# AD 278 585

QMFCIAF REPORT NR. 8-62

# DESIGN OF LOAD CONFIGURATIONS FOR THE M-4A HIGH SPEED AERIAL DELIVERY CONTAINER XI

## Load Configurations for Individual Combat Meals, Training Grenades (inert), and Carbines and Ammunition





Interim Report
March 1962

QUARTERMASTER FOOD AND CONTAINER INSTITUTE FOR THE ARMED FORCES
QUARTERMASTER RESEARCH AND ENGINEERING COMMAND, U.S. ARMY
CHICAGO 9, ILLINOIS

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QM Food & Container Institute for the Armed Forces, QM Research & Engineering Command, U. S. Army, Chicago 9, QMFCIAF Rpt. No. 8-62

Date Mar. 1962 Proj. No 7-87-03-004

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Design of Load Configurations for the M-4A High Speed Aerial Delivery Container XI. Load Configurations for Individual Combat Meals, Training Grenades (inert), and Carbines and Ammunition. by E.H. Schembor and A.S. Young

An analysis was made of the loading configurations in the M-4A High Speed Aerial

Primary Field: Aerial Delivery

Secondary Field(s): Aerial Delivery Containers

1. Airdrop
2. Containers

I. Schembor, E.H.

II. Young, A.S.

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QMFCIAF Report Nr. 8-62
Technical Report Nr. 227

**PROJECT:** Aerial Delivery Equipment 7-87-03-004

**SUBPROJECT:** Methods and Equipment Supporting Aerial Delivery Operations

**SUBTASK:** Determination of shock ratings, packaging, packing and preservation methods and techniques required for the aerial delivery of specific Army supplies.

**WORKPHASE:** Determination of the maximum allowable shock ratings for rations, inert small arms ammunition, and medical supplies that can be packaged within the cargo compartment of the Marine Corps M-4A container.

**PROBLEM:** Preparation and evaluation of load configurations and impact energy dissipating systems to be used in the M-4A container.

# Design of Load Configurations for The M-4A High Speed Aerial Delivery Container XI

## Load Configurations for Individual Combat Meals, Training Grenades (inert), and Carbines and Ammunition

by
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Container Division

Interim Report
March 1962

Quartermaster Food and Container Institute for the Armed Forces

ABSTRACT

An analysis was made of the loading configurations of three separate loads in the M-4A High Speed Aerial Delivery container. The loads were: (1) Individual Combat Meals; (2) Inert hand grenades; (3) Carbines and ammunition.

Factors considered in this analysis were resistance to damage, space utilization, ease of loading, and ease of distribution.

Shock ratings were determined for the rations to predict the resistance of two load designs to the impact forces developed. The first load configuration of 144 intermediate cartons sustained impact forces at velocities up to 35 feet per second. The second load configuration of 108 intermediate cartons sustained impact forces at velocities up to 53 feet per second.

A load configuration of six cases of inert hand grenades was dropped at an impact velocity of 35 feet per second. With the addition of cushioning material, the same load was dropped at 49.5 feet per second, but was not found to be capable of withstanding the impact forces.

A load consisting of five caliber 30 M-1 carbines and nine boxes of caliber 30 ammunition was dropped twice to obtain resulting impact velocities of 35 and 49.5 feet per second. No significant damage occurred.

A prediction of the reactions of the loads to the impact forces developed was determined with the aid of the dynamic characteristic curves of the M-4A nose cone. Free-fall drop tests were then made to verify the predicted performance.

# DESIGN OF LOAD CONFIGURATIONS FOR THE M-4A HIGH SPEED AERIAL DELIVERY CONTAINER XI

## Load Configurations for Individual Combat Meals, Training Grenades (inert), and Carbines and Ammunition

## INTRODUCTION

The Quartermaster Food and Container Institute for the Armed Forces has been assigned the project of developing load configurations for the M-4A High Speed Aerial Delivery Container described in Appendix A. As part of the project, this study was conducted to design and evaluate load configurations for the Individual Combat Meal, Hand Grenades (inert), and Caliber 30, M-1 Carbines and Ammunition. The primary objective was to develop a load configuration which would not be damaged when dropped at the operational descent velocity of 35 feet per second. This descent velocity is based on a Psychological Warfare Board report[1/] which sets forth the military characteristics for a high speed aerial delivery container. A secondary objective was the acquiring of information on the feasibility of dropping at velocities higher than 35 feet per second.

### Materials, Equipment and Instrumentation

A laboratory "drop rig" was used in making shock-rating determinations. This test apparatus (Figure 1) consists of a 136 pound drop weight which can be released from heights up to 12 feet. The drop weight is guided in its fall by means of guide wires located on either side of the weight.

1. Psychological Warefare Center, Ft. Bragg, N.C., "Military Characteristics for a High Speed Aerial Delivery Container," 12 October 1955.

The transducers used in measuring the shock ratings and impact force values were Statham accelerometers (25 to 100 G ranges). The voltage pulse developed at impact by an accelerometer was converted into a visible acceleration-time pulse on the screen of the Tektronix oscilloscope, type 507. By means of a Polaroid Land Camera, a photographic record was made of the acceleration-time pulse.

The "elevator" drop-shaft used in the simulated airdrops of the M-4A container consists of a guide bar from which the load is suspended (Figures 5 and 6). The elevator car is used as a lift device and the elevator rails as the guide bar runners. An electrically actuated bomb release is attached to the bottom of the elevator. The impact surface is a concrete pad (Figure 7).

The supply items used in the load configurations consisted of the following:

1. Individual Combat Meals. Each case contains 12 intermediate cartons, each of which contains three cans of rations and one accessory pack. These rations, representing the latest pack design, were packed in March 1961.

2. Inert Hand Grenades. These training type grenades are hollow, cast metal replicas of "live" grenades. The grenades, packed 24 to a nailed wood case, were separated by means of a wood partition (Figure 2).

3. Carbines and Ammunition. The caliber 30 carbines were of the M-1 type. The caliber 30 carbine ball ammunition was packed in metal cans, two cans per nailed wood case.

The paper honeycomb cushioning material used in the load system for individual combat meals was Type UB-5, manufactured by the Union Bag-Camp Paper Corporation. It was of one-inch cell size and had a constant dynamic force level of 2,580 pounds per square foot. The paper honeycomb used for cushioning the hand grenade load was type UB-1 with a cell size of 3/4 inch, and a constant dynamic force level of 5,400 pounds per square foot. Paper honeycomb was also used for dunnage where needed. Styrofoam was used principally for supporting the M-1 carbines. But since the carbines were resting on the styrofoam, there was also a cushioning effect.

Procedure

Initial investigations indicated that greatest space utilization could be achieved by discarding the exterior Individual Combat Meal case and using just the intermediate cartons in the load. A shock rating was determined for the intermediate carton along its top-to-bottom principal axis since the cartons were to be stacked in the M-4A container with the top-to-bottom axis parallel to the longitudinal axis of the container.

The shock ratings of the packages are determined by dropping the cartons on specific areas of honeycomb. Since the dynamic force per unit area required to crush the honeycomb is known, the maximum area of honeycomb that can be used to absorb the impact shock without causing damage to the carton can then be used to determine the shock rating of the carton. Without the cushioning effect of the honeycomb, the force level would be difficult to obtain since the effect of the honeycomb is to elongate the pulse base making it readable on the oscilloscope.

