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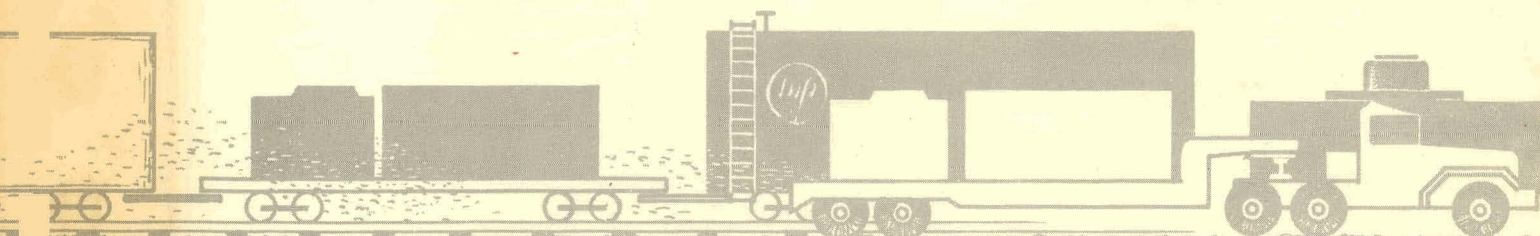
ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM

TRANSPORTABILITY STUDIES ML-1 NUCLEAR POWER PLANT

APRIL 1960

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Aerojet-General NUCLEONICS

A SUBSIDIARY OF AEROJET-GENERAL CORPORATION

SAN RAMON, CALIFORNIA



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TRANSPORTABILITY STUDIES

ML-1 NUCLEAR POWER PLANT

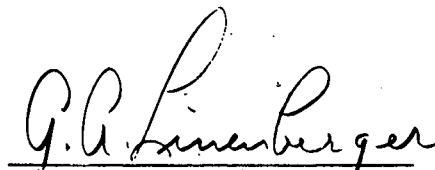
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ABSTRACT

This report discusses testing programs undertaken to determine the transportability of the ML-1 nuclear power plant. Three transport media were investigated: tractor-trailer, aircraft, and railroad. The document includes illustrations; original data (tapes and charts made in the field by various recording instruments) and detailed, illustrated appendixes.

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I. SUMMARY

The ML-1 is the prototype, mobile, gas-cooled nuclear power plant developed under the Army Gas-Cooled Reactor Systems Program. The military characteristics of the power plant specify that the unit shall be transportable by any of the several media available to the Army.

A comprehensive program was undertaken to test proposed loading and tiedown techniques and to demonstrate that the plant will satisfy the transportability requirements specified by the customer. The tests explored the problems of loading, cross-country transport, vibration spectra, switching and "humping" shocks, and field evaluations of the shock mount and tiedown systems.

The military characteristics specify that primary means of transporting the ML-1 is to be the U. S. Army M-172, or M-172-A-1, low-bed semi-trailer. It is further specified that the control cab be transported by a U. S. Army M-35 2½-ton cargo truck; and that auxiliary equipment be transported either on the M-35 or on M-55 5-ton trucks. Because mobility and rapid deployment are among the prime requisites of the ML-1, it must also be capable of being transported by aircraft. U. S. Air Force C-124, C-130, and C-133 aircraft are the specified carriers. In the case of both the C-124 and the C-130, three separate air lifts are required to transport the ML-1. (One aircraft carries the reactor; a second, the power conversion equipment; and a third, the seven-man crew, the control cab, and the power plant auxiliaries.) The C-133 has the capacity to transport the entire power plant, including its crew, control cab, and auxiliaries, in one flight. A third transport method specified for the ML-1 is by standard railroad flatcar. When positioned on a flatcar, the ML-1 must satisfy the clearance requirements of United States and European main lines.

The ML-1 plant consists of: 1) the nuclear reactor package, 2) the power conversion package, 3) the control cab, and 4) the auxiliary package. Full-scale mockups of the reactor and power-conversion packages were fabricated. The mockups duplicated the overall dimensions, the weight, and center-of-gravity of the ML-1 packages. Mockups were not constructed of the control cab or of the auxiliaries package, because the weights and sizes of these units permit handling by conventional techniques. The dimensions and weights of the mockup packages are listed below along with tiedown data:

<u>Item</u>	<u>Dimensions L x W x H (Inches)</u>	<u>Weight (Pounds)</u>	<u>Number of Tiedown Fittings</u>	<u>Capacity of Each Fitting (Pounds)</u>
Reactor	111 x 108 x 93	30,000	48	20,000
Power conversion equipment	168 x 113 x 93	30,000	8	60,000

The mockups duplicated the skid-mounting concept and the shock mounts, consisting of silicone rubber cores bonded to aluminum supports, planned for the ML-1. The shock mounts, in conjunction with nylon rope tiedowns, are designed to attenuate the shock loads encountered during transport and to reduce these loads to values less than the maximum allowable.

The test results substantially confirmed theoretical calculations and predictions. The following conclusions are particularly significant:

A. GENERAL CONCLUSIONS

The designed overall dimensions are compatible with the space available under all specified modes of transport. Satisfactory loading procedures were demonstrated for all specified modes of transport. The shock mount and tiedown system perform as designed to protect the units from excessive shock loads.

B. TRAILER TRANSPORT

The ML-1 power plant can be loaded in the field by conventional methods, and transported by the M-172 trailer.

The ML-1 can be satisfactorily transported cross-country by the M-172 trailer and M-52 tractor.

When the reactor and power conversion packages are coupled and loaded on the M-172 trailer, the resulting tandem axle load exceeds the maximum permitted on most U. S. highways.

Overseas military height restrictions can be met with the ML-1 loaded on the M-172 trailer. The height restriction is exceeded with the load on a M-172-A-1 trailer but the rear wheel tires can be partially deflated, temporarily, to permit clearing overhead obstructions.

C. AIRCRAFT TRANSPORT

The ML-1 packages may be loaded satisfactorily aboard C-124, C-130 and C-133 aircraft with equipment normally available in the field. In the case of the C-130, side clearances are less than

the minimum specified for personnel passage.

The tiedown system is adequate to protect the ML-1 during aircraft emergency landings (as specified in MIL-A-8421A USAF).

D. RAILROAD TRANSPORT

When loaded and tied down on railroad flatcars, the ML-1 will meet all clearance limitations specified for both United States and European main lines.

The tiedowns and shock mounts isolate all shocks sufficiently to eliminate any danger of damage to the ML-1 during railroad switching and "humping" operations.

The power conversion package was winched aboard the aircraft, (See Figure III-5) and loaded in 4 hr and 32 min. The package was off-loaded in 1 hr and 49 min by using the M-52 winch to pull the package while the Euclid winch provided the backup restraint.

Due to time limitations the reactor package was not loaded.

D. CONCLUSIONS AND RECOMMENDATIONS

The general conclusions of the tests are:

1. The ML-1 is air transportable.
2. The 30,000-lb package weights are compatible with the capabilities of all three cargo aircraft.
3. The package lengths can be satisfactorily accommodated by all three aircraft; the clearance between package and aircraft is tolerable in all cases, although side clearance in the C-130 is insufficient for rapid personnel evacuation.
4. The ML-1 can be tied down with standard USAF chain-type devices, although it might not survive an emergency landing in an operable condition under such an arrangement.

The following specific points will be included in the loading instructions based on the test results:

1. Greased shoring will be used instead of the roller-conveyors.
2. The aircraft must be kept in a level position throughout the loading operations.
3. Loading will be made directly from the trailer.
4. The use of a nylon rope tiedown system will be specified to insure plant serviceability after emergency landings.
5. A pre-tension of approximately 1000 lb will be applied to the nylon rope tiedown.
6. The winch on the M-52 tractor will be utilized for moving the packages aboard all three aircraft.
7. Package misalignments occurring during loading and off-loading will be corrected either by tightening one side of the winching bridle or by dead-ending the winching cable in an off-center position.

II. TRAILER TRANSPORT

Trailer transport tests were performed with the mockup packages near the AGN plant at San Ramon California, in September 1959. The U. S. Army supplied the M-172 trailer, M-52 tractor, and a 3-man crew for the tests.

The purposes of the tests were to determine: 1) that the ML-1 packages could be loaded by standard techniques, and 2) that the experimental shock mounts were satisfactory both during loading and while in transit. The tests, augmented by time and motion studies (Appendix A) also provided data for the development of loading procedures.

A. LOADING PROCEDURES

A trailer was prepared to receive the packages by covering the open wheel-wells with steel channels and by shoring the trailer bed with 3-in.-thick lumber, as shown in Figure II-1. The trailer was then placed on rough ground; the brakes were set; the wheels were blocked; and the parking gear was dropped. The tractor was located in front of the trailer gooseneck, facing the trailer (See Figure II-2).

A pair of loading ramps (standard equipment with the trailer) was used in all the loading operations. The ramps were shored with 3-in.-thick lumber, to match the inverted channel on the trailer bed. The shoring was greased. A block and tackle arrangement powered by the winch on the tractor, pulled the packages up the ramp and onto the trailer.

1. Individual Package Loading

The first unit loaded was the reactor mockup. This loading showed that the shock mounts were suitable for ramp-loading techniques. The package, while passing the 13-degree crest of the ramp, rested on at least four shock mounts. (See Figure II-3). The reactor package was unloaded with two winches. One winch, on the ground, pulled the package down the ramp, while the M-52 winch restrained the package. These first tests indicated that, to avoid trailer settling, it was necessary to block up the rear of the trailer during loading and unloading.

The power conversion mockup was loaded next. Again, the shock mounts were satisfactory. (See Figure II-4.) The package was winched onto the trailer bed in 53 minutes. During the unloading, an auxiliary winch was used occasionally to straighten the descent path of the mockup. The same effect could be achieved by dead-ending the cable in an off-center position, or by using a side-load on the same cable.

2. Complete Assembly Loading

The two mockups were bolted together, on the ground, and preparations were made to winch the entire assembly onto the trailer. The rigging system used gave a mechanical advantage of six. Figure II-5 shows the package part way up the ramp. The entire weight of the combined mockups (60,000 lb) rested on only four shock mounts. Figure II-6 shows the ML-1 mockups balancing on the crest of the ramp at their composite center of gravity. The entire unit was loaded in one hour and 22 minutes.

