devices were tested without failure. A satisfactory statement of reliability could not be made because of the small sample size available for tests. The approach taken in this analysis was, therefore, to assign a value of 95 percent reliability to determine the confidence level of such a statement.

$$R = 95\%$$

$$r = 0$$

$$t = 1$$

$$T = 2$$

$$R = e^{-t/\theta}$$

$$\theta = \frac{t}{\ln\left(\frac{1}{R}\right)}$$

$$= \frac{1}{\ln(1/.95)}$$

θ = 19.5 mean firings between failures

$$\theta = \frac{2T}{\chi^2_{\alpha,\ 2(r+1)}}$$

$$= \frac{2T}{\theta}$$

$$= \frac{2(2)}{19.5}$$

$$\chi^2_{\alpha,\, 2} = 0.205$$

$$\alpha = 0.903$$

$$\underline{c = 9.7\% \text{ (with 95\% reliability)}}$$

c. Release Mechanism. The redesigned release mechanisms and timers were tested 100 times without failure. Because only two timers and release mechanisms were available for these tests, the following calculations reflect only the adequacy of the design. Production will affect the computed reliability statement. However, the influence of production can be controlled by quality assurance.

$$C = 90\%$$

$$\alpha = 10\%$$

$$T = 100$$

$$t = 1$$

$$r = 0$$

$$\theta = \frac{2\,T}{\chi^2_{\alpha,\, 2\,(r + 1)}}$$

$\theta = 43.4$ mean firings between failures

$R = e$ [illegible]

$$R = e^{-1/43.4}$$

$$\underline{R = 97.7\% \text{ (with 90\% confidence)}}$$

d. Interpretation of Results. The obstacles, as delivered by the contractor, were 46 percent reliable with 90 percent confidence. Only two obstacles with all modifications installed were available for tests. Therefore, a satisfactory statement of reliability could be made with only 9.7 percent confidence. However, with the exception of the timer/release mechanism, the causes of failure were simple to detect and easy to correct.

An acceptable degree of satisfaction is anticipated from these corrections. The doubtful area, prior to retest, was the timer/release mechanism. This assembly was tested to 97.7 percent reliability with 90 percent confidence. Therefore, the statement of 95 percent reliability for the modified obstacle device can be made with sufficient confidence to justify acceptance of the unit.

IV. CONCLUSIONS

11. Conclusions. It is concluded that:

a. The barbed tape material is more effective as an antipersonnel obstacle than triple standard concertina.

b. The modified obstacle device design provides satisfactory operating reliability within the environmental and rough handling conditions described in this test report.

c. The erected barbed tape pattern is not altered by the environmental conditions described in this test report.

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APPENDIX

AUTHORITY

RESEARCH AND TECHNOLOGY RESUMÉ	DA 0A 3667 — CSCRD-103
10 65 — U. U	N/A — NL — D Task Area
6.41.33.12.1 1M543312D46405	6.41.33.12.1 1D543312D46405
(U) Obstacle, Rapid Emplacement; Anti-Personnel	
Civil and Structural Engrg; Defense	N/A — 06 67 — N/A
N/A — Date 02 63 — DA-44-009 AMC 100(T) — Type CPFF — Amount 216,239	65 — 3.0 — 110
	66 — 2.7 — 145
U.S. Army Engineer Research and Development Laboratories Fort Belvoir, Virginia 22060	Performing Organization
Rinehart, Bernard F. 703 781-8500 X-62242	
Barrier Component, Steel Fabrication	Coordination: None

Keywords: Barriers; Denial; Barrier Systems; Barbed Tape

(U) Objective of Task: To develop a compactly packaged, barbed steel tape anti-personnel obstacle giving the forward area combat soldier a new capability of having close-in protection within minutes with 1/20th the effort and be as effective as the triple standard concertina.

(U) Plans for FY 67: Make partial (at present funding level) delivery of ET/ST models to TECOM. Provide technical assistance to TECOM during ET/ST. Complete final report.

(U) Plans for Future Years: Provide technical assistance to complete type classification of the item.