Determination of dynamic shock ratings require destructive testing. Because of the limited quantity of hand grenades and ammunition cases available, dynamic shock rating tests were not made.

The dynamic shock rating of the intermediate carton was determined with the laboratory drop rig. The carton was attached to the under surface of the guide bar (Figure 1). Paper honeycomb was attached to the bottom of the ration carton.

The intermediate cartons were loaded while the M-4A container was in a horizontal position. For the load system designed for an impact velocity of 35 feet per second, 144 cartons were arranged in 12 layers of 12 cartons each (Figure 4). Paper honeycomb was used as dunnage to fill the remaining void space at the rear of the cargo compartment. For the higher impact velocity of 53 feet per second, the load consisted of 108 cartons arranged in nine layers of 12 cartons each and utilized six inches of the 16 inch diameter paper honeycomb, type UB-5, for cushioning the load. Paper honeycomb was used for dunnage in the remaining void space at the rear of the cargo compartment.

After each drop, the rations were examined for damage. The damaged rations were replaced for the next drop.

For the hand grenades, a load configuration of six cases was used (Figure 4). At an impact velocity of 35 feet per second, no cushioning material was required. At an impact velocity of 49.5 feet per second, six inches of 17 inch diameter paper honeycomb was used. A plywood separator was placed between the two layers of cases for even distribution of impact forces.

The caliber 30, M-1 carbine and ammunition load, consisted of two sections (Figures 3 and 4). The upper section was comprised of five weapons mounted parallel to the container, butt down. Styrofoam disks, 17 inches in diameter, with appropriate cut-outs held the rifles in place. The load configuration of the carbines will actually hold a total of 11 pieces. However, only five carbines were available for this study. An additional three inches of styrofoam were placed at the bottom of the load to offer more cushioning.

The lower section consisted of three layers of three boxes each of caliber .30 carbine cartridges. This section was separated from the upper section by a plywood load spreader. The same load configuration was used for impact velocities of 35 feet per second and 49 feet per second. No additional cushioning material was used for the drop made at an impact velocity of 49 feet per second.

Before making any test drops in the elevator shaft, the dynamic characteristics of the M-4A nose cone, expressed in the form of force-displacement and displacement-energy curves (Figures 8 and 9), were used to determine whether the load configurations described above could be dropped at the specified descent velocity without the need for any additional shock absorbing protection. Calculations for these determinations are shown in the attached Appendices.

After each drop, the nose cone displacement was found by taking the average of measurements at eight equally spaced points around the top rim of the nose cone.

## Results

The intermediate carton of the Individual Combat Meal was found to have a shock rating of 310 pounds in a direction parallel to its top-to-bottom axis. In the drop tests, minor damage occurred to the rations located in the bottom layers. The majority of damage was in the form of dents, 1/16 to 1/8 inch in depth.

The hand grenades suffered no damage in either drop, but at the higher velocity impact, the wooden compartments within the cases were broken in several places.

The caliber 30 M-1 carbines were not damaged by either impact velocity, but all rifles were cocked by the impact. The caliber 30 carbine ammunition carrying cases received very slight dents and only at the higher impact velocities. The results of the tests are presented in Table 1.

## Discussion

Damage to the ration laod was negligible. Though the force on the bottom layer of rations was twice the shock rating, insignificant damage resulted, perhaps because substantial energy is absorbed by the deflection and buckling of the intermediate cartons. Another explanation could be the difference in the pulse shape obtained in the "shock" rating determination and the pulse shape encountered in the M-4A drop tests.

Because of the breakage of the interior compartments in the hand grenade case the load system for the hand grenade was not considered suitable for higher velocity drops. Damage to the interior compartments might result in the impacting of one grenade against another.

The impact surfaces in this study probably represent the most severe conditions that would be encountered in actual field operations. In comparison with the usual soil conditions, the concrete test pad absorbs very little of the impact energy (Figure 7).

Conclusions

The three different load configurations developed in this study were found to be capable of withstanding forces due to impact velocities of 35 feet per second without the need for additional energy absorbers. By using cushioning material in the manner described, the load configurations of the rations and carbines with ammunition are capable of withstanding higher impact velocities.

## APPENDIX A

### Description of the M-4A High Speed Aerial Delivery Container

The M-4A high speed aerial delivery container (see photograph) developed by the Marine Corps, is used for resupply of troops in emergency situations where supply is impossible by any other means. The container is aerodynamically designed to be carried under the wings of fighter bombers and tactical aircraft traveling at speeds up to 660 miles per hour. It can be released from the plane at speeds of 450 miles per hour. After the M-4A container is dropped from the aircraft, a parachute is deployed which lowers it to the ground. The energy of impact is absorbed by the crushing of the nose cone.

The M-4A aerial delivery container is made of aluminum. Its length, including the nose and tail cone, is 109-3/4 inches. The inside dimensions of the cargo compartment; diameter of 21 inches, length of 61 inches. Total weight of the container is 110 pounds. The nose and tail cone, which are identical, have a base diameter of 21 inches and a height of 20-5/8 inches. A cross section of the cone, obtained by a plane passing through its longitudinal axis, gives a parabola of equation $y^2 = 6.8x$, where

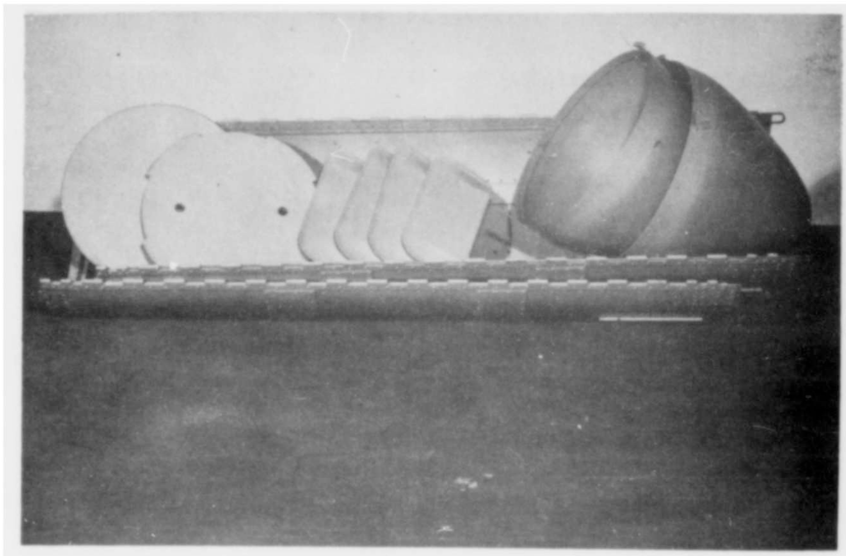
$x$ = the distance from tip of nose cone to a point on its longitudinal axis.
$y$ = radius of nose cone at a point on its longitudinal axis.

The force-displacement and displacement-energy characteristics of the nose cones are presented in the graph shown below.