The loading tests showed that smooth, greased shoring; level ground; and blocking under the trailer carriage were necessary for successful loading. Trailer and tractor "deadmen" may be necessary if the units are loaded under adverse weather conditions.

B. STATIC MEASUREMENTS

Measurements were made of the coupled trailer and tractor, while they were parked on a level concrete pad, to determine how much the trailer settled under a 30-ton load. The pad had been surveyed and marked with a grid pattern. The tractor-trailer rig was placed in the same position for each measurement. All measurements were accurate to within $\pm 1/16$ inch.

1. Trailer Bed Height

The first measurement was made to determine the height of the unloaded trailer bed. The average height, at a tire pressure of 80 psig, was $36\frac{1}{2}$ inches.

With the power conversion package loaded on the trailer, the average height of the bed was $35\frac{1}{2}$ inches. (The center of gravity of the power-conversion mockup was 61 in. behind the trailer gooseneck.)

With the reactor mockup on the trailer bed, the average height of the trailer bed was again $35\frac{1}{2}$ inches. (The center of gravity of the reactor mockup was $85\frac{1}{2}$ in. behind the gooseneck.)

When both packages were loaded on the trailer, the average bed height was $34\frac{1}{2}$ inches.

2. Load Height

The maximum height of the load (the top of the power

conversion package as it rested on the 3-in. shoring) was 131½ inches. This height is less than the 132-in. maximum height specification for loads transported by vehicles overseas.

The bed of the M-172A-1 trailer is 3 in. higher than that of the M-172; thus, to satisfy the 132-in. height restriction, it will be necessary to lower the bed 3 in. by deflating the rear wheel tires. This procedure was tested with the M-172 trailer. Reducing the pressure in the rear tires from the normal 80 psig to about 40-50 psig lowered the bed the required 3 inches.

C. CROSS-COUNTRY TESTS

The mockups were bolted together on the trailer, and tied down with chains and load binders. Vertical and horizontal accelerometers were attached to the mockups at the composite center of gravity. Accelerometers were also attached to the trailer bed directly below this point. The accelerometers were capable of measuring shock loads in the range of ± 25 g, and vibrations in the range of 0 to 370 cps. The recording equipment was located in the tractor cab. To reduce error in the recording system due to shock loading of the galvanometers, the oscillograph was wrapped in a layer of 2-in.-thick foam rubber and then mounted on the tractor seat. An undamped galvanometer with a balance factor equal to that of the recording galvanometer was used to detect errors introduced by galvanometer shock loading. The error was not greater than 0.1 g at any time during the tests. The schematic diagram of the instrumentation circuit is shown in Figure II-7. Figure II-8 shows the location of the instruments on the trailer and mockups.

The cross-country tests were conducted in a plowed field. The condition of the ground was dry and hard, with rows of furrows and cracks. The field was surveyed, and a course was laid out to cover the roughest terrain available. The speed of the trailer varied from 5 to 20 mph. Figure II-9 shows the mockups as they were transported across the field.

Very low frequency vibrations (1-3 cps fundamental) were found to exist on the trailer bed. Apparently, these frequencies were below the threshold isolation frequencies of the shock mounts, and were directly transmitted to the package. However, nearly all high-frequency vibrations existing on the fundamental pulse were isolated by the shock mounts, and were not transmitted to the packages. All high-amplitude shock pulses were effectively isolated by the shock mounts. The maximum vertical acceleration on the trailer bed was about 1.5 g. This low value can be explained by the efficiency of the unsprung bogie axle system used on the M-172 trailer, and by the fact that the ground actually deformed under the trailer wheels. The rear bogie axle of the trailer is particularly effective in plowed furrows or in places where the bogie can move vertically.

D. HIGHWAY TRANSPORT

Data concerning highway transport were obtained while the power conversion mockup was moved on the M-172 trailer over paved high-

ways from San Ramon to Fairfield, California, a distance of about 40 miles. Tests with the combined reactor and power conversion packages could not be carried out, because this load was in excess of that allowed on California highways.

The power conversion mockup was centered on the M-172 bed and tied down with chains. Accelerometers were mounted at the package center of gravity and on the trailer bed. During highway travel, fundamental frequencies ranging from 2 to 20 cps were recorded on the trailer bed, with higher frequencies ranging from 40 to 200 cps superimposed on the fundamental. Vertical accelerations exceeded 1 g only a few times during the trip. The maximum vertical acceleration recorded was 2.4 g on the trailer bed; this value was reduced to 0.9 g on the package. A vibrational frequency of 10-11 cps was recorded while travelling over a secondary blacktop road. The average vibrational frequency of the package was about 8 cps. Horizontal acceleration was negligible in all cases.

E. CONCLUSIONS

1. Loading Procedure

The ML-1 can be loaded either as individual packages, or as one unit. The loading can be accomplished within a reasonable time, using only standard U. S. Army field equipment.

2. Cross-Country Transport

The M-172 and M-52 trailer-tractor combinations are able to transport the ML-1 cross-country and over hilly terrain at speeds up to 20 mph.

3. Shock Mount Performance

Excellent shock and high-frequency vibration isolation were achieved with the experimental shock mounts, although vertical package deflections were restricted by the tiedowns.

4. Load Height

The load height on the M-172 trailer meets the maximum height specification. When the M-172A-1 trailer is used, the maximum height specification is exceeded by approximately 3 in. Reducing tire pressure is a satisfactory temporary expedient to reduce the load height in this case.