Mission Objective: CDOG 639 g(14)	Special Equipment: None
Est. Funds (in thousands): 10	

DD FORM 1498

FY 67-68 PROGRAM DATA SHEET

PROJECT OR TASK NO.: 1M543312D46405 | 37. CDOG Priority III

PROJECT OR TASK TITLE:

Obstacle, Rapid Emplacement: Anti-Personnel

38. FUNDING (In thousands)

TYPE	FY 66	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	COMPLETE
a. INHOUSE AMC	73 (50)	10						
b. CONTRACTUAL	72							
c. OTHER								
d. TOTAL	145 (50)	10						

39. PLANNED PROCUREMENT, DELIVERY, & TEST OF TEST ITEMS

TYPE TEST	PROCUREMENT FY	PROCUREMENT COST	PROCUREMENT QTY	TEST FY	TEST SITE	TEST COST	TEST QTY	TEST SYM	DEL'Y TO SITE	START TEST	COMPLETE TEST	SUBMIT REPORT	NOTES
Engrg/Svc	66	72	75	66	ERDL	1	5	R/D Accep	4Q66	4Q66	4Q66	- -	
					APG	(50)	70	ET	4Q66	4Q66	1Q67	2Q67	1.
Engrg/Svc	66	110	271	66	ERDL	1	5	R/D Accep	4Q66	4Q66	4Q66	- -	
					APG	(50)	70	ET	4Q66	4Q66	1Q67	2Q67	2.
					INFB		126	ST	1Q67	1Q67	2Q67	3Q67	
					ESWB		20	Air Drop	1Q67	1Q67	2Q67	2Q67	
					TTC		25	STT	1Q67	1Q67	2Q67	2Q67	
					ATC		25	STA	1Q67	2Q67	3Q67	3Q67	

Note 1. At present funding level.
2. Quantity required by TECOM for complete test.

40. CMD, IND LAB, OR PROJ. MGR SUBMITTING TO AMC: U.S. Army Mobility Equipment Ctr | DATE PREPARED: 15 October 1965

Page 2 of 3 Pages

FY 67-68 PROGRAM DATA SHEET

PROJECT OR TASK NO.: 1M543312D46405

PROJECT OR TASK TITLE: Obstacle, Rapid Emplacement: Anti-Personnel

41. Present Status and Planned Action FY 66:

Under contract DA-44-009 AMC 300(T), EDT models are scheduled for delivery 1 Nov 65. Engineering Design Tests will be performed in November 65 and an In-Process Review is scheduled in Dec 65. Upon favorable action from the IPR, the quantity for ET/ST will be procured by contract. Present funding level for FY 66 will provide only 75 devices for ET/ST whereas TECOM requires 271 devices. Delivery of the ET/ST device is scheduled for 4Q66 and 1Q67. The planned contract is as follows:

Item	Amount
75 ET/ST devices	$ 72,000

42. Planned Action for FY 67:

Complete delivery of ET/ST items and provide technical assistance to testing agency and prepare the final report draft for the Obstacle, Rapid Emplacement, A. P. will provide the forward area combat soldier with the capability of having an A. P. obstacle in minutes and with 1/20th the effort now required for barbed wire obstacles. If emplaced for trip wire or lanyard operation, it can be made safe to move to another location with little effort and a short time. It is compactly packaged and easier to handle and transport than the concertina. Assuming that it will not be expanded more than 50% of the time, cost of logistical support will be decreased 40 to 45%. No contracts are planned for FY 67. It will be capable of normal rough handling, will function under adverse climatic conditions and can be air dropped in phase I when palletized for such an operation. It will not replace current A. P. obstacle materials for general use. No maintenance is required and live items will be used for training. The standard NATO rifle cartridge is employed to obtain energy for expansion and is the only additional item required for use of the obstacle units.

43. Planned Action for FY 68:

Provide technical assistance for type classification.

44. Objectives for Technology:

Not applicable.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

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

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE RAPIDLY EMPLACED ANTIPERSONNEL OBSTACLE	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Interim Report June 1964 - March 1966	
5. AUTHOR(S) (Last name, first name, initial) Stanley, Arthur T.	
6. REPORT DATE May 1966	7a. TOTAL NO. OF PAGES 66 / 7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This report covers an investigation of the Rapidly Emplaced Antipersonnel Obstacle to evaluate obstacle effectiveness and design adequacy. Report concludes:

a. The barbed tape material is more effective as an antipersonnel obstacle than triple standard concertina.

b. The modified obstacle device design provides satisfactory operating reliability within the environmental and rough handling conditions described in this test report.

c. The erected barbed tape pattern is not altered by the environmental conditions described in this test report.

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Delay time						
Release mechanism						
Actuator assembly						
Barbed Tape						
Coil axis						
Coil length						
Coil height						
Automatic operation						
Lanyard operation						

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