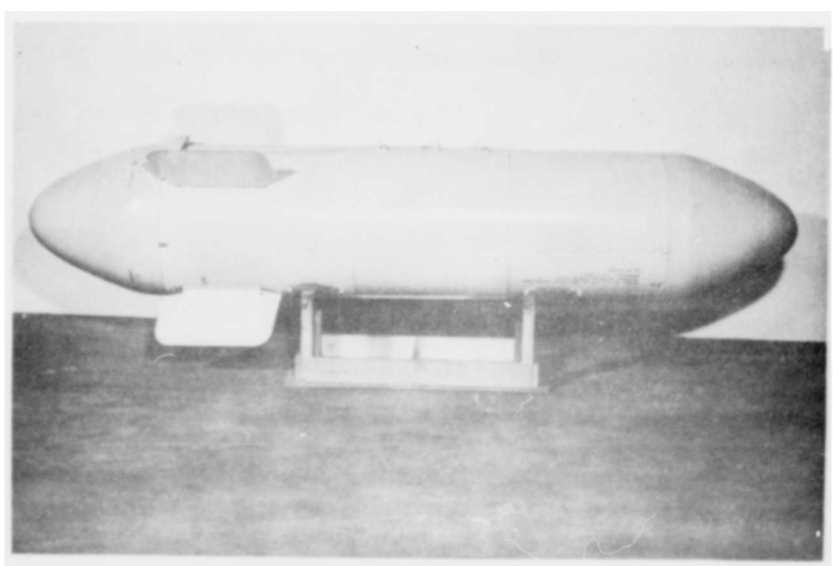
The body of the M-4A container is made of two longitudinal sections connected with a piano hinge and rod. Four carrying straps are provided. Four removalbe aluminum fins are located on the aft end of the container. Forward and aft plywood bulkheads fit into slotted sections of angle aluminum.

## Appendix A

A recessed area in the aft section of the cargo compartment provides for stowage of the parachute. A release cable simultaneously releases the tail cone and the pilot parachute.



The M-4A High Speed Aerial Delivery Container Unassembled



The M-4A High Speed Aerial Delivery Container Assembled

## APPENDIX B

### Predicted Performance of the M-4A Container Individual Combat Meal Load (144 Intermediate Cartons) Low Velocity

Following is the known information concerning the system:

| | |
|---|---|
| Weight of M-4A container- ---------------- | 104.5 pounds |
| Weight of intermediate cartons------------ | 252 pounds |
| Total weight of system-------------------- | 356.5 pounds |
| Impact velocity--------------------------- | 35 feet per second |
| Shock rating of intermediate carton (top to bottom axis)------------------------------ | 310 pounds |

The kinetic energy of the system at impact can be found from the following expression:

$$K.\ E. = \left(\tfrac{1}{2}\right)\left(\frac{W}{g}\right) V^2$$

W = total weight of system in pounds

V = velocity of system at impact in feet per second

g = acceleration due to gravity (32.2 feet per $second^2$)

$$K.\ E. = \frac{356.5 \times (35)^2}{2 \times 32.2}$$

K. E. = 6800 foot pounds

From the graph of the displacement-energy curve (Figure 8) of the M-4A container nose cone, the displacement for the energy value calculated above would be 14.7 inches. The force required for this displacement can be found by referring to the displacement-force curve (Figure 9). The force would be 12,500 pounds.

The maximum "G" value acting on the system can be found from Newton's Second Law of Motion:

$F = W\ G$

F = maximum force in pounds

W = total weight of system in pounds

G = the maximum deceleration expressed in multiples of the acceleration due to gravity

$G = F/W$

$$G = \frac{12,500}{356.5} = 35 \text{ g's}$$

Assuming the system to be rigid throughout except for the nose cone, the "G" value calculated above will be the same for every point in the system. However, the forces acting throughout the system will depend on the weight distribution. The forces acting on the intermediate carton in the bottom layer can be calculated from the expression:

$F = W\ G$

W = weight of intermediate cartons in one column of the load = 19.25 pounds

G = maximum deceleration expressed in multiples of acceleration due to gravity = 35 g's

$F = (19.25)\ (35) = 674$ pounds

Since the calculated force of 674 pounds is more than twice the intermediate carton shock rating, it is expected that the load will be damaged when dropped.

## APPENDIX C

### Maximum Permissible Drop Velocity for Load Configuration of Individual Combat Meal (108 Intermediate Cartons - 9 Layers)

In using paper honeycomb for increasing the drop velocity of the system, two factors had to be considered. First, it was necessary that the thickness of the paper honeycomb pad be such that it did not shift the center of gravity of the load to a point aft of the geometric center of the cargo compartment. This was a precaution to prevent aerodynamic instability. Second, the peak force required to start the crushing of the paper honeycomb must not be higher than that developed at the impact end of the items tested, when the nose cone is crushed to a point just short of bottoming. If the paper honeycomb peak force is much higher than this, the honeycomb will not begin to crush and absorb energy until large bottoming forces have been developed.

Following is the known information concerning the system:

| | |
|---|---|
| Weight of the M-4A------------------------- | 104.5 pounds |
| Weight of 108 cartons---------------------- | 189.0 pounds |
| Total weight of system--------------------- | 293.5 pounds |
| Shock rating of carton--------------------- | 310.0 pounds |

Maximum force on paper honeycomb cushioning material is:

F = N x S

where N = number of cartons in bottom layer

S = shock level of a carton, in pounds force

F = 12 x 310 = 3,720 pounds

The area of honeycomb needed is:

$$A = \frac{F}{F_L}$$

where $A$ = area in square feet

$F$ = maximum force on paper honeycomb, in pounds

$F_L$ = force level of paper honeycomb in pounds per square feet

$$A = \frac{3,720}{2,580}$$

$$A = 1.44 \text{ square feet}$$

The energy absorbed by the paper honeycomb is:

$$E = F \times T \times f$$

where $E$ = the energy absorbed in foot-pounds

$F$ = maximum force on honeycomb in pounds

$T$ = the thickness of the honeycomb in feet (0.5 feet are used to maintain the center of gravity requirements)

$f$ = paper honeycomb efficiency factor

$$E = 3,720 \times \frac{6}{12} \times \frac{3}{4}$$

$$E = 1395 \text{ foot-pounds}$$

The total energy absorbed at impact is:

$$K.E. = E + En$$

where $K.E.$ = the total energy of impact in foot-pounds (also the kinetic energy at impact)

$E$ = the energy absorbed by the honeycomb in foot-pounds

$En$ = the energy absorbed by the nose cone (under bottoming conditions) in foot-pounds

$$K.E. = 1395 + 11,700$$

$$K.E. = 13,095 \text{ foot-pounds}$$

The height from which the container is dropped is:

$$K.E. = P.E. = W \times h$$

$$h = \frac{P.E.}{W} = \frac{K.E.}{W}$$

where $h$ = the drop height, in feet

$W$ = the total weight of the system in pounds

$K.E.$ = the kinetic energy of the system equal to $P.E.$

$P.E.$ = the potential energy of the system in foot-pounds

$$h = \frac{13095}{293.5}$$

$$h = 44.6 \text{ feet}$$

The velocity at impact is:

$$V = (2gh)^{\frac{1}{2}}$$

where $V$ = feet per second

$g$ = acceleration due to gravity (32.2 feet per second)$^2$

$h$ = drop height in feet

$$V = (2 \times 32.2 \times 45)^{\frac{1}{2}}$$

$$V = 53.7 \text{ feet per second}$$

## APPENDIX D

Predicted performance of the M-4A container load

(Six cases of inert hand grenades - low velocity drop)

Following is the known information concerning the system:

| | |
|---|---|
| weight of the M-4A container--------------- | 104.5 pounds |
| weight of six cases------------------------ | 288 pounds |
| total weight of system--------------------- | 392.5 pounds |
| impact velocity---------------------------- | 35 feet per second |

The kinetic energy of the system at impact is:

$$K.E. = \frac{1}{2}\left(\frac{W}{g}\right)V^2$$

W = the total weight of the system in pounds

g = the acceleration due to gravity (32.2 feet per second)$^2$

V = the impact velocity of the system in feet per second

$$K.E. = \frac{1}{2} \times \frac{392.5}{32.2} \times (35)^2 = 7{,}450 \text{ foot-pounds}$$

From the graph of the displacement-energy curve (Figure 8) of the M-4A container nose cone, the displacement for the energy value calculated above would be 15.3 inches. The force required for this displacement can be found by referring to the force-displacement curve (Figure 9). The force would be 14,000 pounds.