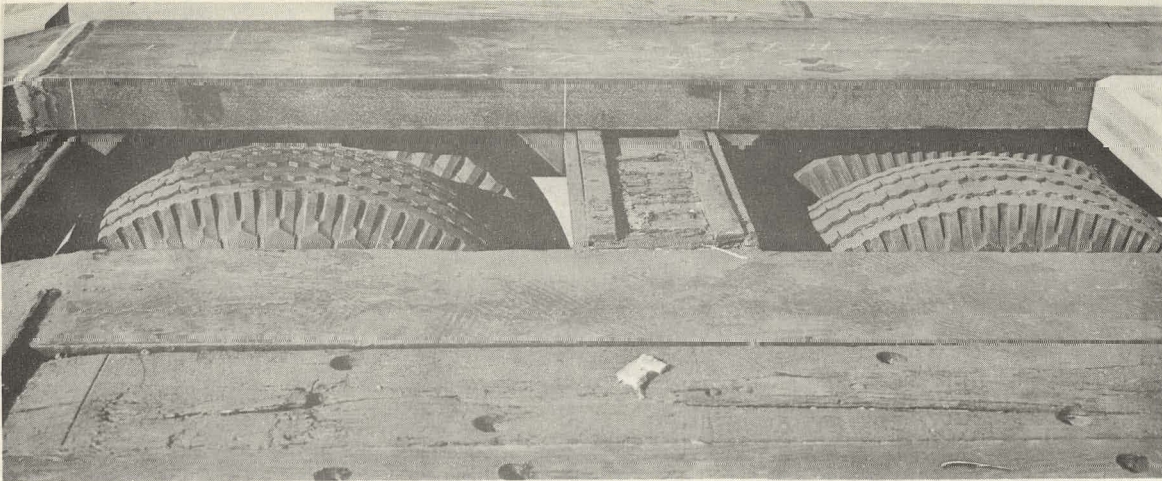


Figure 11-1 : Preparing M-172 trailer for loading tests

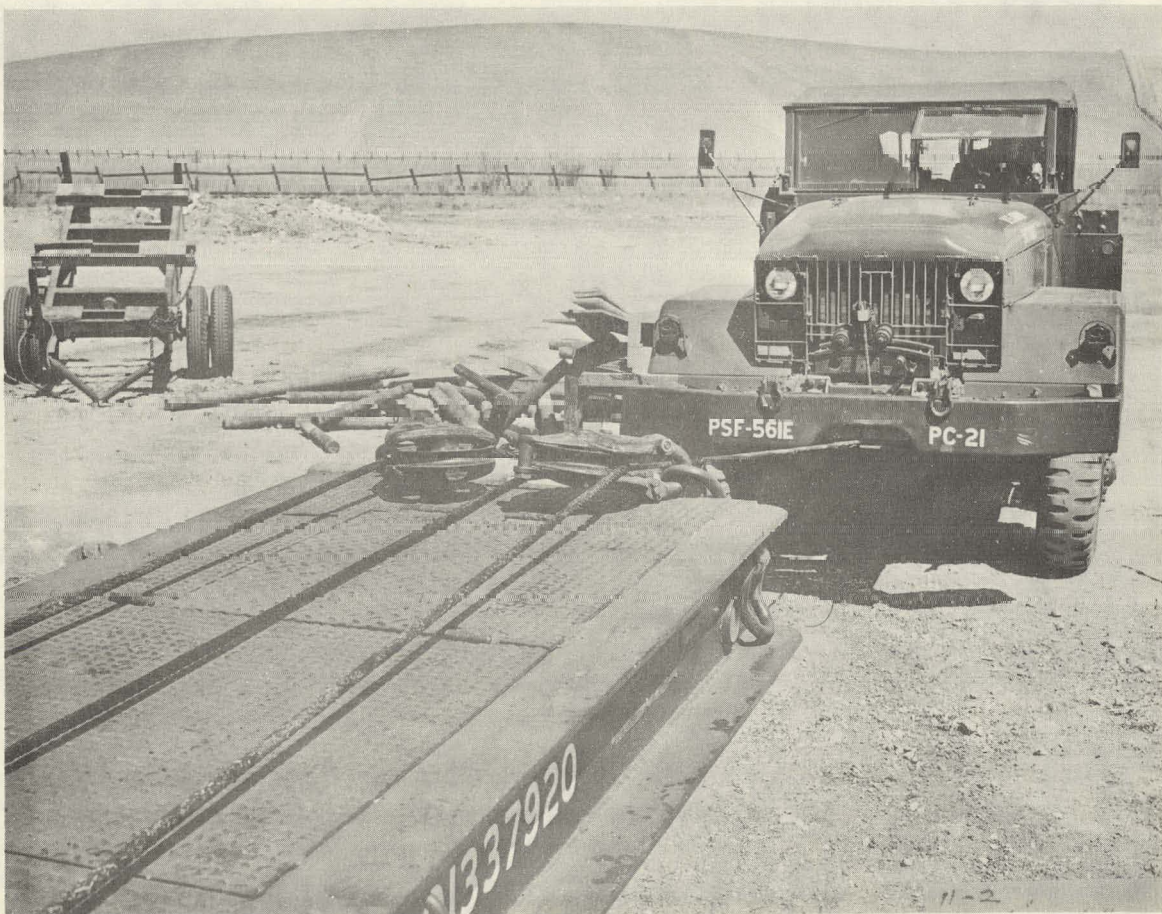


Figure 11-2 : Tractor and trailer in position for loading

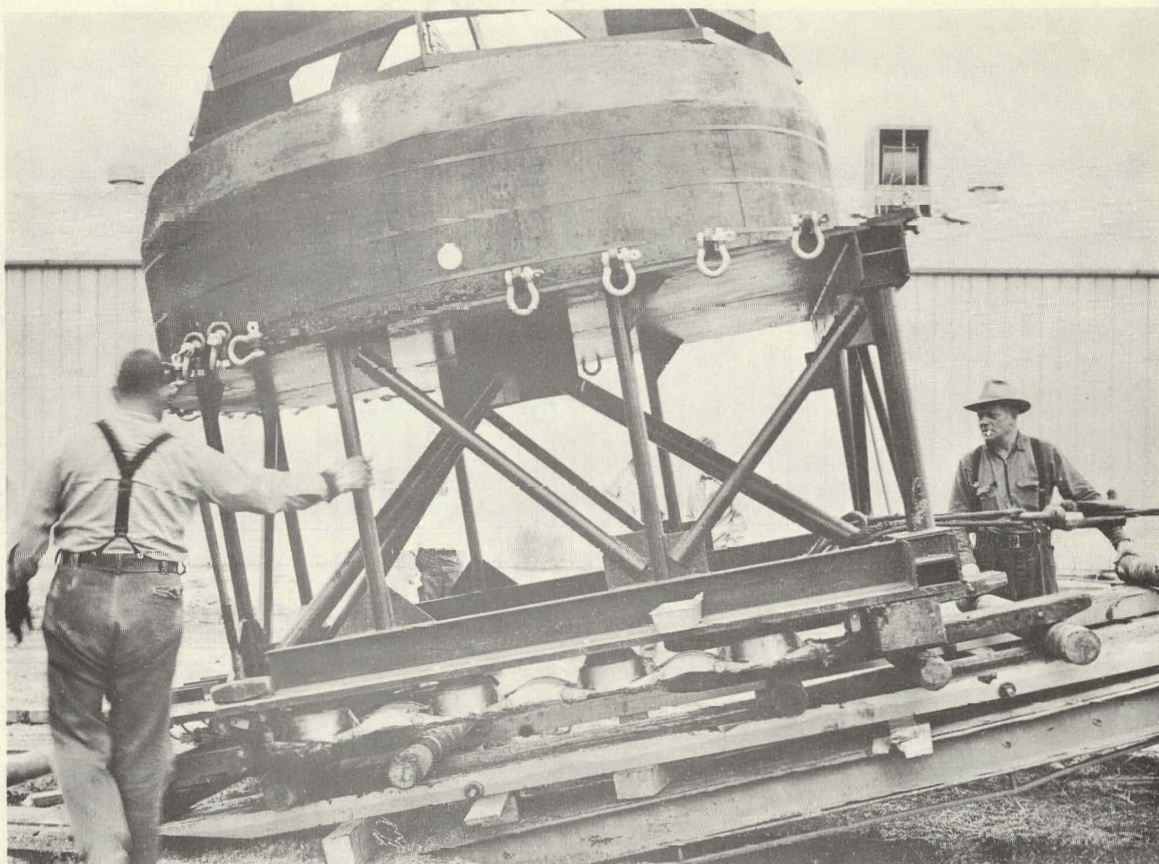


Figure 11-3 : Loading ML-1 reactor mockup

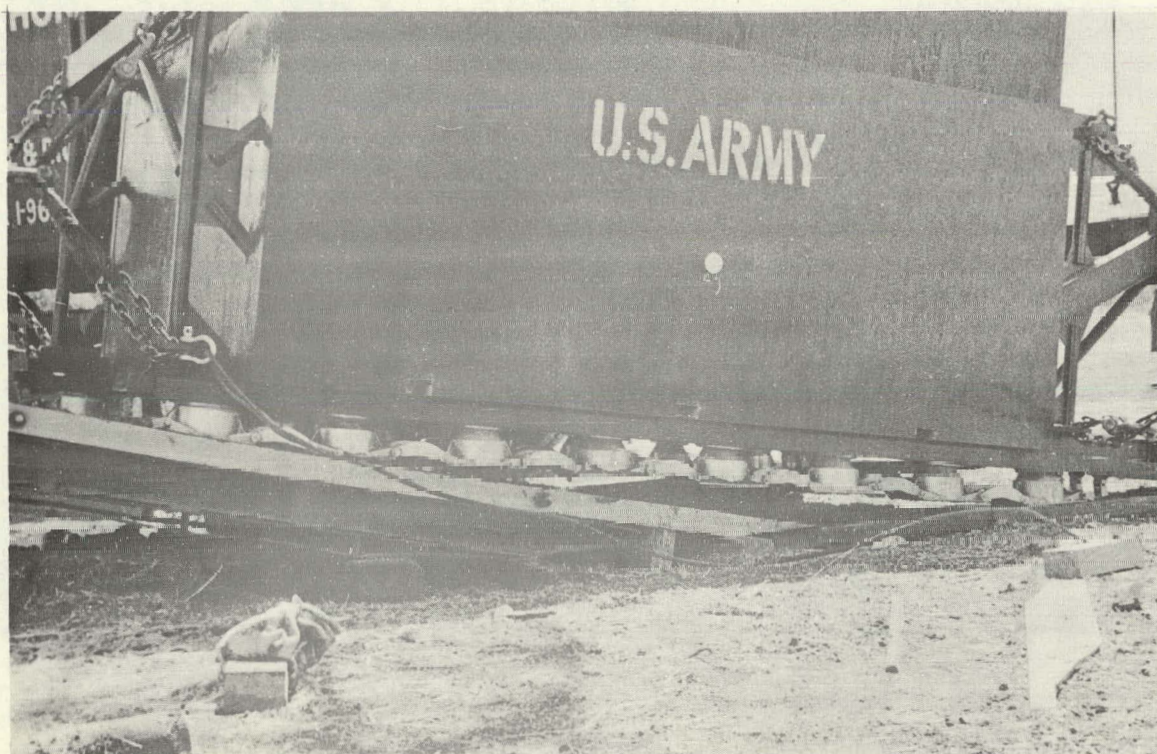


Figure 11-4 : Loading ML-1 power conversion mockup

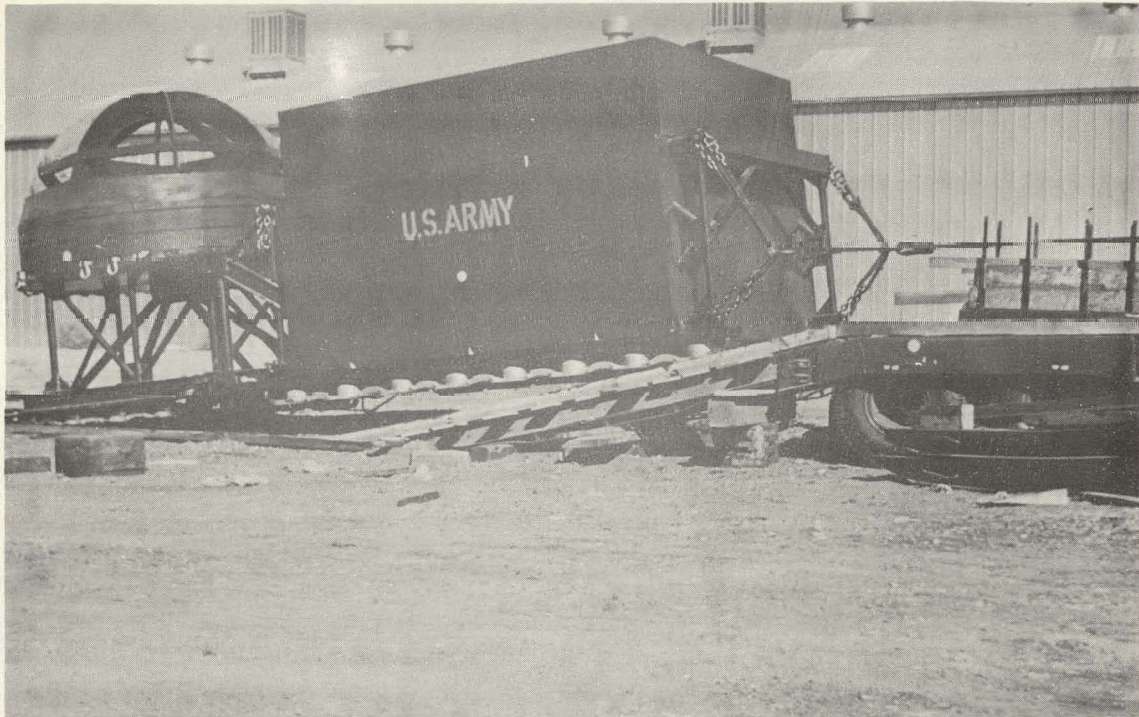


Figure 11-5 : Loading combined mockup packages

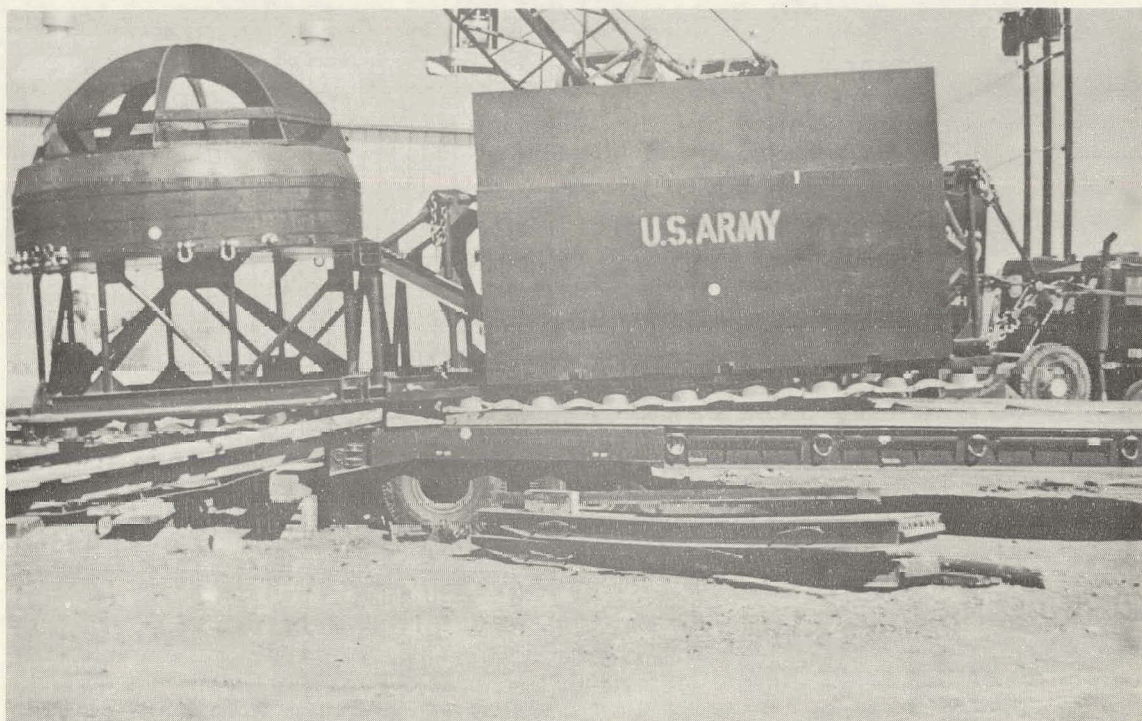


Figure 11-6 : Combined mockups at crest of loading ramp

INSTRUMENTATION INTERCONNECTION DIAGRAM RAILROAD DYNAMIC TEST ML-1 MOCKUP

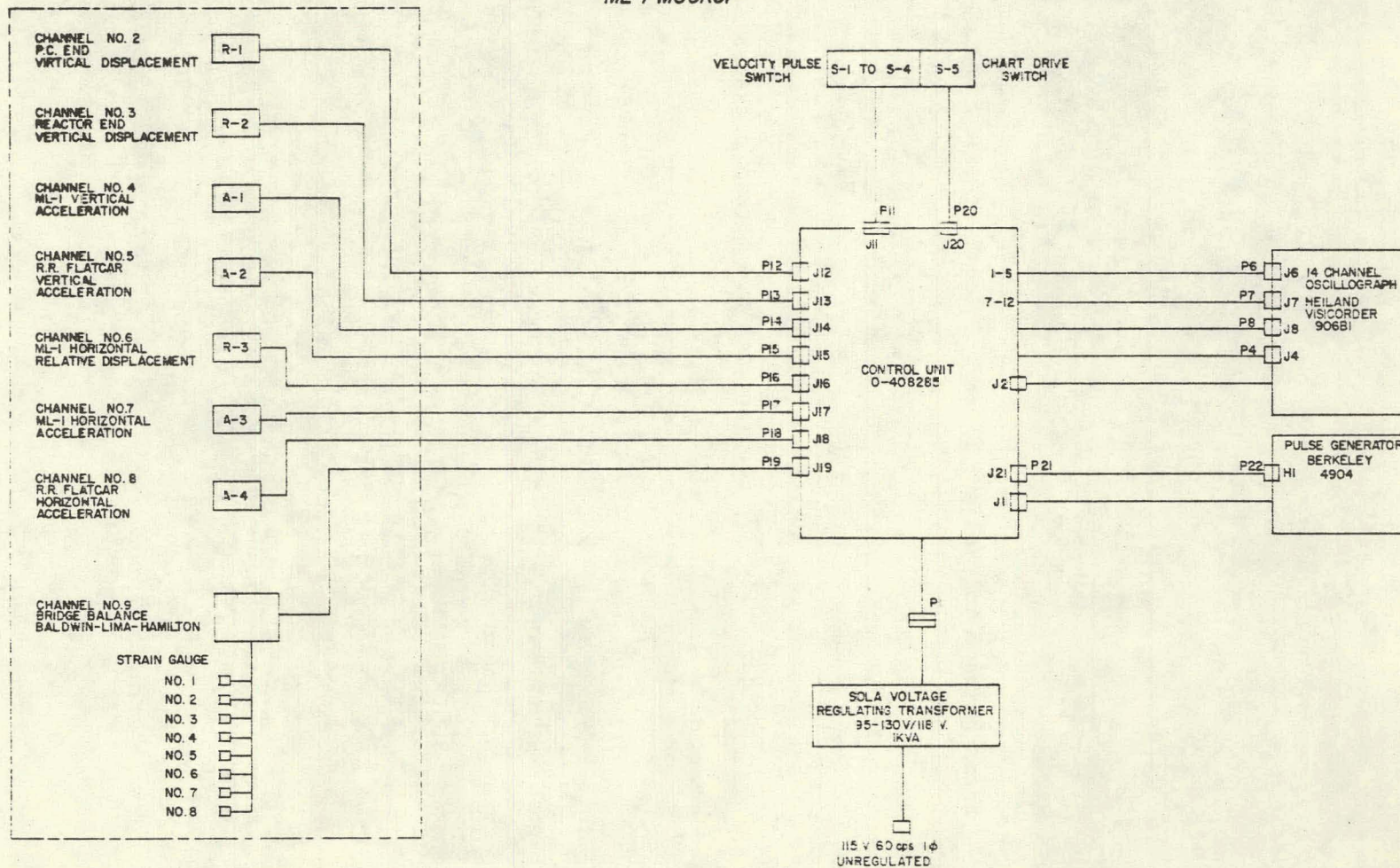


Figure 11-7

INSTRUMENTATION, MOCKUPS ABOARD M-172 TRAILER

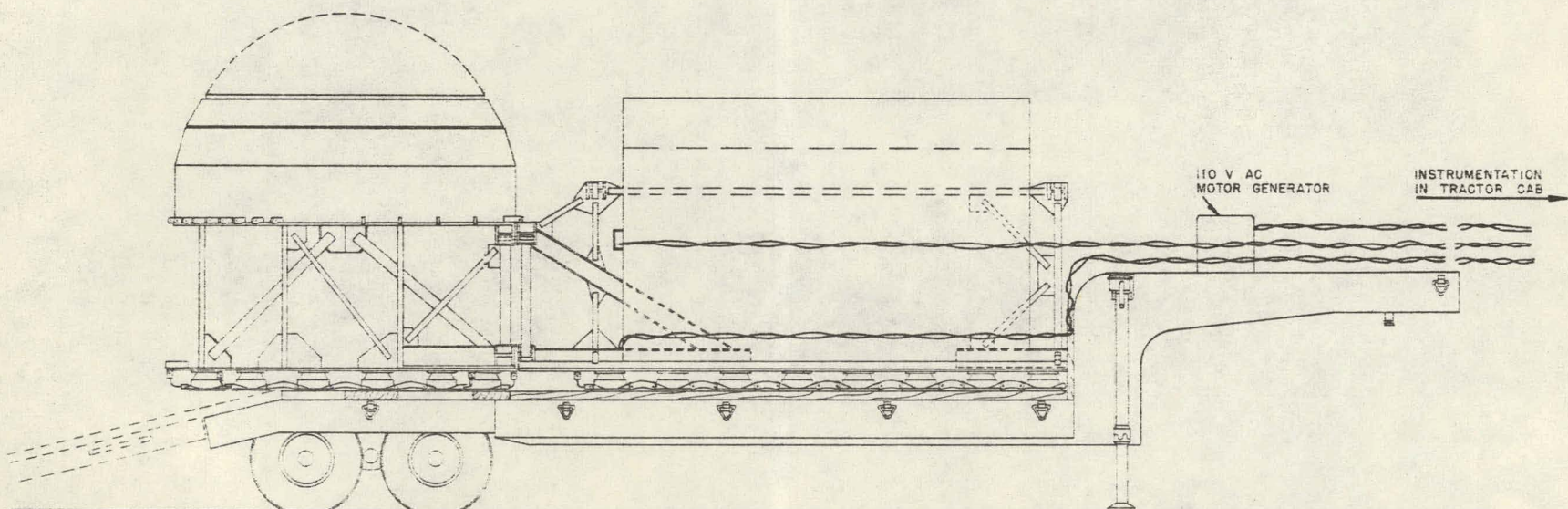
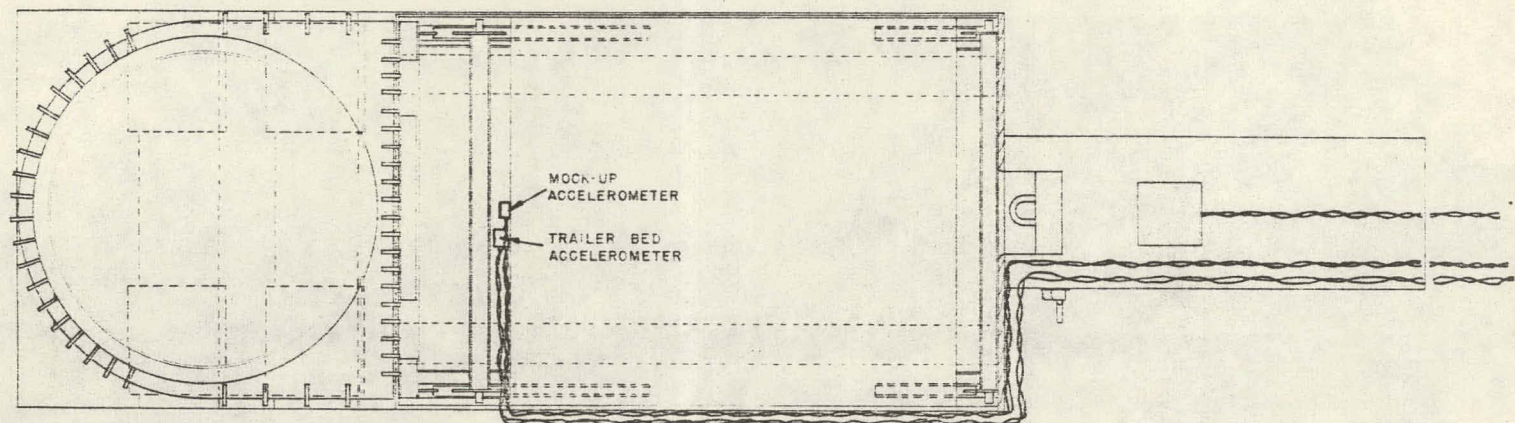
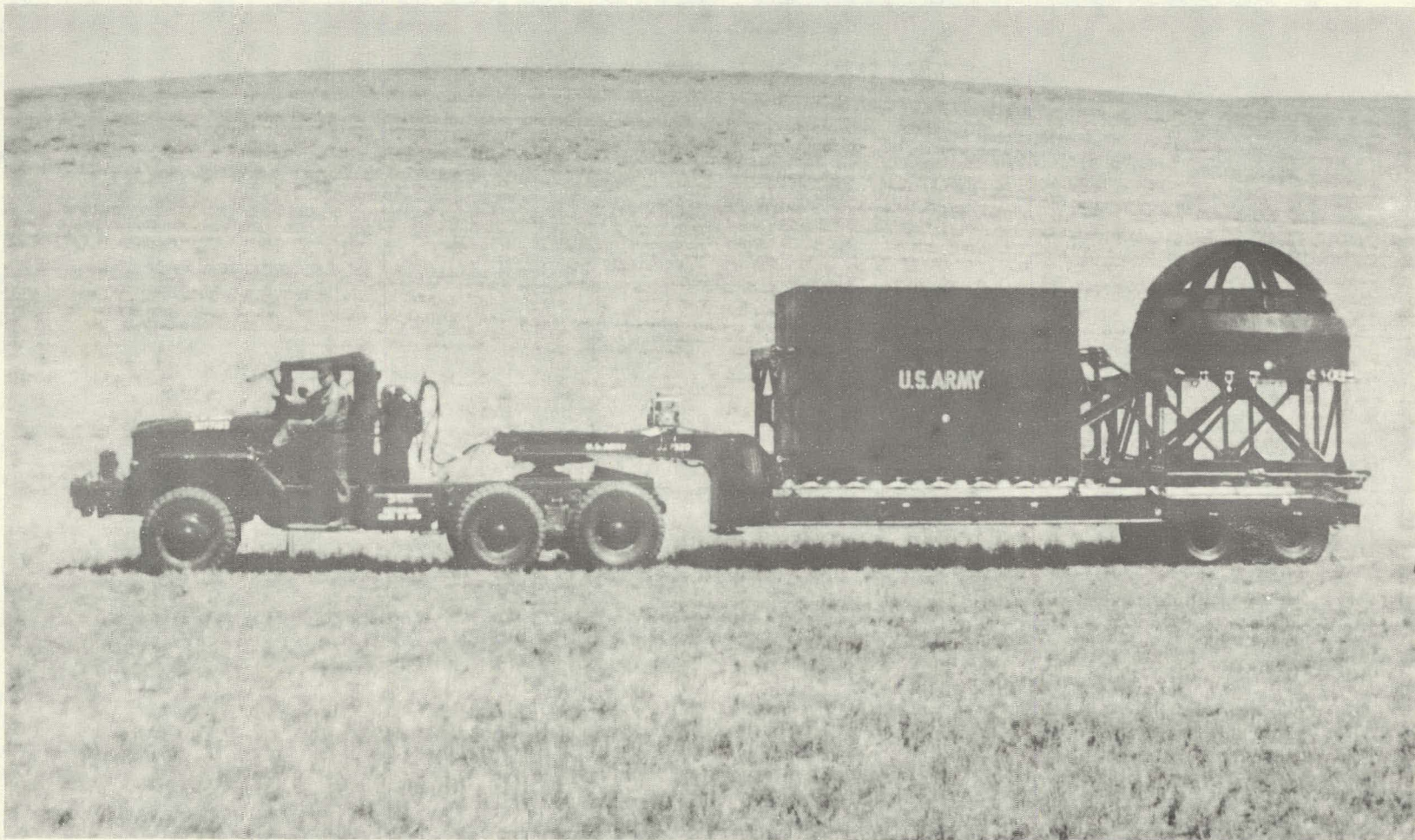


Figure 11-8



Mockups being transported cross-country

III. AIRCRAFT LOADING TESTS

These tests were conducted at Travis Air Force Base, Fairfield, California, during the period 15 - 23 September 1959. All tests were under the supervision of Aerojet personnel. Members of the U. S. Army Airborne and Electronics Board, Ft. Bragg, North Carolina, were present during the tests. In addition, a 3-man loading crew was provided by Ft. Bragg. Technical assistance and ground support were provided by the 1501st Air Transportation Wing and by Headquarters, WESTAF, Travis AFB.

At the completion of each loading operation, Weight and Balance Clearance Forms (Form F, USAF) were obtained from the loadmaster of each aircraft. The loadmaster certified that the load was properly tied down and that the aircraft was ready for flight.

Appendix B to this report contains detailed descriptions of the loading procedures, photographs of the operation at various stages, and time studies of the loading operation. In addition, tiedown drawings (as of April, 1960) are included for each aircraft.

A. LOADING MANUAL

Prior to conducting the loading tests, a comprehensive loading manual was prepared. This manual outlined procedures to be used with the three USAF cargo aircraft specified for ML-1 transport (C-124, C-130, and C-133) and presented winching and tiedown systems; alternate loading techniques; and diagrams for winching, load placement and tiedown arrangements. The procedures were in accordance with the provisions of USAF General Specifications for Air Transportability Requirements (MIL Spec 8421-A, Appendix E) loading instructions handbooks (TO-1C-130A-9, TO-1C-133A-9, and TO-1C-124A-9), and other USAF criteria for loading, load placement, weight, bearing loads, and tiedown restraint.