The maximum "G" value acting on the system can be found from the expression:

$F = W G$

$W$ = the total weight of the system in pounds

$G$ = the deceleration expressed in multiples of gravity

$F$ = the force required for the displacement of the nose cone in pounds

$$G = \frac{F}{W} = \frac{14,000}{392.5} = 35.7 \text{ g's}$$

The force acting on a case in the bottom would be:

$F = w G$

$w$ = the weight of one case in pounds

$F = 48 \times 35.5 = 1730$ pounds

# APPENDIX E

The predicted performance of the M-4A container load

(Six cases of inert hand grenades - high velocity drop)

Following is the known information concerning the system:

weight of the M-4A container------------------104.5 pounds

weight of the six cases----------------------288 pounds

total weight of the system-------------------392.5 pounds

The energy absorbed by the nose cone under bottoming conditions is 11,700 foot-pounds.

The energy necessary to crush 4.5 inches of a paper honeycomb that has a force level of 5,400 pounds per square feet and a diameter of 17 inches is:

$$E = F_L \times A \times \frac{t}{12}$$

$F_L$ = force level of honeycomb, pounds per square foot

$A$ = area of honeycomb in square feet

$t$ = thickness of honeycomb in inches

$$E = 5{,}400 \times 1.57 \times \frac{4.5}{12} = 3{,}180 \text{ pounds}$$

Six inches of paper honeycomb were used to provide a safety factor.

The total allowable energy of impact for the system is:

$$K.E. = En + E$$

$$K.E. = 11{,}700 + 3{,}180 = 14{,}880 \text{ foot-pounds}$$

The maximum velocity of impact for the system is:

$$V = \left[2\ K.E.\left(\frac{g}{W}\right)\right]^{\frac{1}{2}}$$

K.E. = the total energy of impact of the system in foot-pounds

g = the acceleration due to gravity (feet per second)$^2$

W = the total weight of the system in pounds

$$V = \left[(2)\ (14{,}880)\ \left(\frac{32.2}{392.5}\right)\right]^{\frac{1}{2}} = 49.5 \text{ feet per second}$$

The force required for the bottoming of the M-4A nose cone can be found from the force-displacement curve (Figure 9). The force would be 16,200 pounds.

The maximum "G" value acting on the system can be found from:

$$G = \frac{F}{W}$$

G = the deceleration of the system expressed in multiples of the acceleration of gravity

F = the maximum force acting on the system at impact in pounds

W = the total of the system in pounds

$$G = \frac{16{,}000}{392.5} = 41.3 \text{ g's}$$

The force acting on a case in the bottom layer is:

$$F_c = wG$$

$F_c$ = the force on a bottom case in pounds

w = the weight of one case in pounds

$$F_c = 48 \times 41.5 = 1{,}980 \text{ pounds}$$

## APPENDIX F

Predicted performance of the M-4A container caliber 30, M1 carbines, and ammunition load

(Five carbines in the top layers, nine cases of ammunition in the bottom three layers)

Following is the known information concerning the system:

| | |
|---|---|
| weight of the M-4A container | 104.5 pounds |
| weight of the five carbines | 28.75 pounds |
| weight of the ammunition | 186.75 pounds |
| total weight of the system | 320 pounds |
| the impact velocity | 35 feet per second |

The kinetic energy of the system can be found from the following expression:

$$K.E. = \frac{1}{2}\left(\frac{W}{g}\right)V^2$$

W = the total weight of the system in pounds

g = the acceleration of gravity in $(\text{feet per second})^2$

V = the velocity at impact in feet per second

$$K.E. = \frac{1}{2} \times \frac{320}{32.2} \times 35^2 = 6{,}100 \text{ foot-pounds}$$

From the graph of the displacement-energy curve (Figure 8) of the M-4A container nose cone, the displacement for the energy calculated above would be 14 inches. The force required for this displacement can be found by referring to the displacement-force curve (Figure 9). The force would be 11,000 pounds.

The maximum "G" value acting on the system can be found from Newton's Second Law of Motion:

$F = W\,G$

$G = F/W$

$F$ = the maximum force acting on the system in pounds

$W$ = the total weight of the system in pounds

$G$ = the deceleration of the system expressed in multiples of the acceleration of gravity

$G = 11{,}000/320 = 34.4$ g's

The force acting on one case of ammunition in the bottom layer is:

$$F_c = \frac{W}{3} \times G$$

$F_c$ = the force on one case in pounds

$W$ = the total weight above the bottom layer of ammunition in pounds

$$F_c = \frac{153.25}{3} \times 34.4 = 1{,}758 \text{ pounds}$$

## APPENDIX G

Evaluation of the maximum velocity of impact for the M-4A container, caliber 30, M1 carbines and ammunition

(Five carbines in the top layer, nine cases of ammunition in the bottom layer)

Following is the known information concerning the system:

weight of the M-4A container----------------- 104.5 pounds

weight of five carbines---------------------- 28.75 pounds

weight of nine ammunition cases-------------- 186.75 pounds

total weight of system----------------------- 320 pounds

The maximum energy that is absorbed upon bottoming of the nose cone can be found by extrapolation of the displacement-energy curve (Figure 8). This energy is:

$$K.E. = 11{,}700 \text{ foot-pounds}$$

The velocity needed to obtain this energy can be found from:

$$K.E. = \frac{1}{2}\left(\frac{W}{g}\right)V^2$$

$$V = \left[(2\ K.E.)\left(\frac{g}{W}\right)\right]^{\frac{1}{2}}$$

g = the acceleration due to gravity (feet per second$^2$)

W = the total weight of the system in pounds

$$V = (2 \times 11{,}700 \times 32.2/320)^{\frac{1}{2}} = 48.6 \text{ feet per second}$$

From the displacement-force curves (Figure 9), the force produced by bottoming of the nose cone is:

$$F = 16{,}200 \text{ pounds}$$

The maximum "G" value encountered is:

$G = F/W$

$G$ = the deceleration of the system expressed in multiples of the acceleration of gravity