B. TIEDOWN ARRANGEMENTS

The tiedown system consisted of nylon ropes used with standard aircraft tiedown devices. Twenty-four 1-1/8-in.-dia ropes were used for the tiedowns: Sixteen 7-ft-long ropes restrained the forward motion of the mockups, and eight 7-ft-long ropes restrained aft motion. The ropes isolated shock, and restrained and distributed the load. "Whiffletree" devices further distributed the load to the aircraft tiedown fittings.

The tiedown system was designed to provide minimum interference between vertical and transverse restraints during package displacement. Diagrams of the tiedown arrangements are included in Appendix B.

Although the mockups could be tied down with standard USAF devices, this arrangement does not afford sufficient protection against severe shock loads (for example, the 8-g shock produced in an emergency landing). Furthermore, with the USAF tiedowns, it is difficult to distribute the load equally to the many fittings in an aircraft. Improper load distribution could cause the package to break loose during flight.

The tiedown system was designed to withstand the conditions listed below:

<u>Load Direction</u>	<u>Static Restraint</u>	<u>Critical Condition</u>
Forward	8.0 g	Emergency landing
Aft	3.0 g	Flight
Lateral (transverse)	1.5 g	Flight
Vertical (upward)	3.0 g	Flight
Vertical (downward)	4.5 g	Emergency landing

The determination of the proper location of the packages within the aircraft was based on information from flight manuals and from appropriate loading manuals. Fuel loads were calculated, and the composite "cargo center of gravity" was located.

C. THE LOADING TESTS

1. C-130 Aircraft

A C-130A aircraft supplied by the Tactical Air Command, Seward AFB, Tennessee, arrived at Travis AFB on 15 September 1959. The aircraft was prepared for the tests in accordance with procedures outlined in the loading manual. The ML-1 mockup packages, which had arrived at Travis AFB on trailers, were positioned on the airfield runway.