$F$ = the maximum force at impact in pounds

$W$ = the total weight of the system in pounds

$G = 16,200/320 = 50.6$ g's

The force on one ammunition case in the bottom layer is:

$$F_c = \left(\frac{w}{3}\right) G$$

$w$ = the weight of the load above the bottom layer in pounds

$G$ = the deceleration of the system expressed in multiples of the acceleration of gravity

$$F_c = \frac{153.25}{3} \times 50.6 = 2,580 \text{ pounds}$$

## TABLE 1

### Results of the Drops of Three Loads (with the M-4A Nose Cone)

| Load Description | Velocity | Crush | Damage |
|---|---|---|---|
| 1) Intermediate Individual Combat Rations | | | |
| a) 12 layers of 12 cartons, stacked upright | 35 f.p.s | | 3 spoons broken<br>7 cans crimped<br>13 cans dented |
| b) 9 layers of 12 cartons, stacked upright | 53.7 f.p.s. | 15.4 inches | 2 spoons broken<br>1 can crimped<br>5 cans dented |
| 2) Hand Grenades | | | |
| a) 2 layers, 3 cases each, stacked on end | 35 f.p.s | | |
| b) 2 layers, 3 cases each, stacked on end | 49.5 f.p.s. | 18.3 inches | compartments broken in bottom layer |
| 3) Caliber 30, M1 Carbines and Ammunition | | | |
| a) 5 carbines, 9 cases of ammunition | 35 f.p.s. | 14.875 inches | |
| b) 5 carbines, 9 cases of ammunition | 48.6 f.p.s. | 18.825 inches | slight dent in bottom ammunition case |