The primary winching system for this and all subsequent loading tests was a block and tackle arrangement rigged with a steel cable and powered by the winch on the M-52 tractor. An auxiliary winch was used during the off-loadings.

a. Roller-Conveyor Loading Technique

In this first loading test, attempts were made to use roller-conveyor systems to load the power conversion mockup into the aircraft. Three types of roller-conveyors were tried: 1) commercial steel rollers; 2) light-weight, glass fiber rollers (part of the C-133 standard loading equipment); and 3) aluminum rollers from the C-130 fly-away kit. To facilitate the loadings and to offer a better weight distribution, wood pallets were constructed to support the power conversion mockup while it was on the rollers. Figure III-1 shows the package partially loaded into the aircraft.

All the roller-conveyors used, because of their light construction, failed to support the power conversion package. The roller failures apparently were due to excessive point loadings which occurred at the foot and crest of the ramp. The wood pallets did not sufficiently distribute the load to the rollers at these positions.

It was observed that the aircraft floor must be kept level throughout the loading operations. Otherwise, the heavy packages tend to drift toward the lower side of the aircraft.

Only a 5-in. clearance existed on each side of the package when it was centered on the longitudinal center line of the C-130. This does not provide sufficient passageway for rapid personnel evacuation. However, the USAF has stated that, although this situation is not wholly satisfactory from a safety standpoint, the ML-1 is considered to be suitable for transport by the C-130.

b. Greased Shoring Loading Technique

Because of the unsatisfactory performance of the roller conveyor systems, greased shoring was used in subsequent loading tests. The C-130 was repositioned on the runway with the aircraft in a level position. Wood shoring (2 x 12-in.) was placed on the treadways of the aircraft. The M-172 trailer, with the reactor mockup on its bed, was positioned directly under the tail of the C-130. (See Figure III-2). The aircraft ramp was lowered, and the auxiliary loading ramp toes were installed. These ramp toes, resting on the trailer, provided most of the vertical support for the ramp.