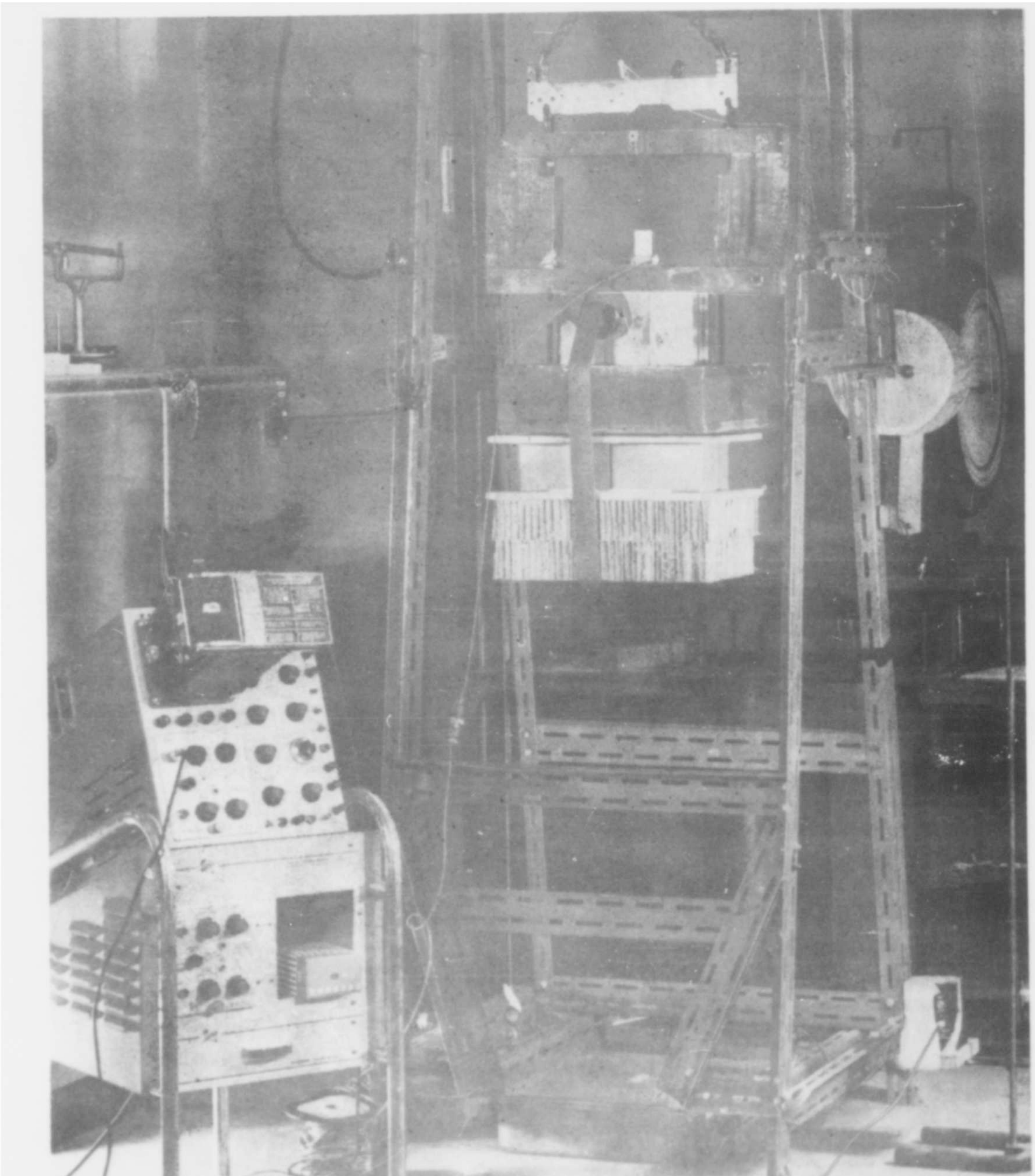


Figure 1. Laboratory "Drop Rig" used in determining shock ratings of loads

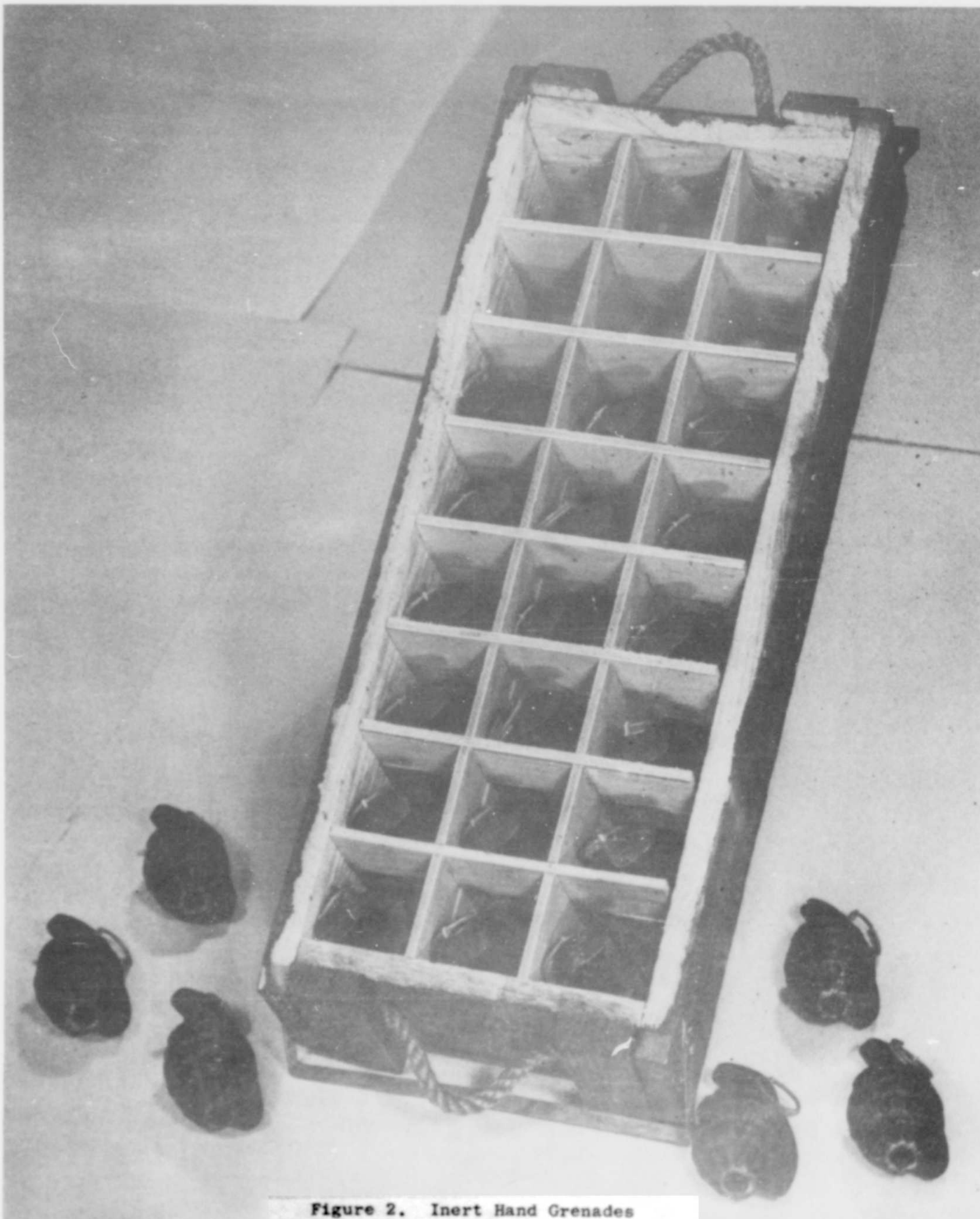
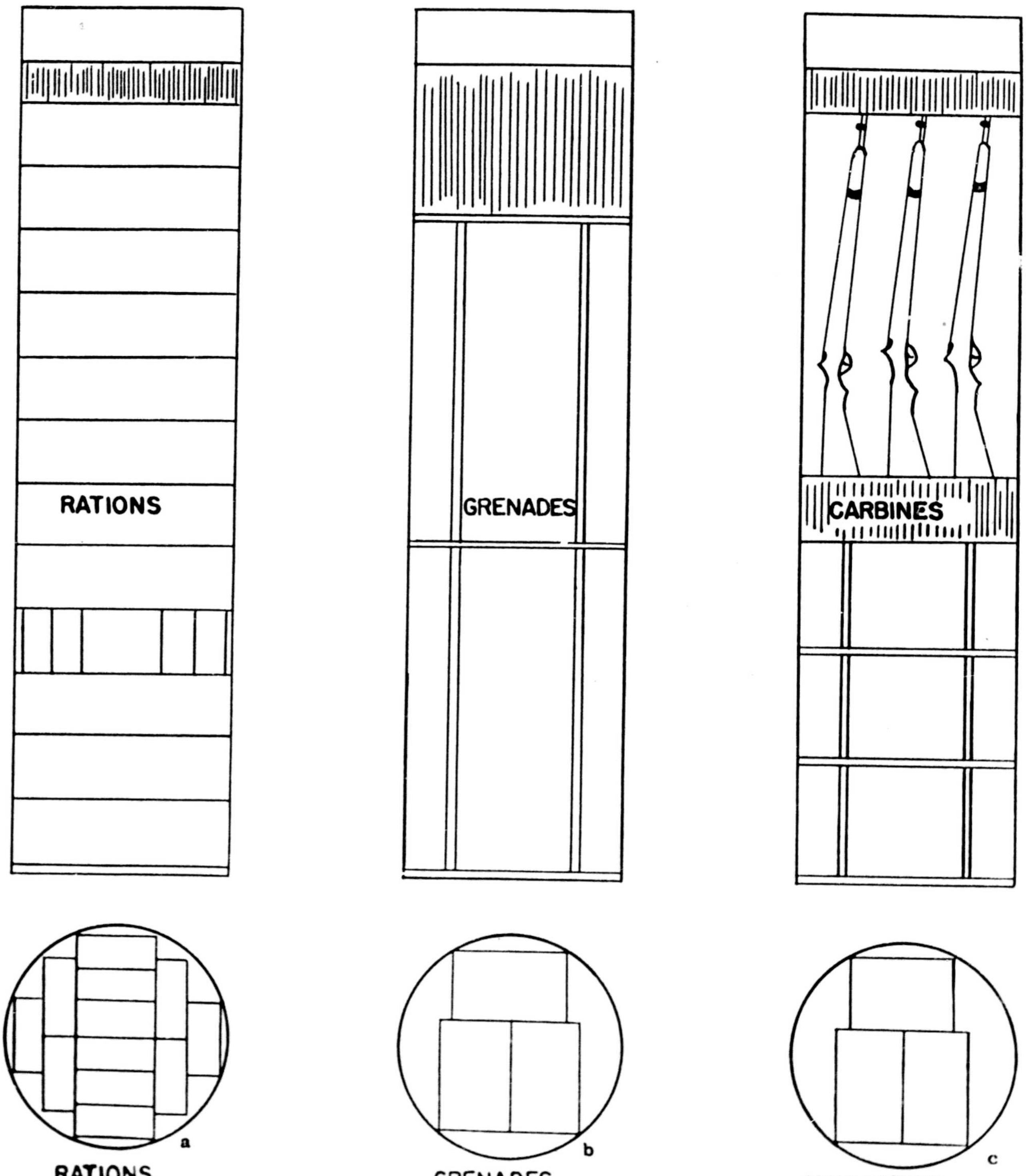


Figure 2. Inert Hand Grenades

**Figure 3.** Load Configurations of Carbines and Ammunition

# LOAD CONFIGURATIONS

(FOR IMPACT VELOCITIES OF 35 FEET PER SECOND)




RATIONS
12 INTERMEDIATE
CARTONS PER LAYER

GRENADES
3 CASES
PER LAYER

AMMUNITION
3 BOXES
PER LAYER

Figure 4

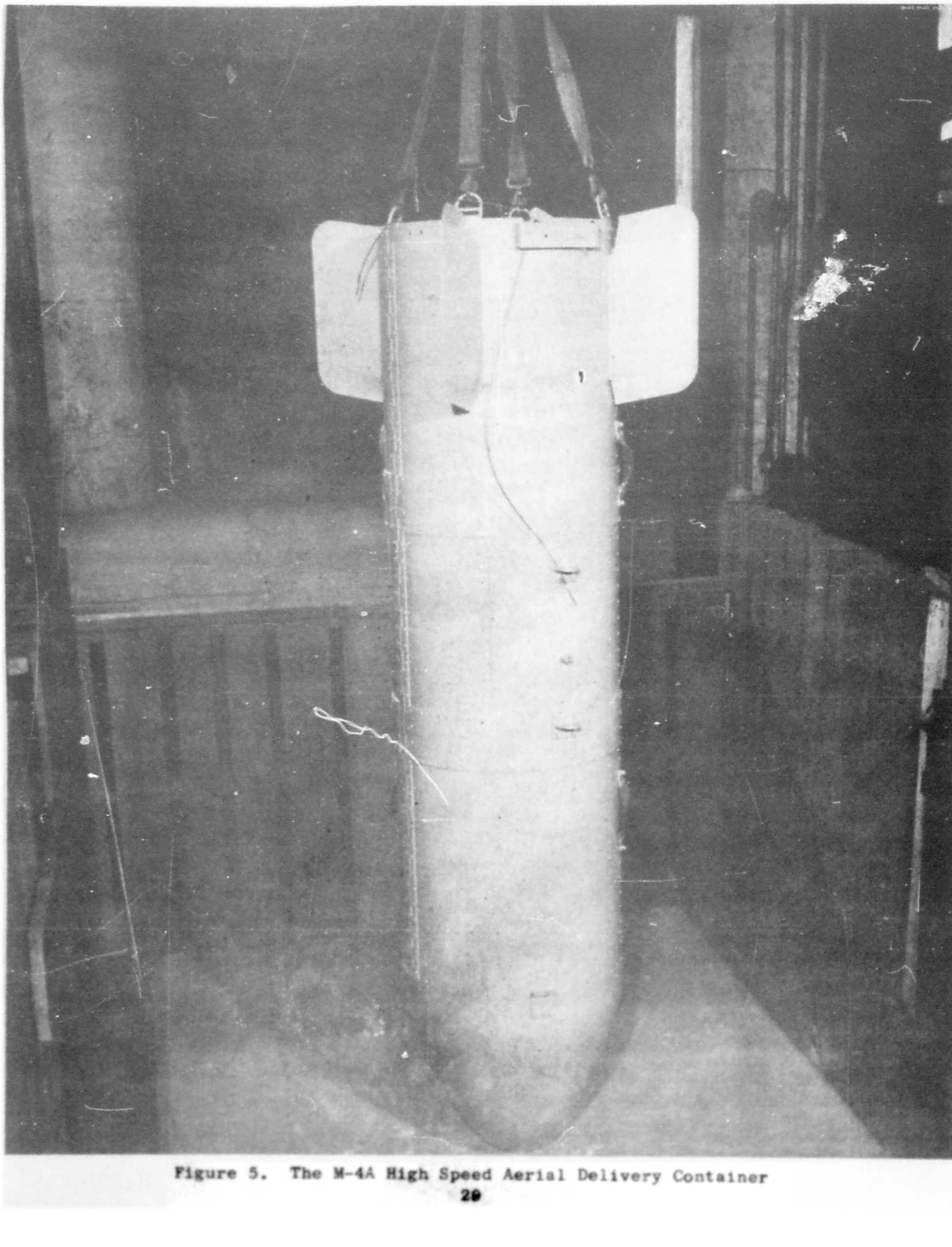


Figure 5. The M-4A High Speed Aerial Delivery Container

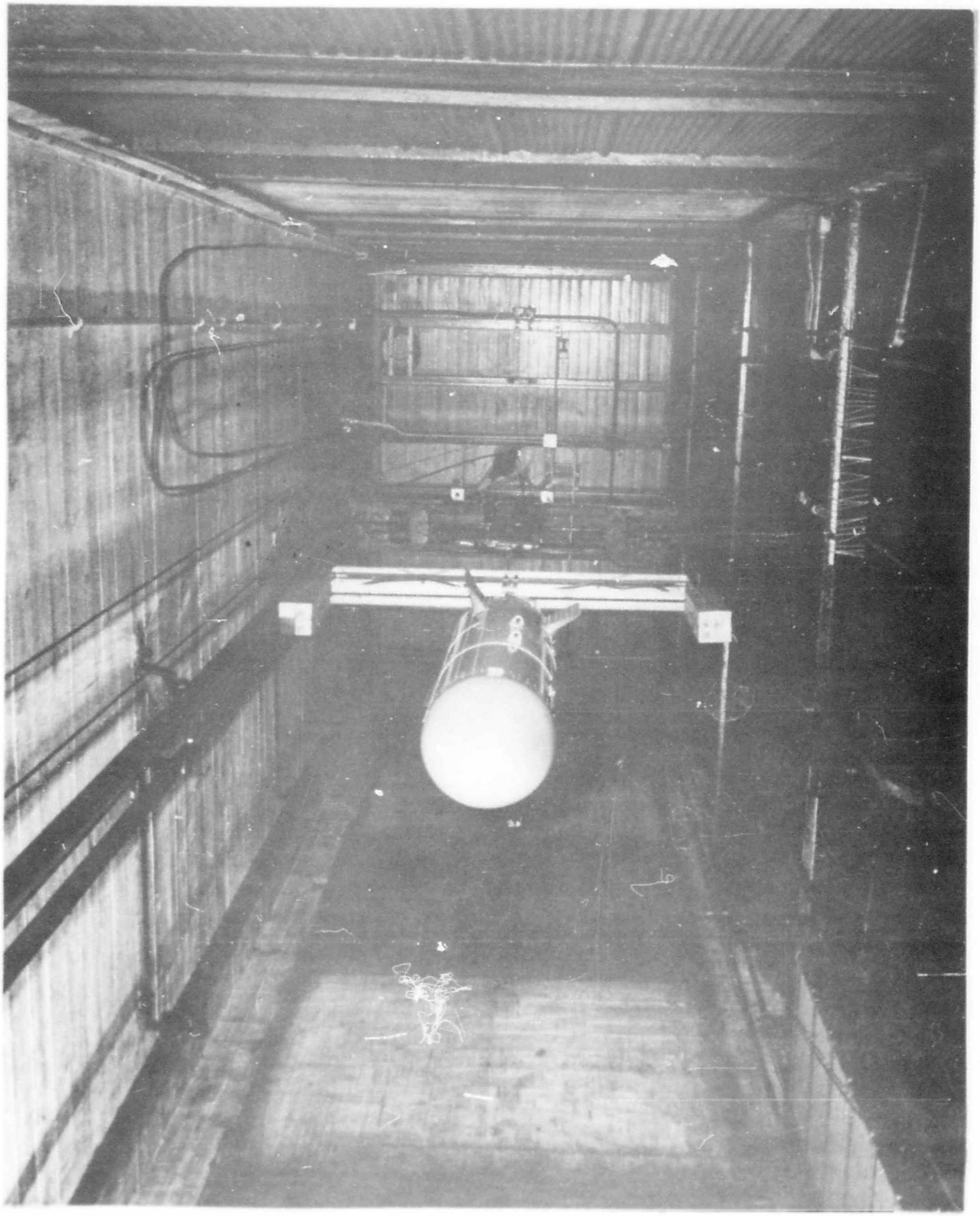


**Figure 6.** M-4A Container in Position for Drop in "Elevator" Dropshaft