The reactor mockup was winched from the trailer, up the aircraft ramps, and into the C-130. The package was positioned and tied down as shown in the diagrams in Appendix B. The loading operation required 3 hr and 12 min.

It was possible to apply a tension of only 300 - 400 lb to the nylon tiedown ropes. This was accomplished by hand tightening, since the USAF tiedown devices were not satisfactory. For this reason, a mechanical tensioning device will be included as a standard item in the ML-1 tiedown equipment to apply the 1000 lb tension required by the tiedown design.

The hand crank for emergency operation of the aircraft landing gear was accessible when the reactor package was loaded and tied down. In addition, it is possible to check the actual position of the landing gear by holding a mirror near the package and looking - periscope-wise - out a window to observe the position of the gear.

2. C-133 Aircraft

Loading and tiedown tests with a C-133A were conducted on 21 and 22 September 1959. The loading procedures actually used were different from those planned for three reasons: 1) the unsatisfactory performance of the roller-conveyors; 2) the demonstrated feasibility of loading the packages directly from trailer to aircraft (without first

off-loading the packages from the trailer to the ground), and 3) the fact that it was necessary to use the M-52 winch, because the C-133 cargo winch had been downgraded from a maximum draw bar strength of 30,000 lb to 3,500 lb.

The C-133A was positioned on the runway. The tipover struts and aircraft wheel chocks were set. Wood blocks were placed under the loading ramp, and the ramp was lowered until its rubber bearing pad rested on the wood blocks. Shoring was placed on the ramp and in the cargo compartment. The M-172 trailer with the power conversion mockup aboard was backed up to within 3 in. of the aircraft ramp, and uncoupled from the tractor. The trailer wheels were chocked, and the rear of the trailer was blocked up. These blocks, and those under the aircraft ramp, supported almost all the weight of the packages during the loading operations.

The winching vehicle was positioned close to the trailer gooseneck, facing the aircraft. The shoring was greased, and the winching operation began. A dynamometer, placed in series with the winching cable, recorded a static force of 4600 lb and a sliding force of 2800 lb on the ramp. The cable tension was approximately 2300 lb on each of the two cables when the package was sliding on the level deck. Thus, the total pulling force was about 4600 lb.

The power conversion package was successfully loaded into the aircraft and remained in position while the reactor package was loaded. The reactor mockup was off-loaded directly from the M-172 and winched into the aircraft (See Figure III-3). Both packages were tied down with nylon rope (See Figure III-4). Tying down both packages required 6 hr and 25 min.

3. C-124 Aircraft

A C-124A was supplied by the Military Air Transport Service at Travis AFB. Loading tests with the power conversion mockup were carried out on 23 September 1959.

The aircraft was prepared for loading by setting the parking brakes, chocking the wheels, and setting the tail support stands. The loading ramps were lowered and adjusted so that the center line of each ramp was 47 in. from the longitudinal center line of the aircraft. This width matches the track width of the shock mounts. Shoring was laid on the ramps and deck areas. The ramps are at a 17-degree angle with the runway initially; the angle becomes 11½ degrees partway inside the aircraft; and finally, well inside the aircraft, the ramp becomes horizontal.

The power conversion package was unloaded from the trailer with a crane and placed on shoring laid on the concrete parking pad. A Euclid tractor was used as the primary winching vehicle for expediency. The M-52 winch was used for control. Safety cables were attached from the power conversion package to the aircraft tiedowns to hold the package if a primary winching cable should break.

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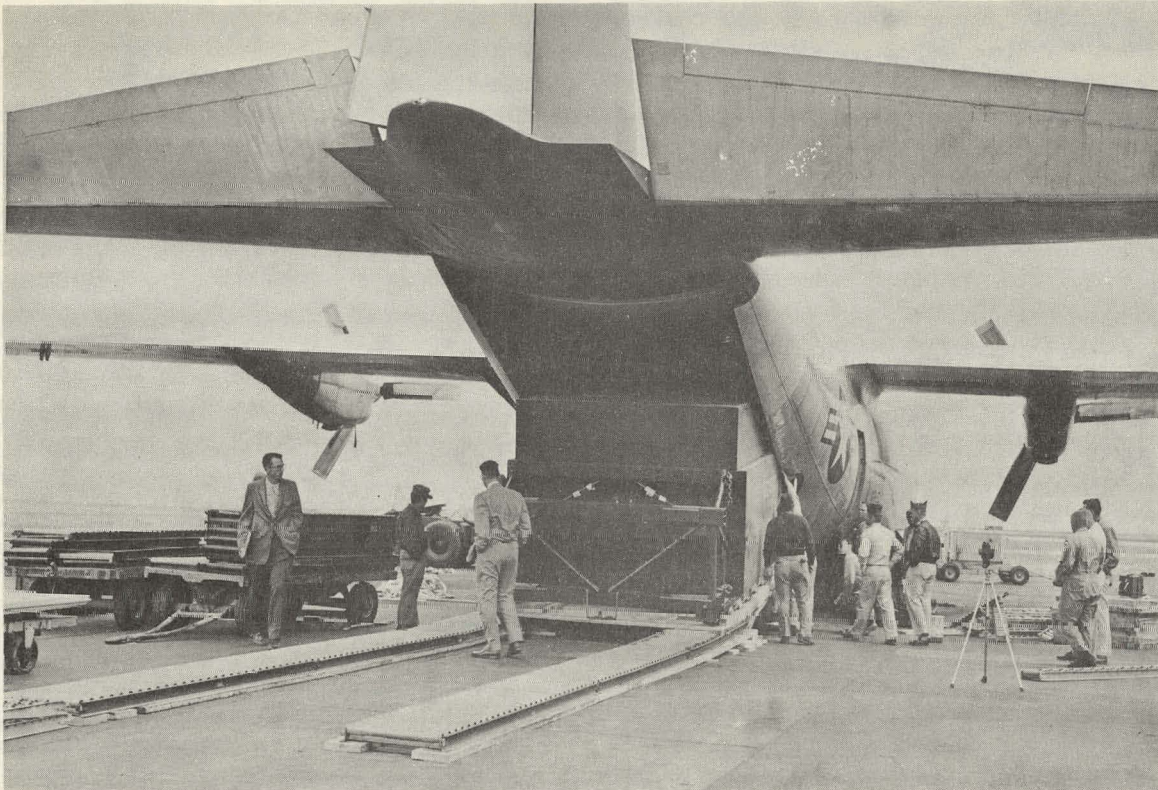


Figure III-1 : Loading power conversion mockup into C-130

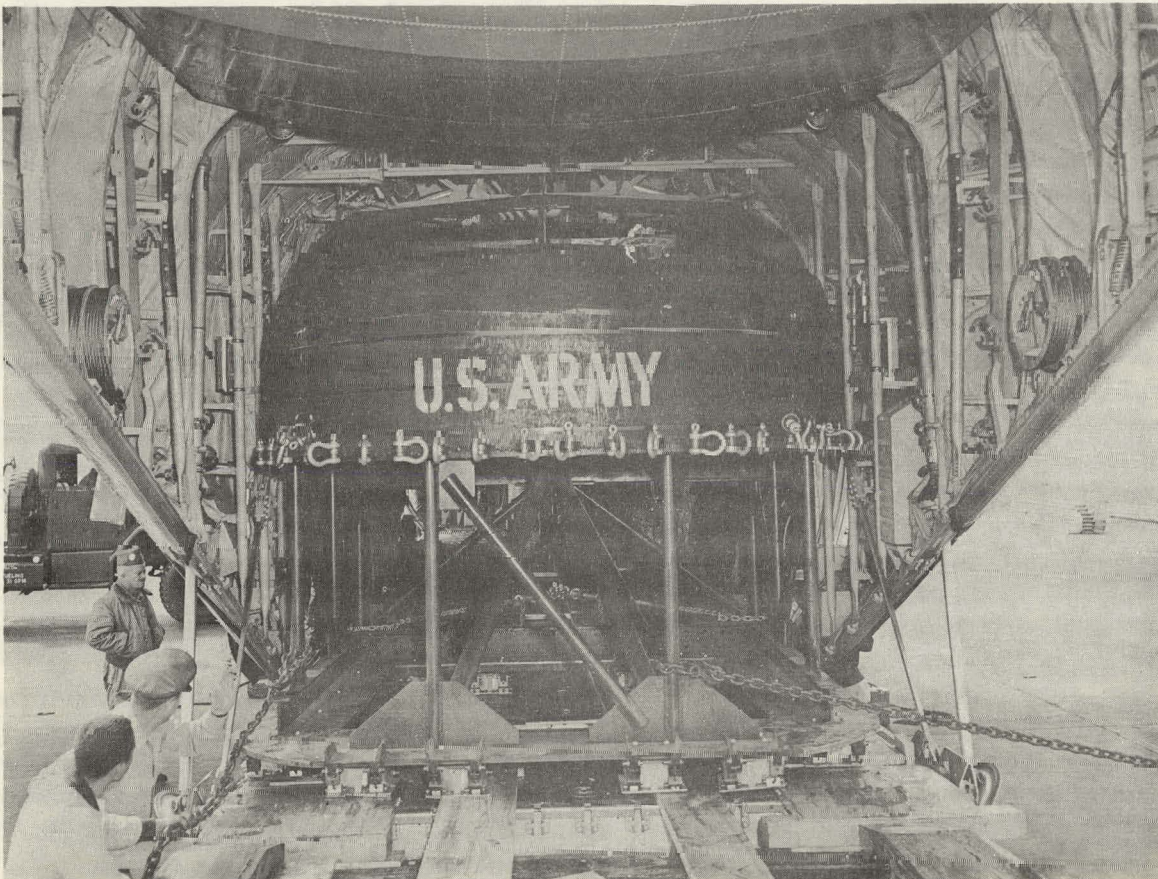


Figure III-2 : Loading reactor mockup aboard C-130

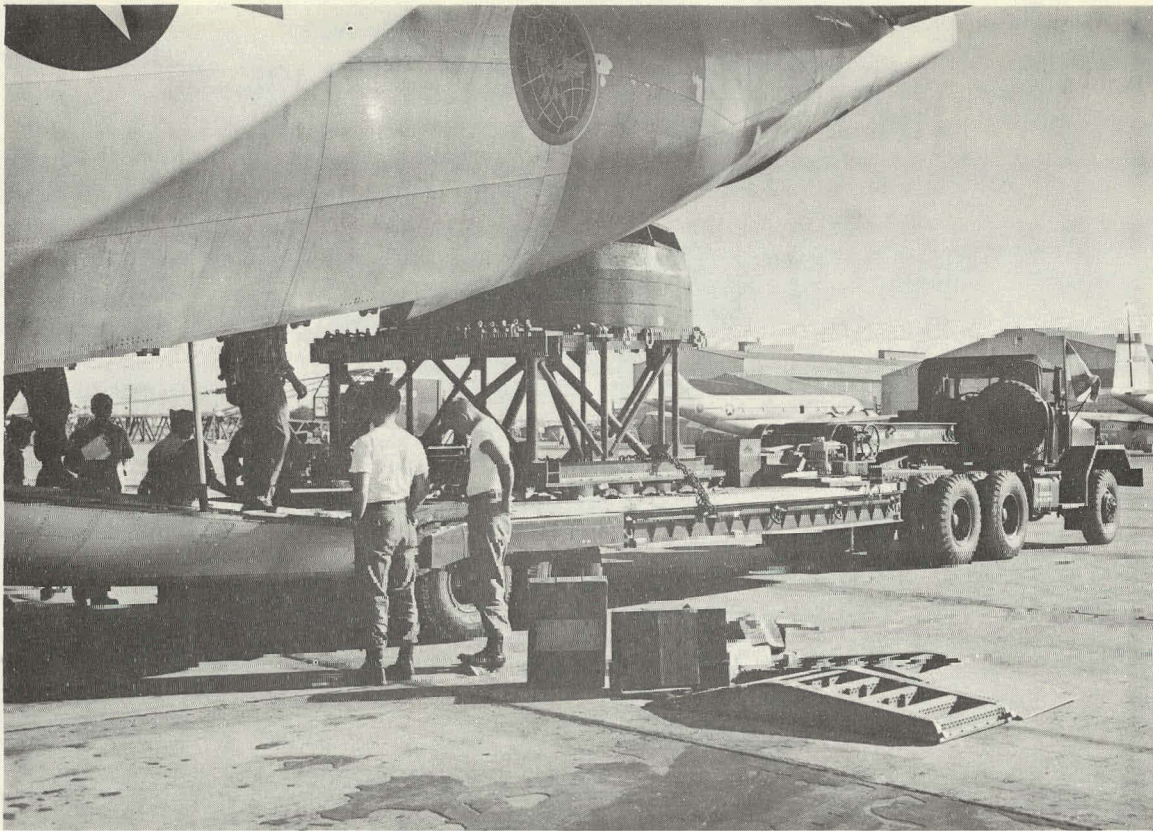


Figure III-3 : Loading reactor mockup aboard C-133

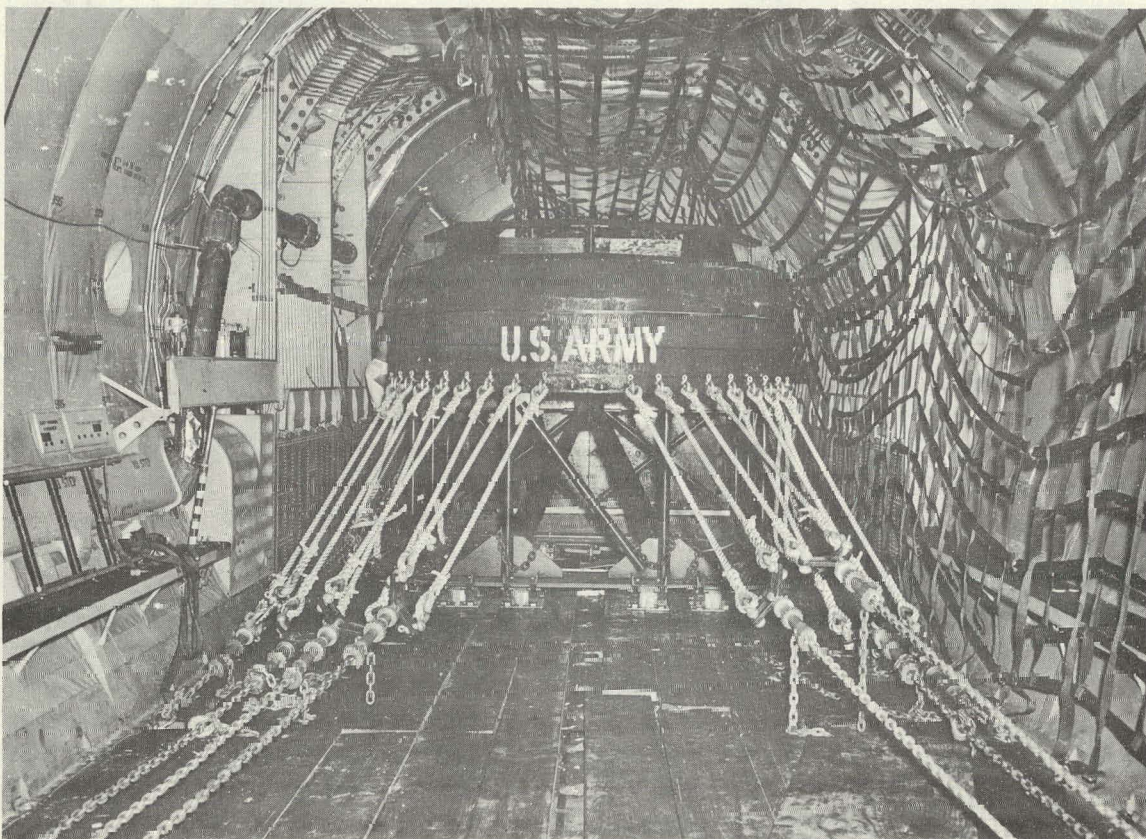


Figure III-4 : Mockups tied down inside C-133

LOADING ML-1 ABOARD C-124 AIRCRAFT



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IV. RAILROAD SHOCK TESTS

These tests were performed for two purposes: 1) to determine the effectiveness of the tiedown system for shock reduction under severe railroad switching and "humping" operations; and 2) to simulate an aircraft emergency landing and establish the effectiveness of the tiedowns during such a landing.

The tests were conducted on the San Ramon spurline of the Southern Pacific Railroad Company, during the last two weeks of October 1959.

A. SWITCHING AND "HUMPING" TESTS

During these tests, the reactor mockup was coupled to the power conversion mockup, and the two packages were tied down as one unit on a standard flatcar (See Figure IV-1). Sixteen nylon ropes, each 7 ft long, secured each end of the mockup to the flatcar. Six short lengths of nylon rope restricted sideways motion. When the packages were on the flatcar, the specifications of the Berne Conference Standard Clearance Diagram for European 4-ft-8½-in.-gauge railroads were satisfied.

1. Instrumentation

A complete set of electronic and mechanical devices was installed on the test flatcar and on the reactor mockup. Accelerometers measured the horizontal, vertical, and transverse accelerations of both the package and the flatcar. A dynamometer measured the tension in a typical nylon rope. The readings were recorded by a high-speed camera (about 400 frames per second). Scratch gauges measured the displacement of the package along the bed of the flatcar and the vertical motion of the package relative to the car. Horizontal and vertical motions were also recorded on an optical recording oscillograph. The velocity of the impacting car at the moment of impact was determined by a series of micro-switches mounted alongside the track, activated by a bracket on the impacting flatcar. See Figure IV-2). Two mechanical impact meters were provided by Southern Pacific to correlate the impact on the car and on the package to the impact measured by the electronic equipment. A detailed description of the instrumentation is presented in Appendix C.

2. Test Procedures

Fifty runs were made in the first test series. In the final 12 runs, the number of nylon ropes was reduced by one half

when it became apparent that the load on the ropes was much less than had been anticipated in the tiedown design. Four runs were made with the test car moving; all other runs were made with the test car stationary.

Tests were performed under a variety of conditions as speeds and weights of impacting loads were altered. The test conditions are summarized in Table IV-A-1 at the end of this section.

3. Test Results

a. Acceleration Data

Figure IV-3 indicates the shock reduction achieved at various velocities. The data are obtained from a curve drawn for Conditions 3 through 7. Conditions 1 and 2 were eliminated from consideration because the flatcar and the mockup accelerations were quite low as a result of the lower impact weights and ungreased shoring. In no case did the measured impact on the package exceed 2.5 g, although the measured value of the flatcar acceleration exceeded 15 g in several runs.

The vertical acceleration on the test car reached a peak value as high as 11.5 g, which was reduced to less than 1.0 g on the test package by the shock mounts. In only one run did the vertical acceleration on the package reach a value as high as 1.4 g.

b. Comparison of Greased and Ungreased Shoring

The first 13 test runs were performed with ungreased shoring (Condition 1). Because of the increased frictional drag, values for the nylon rope tension were approximately 250 lb less than those for the greased condition at a given velocity. (See Appendix C for detailed discussions and illustrations.) No package movement was noted until the impact velocity exceeded 4 mph (with 1000 lb pretension in the nylon ropes). The longitudinal movement of the package was less on ungreased shoring than on the greased shoring. At 6 and 12 mph, "ungreased" movements were, respectively, 2/3 and 1/3 less than comparable "greased" motions.

Typical of the early tests was Run 2, in which the refrigerator car struck the test car at a speed slightly over 5 mph. The maximum horizontal acceleration of the test car was 2 g, while the reactor and power conversion mockups experienced an acceleration of 1 g. The vertical acceleration of the railroad car was 1.1 g; this was reduced to 0.25 g by the shock mounts. The shock load on the mockups was higher than under the ungreased conditions.