Figure 7. M-4A Container After Impact at 35 feet per second

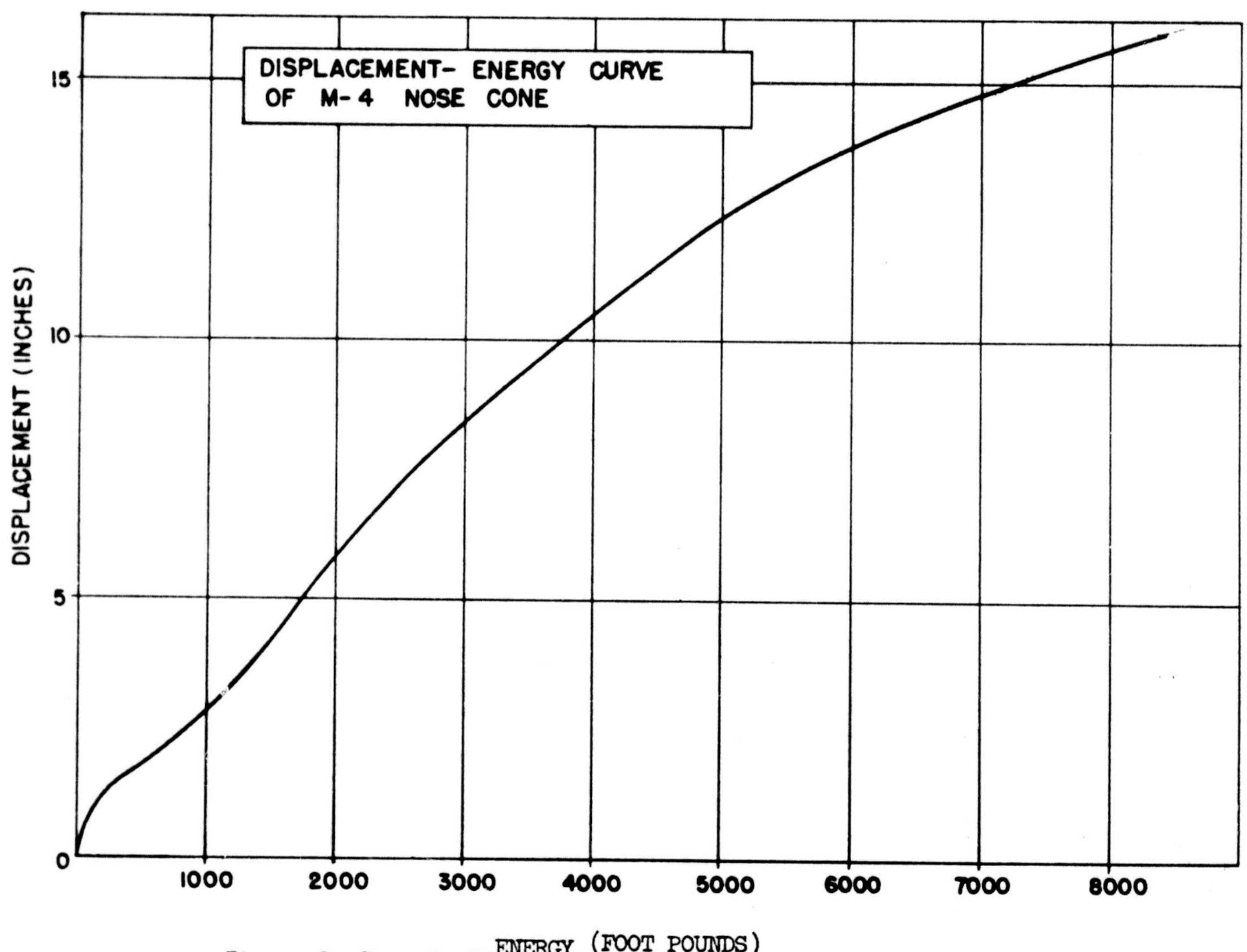



Figure 8. Dynamic Energy-Displacement Curve of M-4A Nose Cone

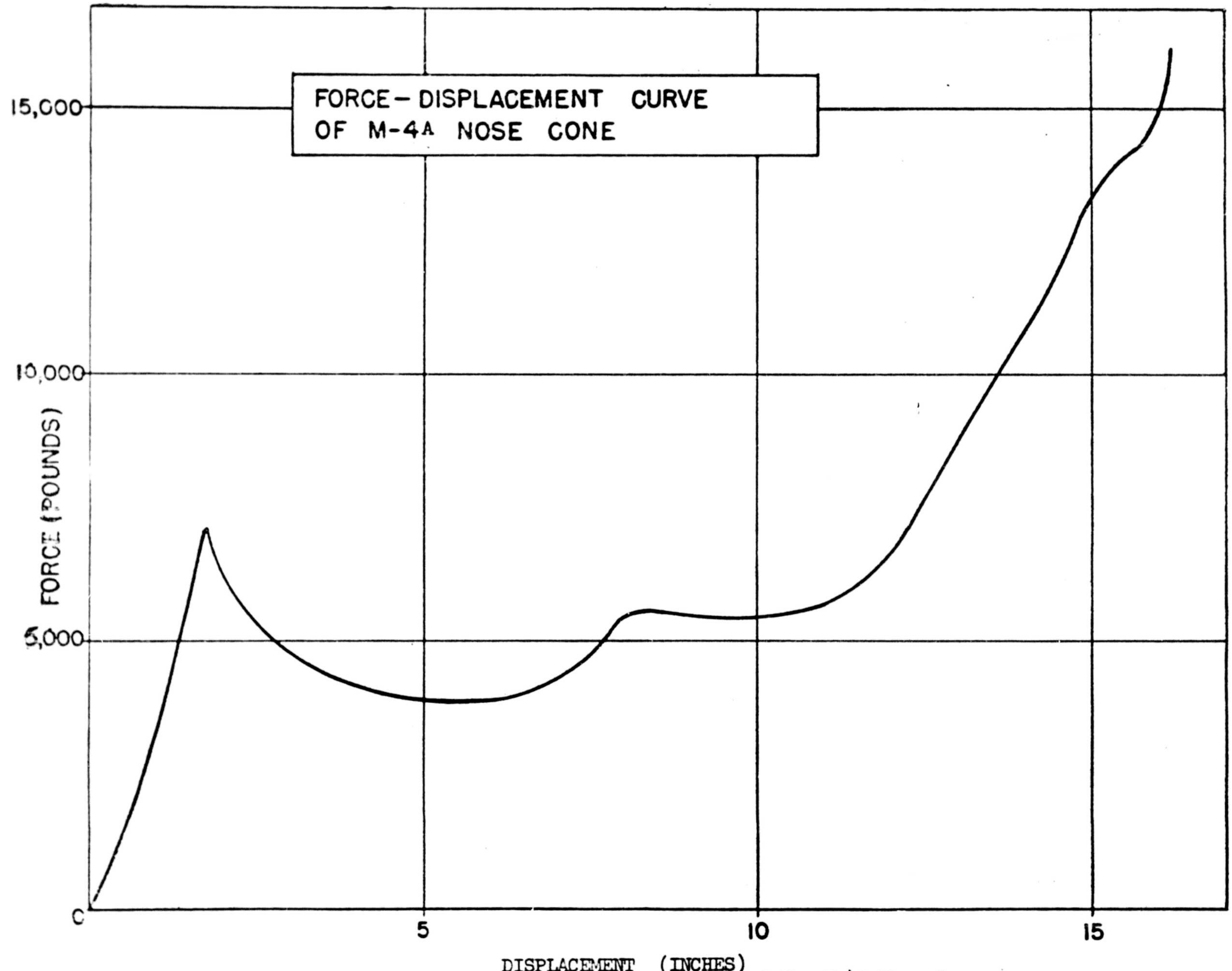



Figure 9. Dynamic Force-Displacement Curve of the M-4A Nose Cone

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