The principal disadvantage of ungreased shoring was that the package did not return to the zero position. Successive "humpings" might necessitate periodic repositioning of the packages to equalize tensions in the nylon ropes.

c. Analysis of the Tiedown System

The tiedown system as originally designed con-

sisted of 44 restraints: 16 fore, 16 aft, and 12 lateral (See diagrams in Appendix C). The design load per rope was 15,000 lb. Tests of the rope indicated that it had a breaking strength of 30,000 lb. The first 38 test runs showed that the number of ropes could be reduced significantly, since rope tension recorded in these tests never exceeded 6000 lb. Accordingly, the number of tiedowns was halved: 8 fore, 8 aft, and 4 lateral (2 on each side of the package).

The only appreciable difference noted by this change was an increase in package displacement on the test car. The tension on the nylon ropes also increased. The maximum tension recorded was 11,000 lb, slightly more than 1/3 of the measured breaking strength of the rope. The shock isolation properties of the system were similar for both the full- and half-complements of tiedowns. The total energy absorbed by the nylon ropes was also about the same in both cases, although there was a corresponding increase in package displacement as the load per rope doubled.

The tension data, as recorded by the high-speed camera, are plotted in Figure IV-4. A straight-line relationship was noted. Points falling above the curve by more than 10% are considered to be erroneous. These points resulted from the fact that the maximum reading needle on the dynamometer was thrown off-scale on sharp impacts. The Master Data Sheet in Appendix C contains data on the tensions as they were recorded.

d. Package Displacement

The package displacement on the flatcar is tabulated in the Master Data Sheet. Fore, aft, vertical and lateral displacements were measured by scratch gauges. Time relationships were determined from the oscillograph charts. A detailed analysis of the data indicated that the package did not oscillate in the fore and aft directions, even when the package was on greased shoring. The damping effect of the nylon rope and the surface friction of the shoring combined to restrict the package motion. Longitudinal displacements occurred in periods ranging from 0.12 to 0.25 sec. The return to the zero position required a much longer time, generally twice the times given above. The final position of the package was usually 0.5 to 2.0 in. short of its initial position. In several of the runs, where impact shock was of short duration and high amplitude, the package overshoot the zero position on its return.

e. Impact Frequencies

Impacting conditions caused input frequencies to vary over a moderate range. In addition to the large input shock from the original impact, high frequencies (ranging from 130 to 400 cps) were measured. Vertical frequencies were found to vary from 125 to 220 cps. All high value horizontal frequencies were completely damped out. The vertical frequencies were damped to a range of 7 to 50 cps. The wide variation in input frequencies is attributed to the friction-type draft gears on the railroad flatcar.

B. SIMULATION OF AN AIRCRAFT EMERGENCY LANDING

The purpose of these tests was to simulate, as nearly as possible, the conditions encountered in an aircraft emergency landing, as outlined in MIL Spec 8421-A. (See Appendix E.) To simulate the mass of a C-130 aircraft, a refrigerator car was coupled to the flatcar. Since the normal carrying capacity of the aircraft permits carrying only one package, the reactor mockup was removed from the flatcar. (See Figure IV-6.) Eight tiedowns were used for forward restraint; four, for aft restraint. This configuration duplicated aircraft tiedown arrangements. Greased shoring was used throughout the tests to duplicate normal aircraft loading techniques.

Wood blocks were placed between the rail car couplings to lengthen the pulse duration. These blocks fulfilled their purpose in making the impact pulses longer; however, they added an uncontrollable factor which made data correlation difficult. The wood did not compress exactly the same way in any two runs, and undoubtedly caused the flatcar draft gears to give more variable results than during the switching and humping tests described in Section A. Data from the simulated landing test series are more scattered than those from the switching tests.

To determine whether or not the specifications of the tests were met, an equivalent time was calculated for each horizontal pulse. This equivalent time was defined by measuring the area under the trace on the oscillograph chart from the moment the pulse originated to the point where the "faired in" curve crossed the horizontal axis. The pulse duration for an equivalent versine curve, (i.e. a curve with an area equal to the area of the actual pulse) was calculated, using the peak of the "faired in" pulse as the amplitude of the versine curve. In one run, this peak was 8 g, and the equivalent time was 0.099 sec. Pulses of 11.3 g for shorter time durations (0.085 sec) were also recorded. The maximum horizontal acceleration of the package was 2.4 g. Thus, the specification for emergency landings was satisfied. (See Appendix D.)

Chains were substituted for the nylon ropes in the last four runs of the series, so that the performance of both tiedown systems could be compared. The effects of this substitution were to reduce the extent of the package displacement and to increase the amount of shock transmitted to the package. (See Figure IV-7.)

In a typical run with nylon tiedowns, the overall displacement of the package on the flatcar was 25.4 in., at an impacting-car speed of 13.8 mph. In a similar run (at 11.1 mph) with chain tiedowns, the overall displacement was 3 in. In another run (at 16.6 mph) with chain tiedowns, the displacement was 7.25 in. The relatively large displacement was caused by the condition of the shoring, which had been crushed and splintered by the action of the chains. The shock transmitted by the chains, even when buffered by the wood shoring, was greater than that transmitted by the nylon ropes, twice as great in some cases. An absolute comparison between the two systems was not possible due to the configuration of the flatcar.

TABLE IV-A-1
RR "HUMPING" AND SWITCHING TEST

CONDI- TION	NO. OF RUNS	RANGE OF IMPACTING VELOCITIES MPH	NO. OF IMPACTING CARS	WEIGHT OF IMPACTING CARS LB	SLIDING SURFACE ON FLATCAR	NO. OF NYLON RESTRAINTS				NO. OF CARS USED FOR BACKUP FOR ML-1
						FORE	AFT	LATERAL	TOTAL	
1	13	5 - 10.6 7.3 - 12.5	1	60,000	Ungreased	16	16	6	44	None
2	8	5.4 - 13.9	1	60,000	Greased	16	16	6	44	None
3	4	4.4 - 8.7	1	169,000	Greased	16	16	6	44	4 ~ 24,000 lb.
4	4	5.6 - 10.0	5	396,000	Greased	16	16	6	44	4 ~ 240,000 lb.
5	4	7.2 - 12.5	ML-1 4 stationary cars	Impacting	Greased	16	16	6	44	None
6	4	4.2 - 10.0	1	169,000	Greased	16	16	6	44	None
7	11	7.2 - 14 +	1	169,000	Greased	8	8	4	24	None

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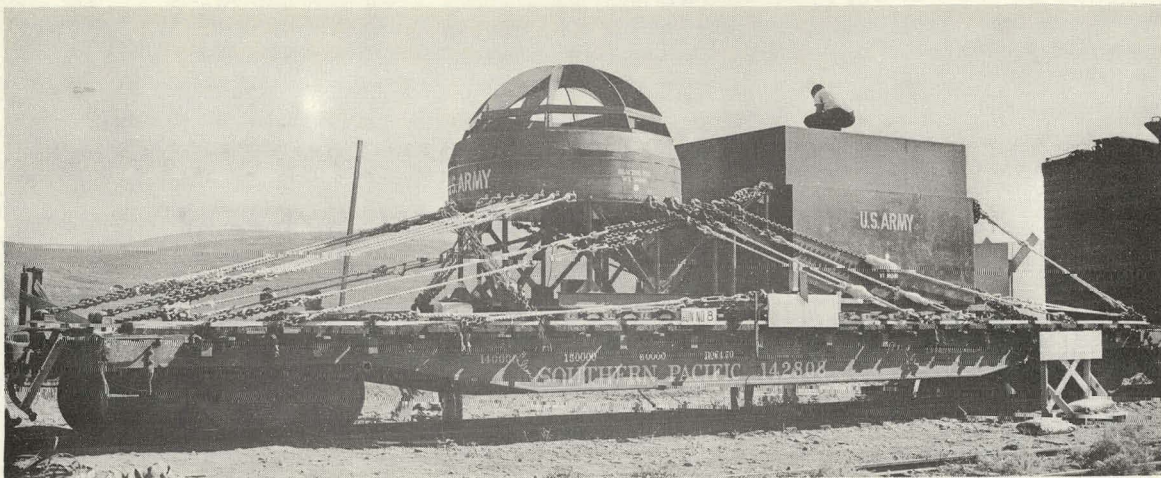


Figure IV-1 : Mockups tied down on railroad flatcar

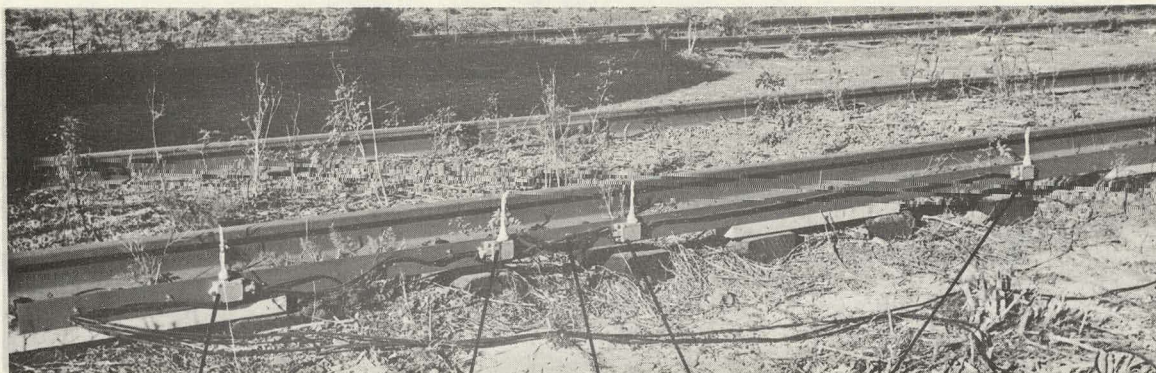


Figure IV-2 : Velocity switch locations

SHOCK REDUCTION RAILROAD SWITCHING ML-1 SHOCK ISOLATION SYSTEM

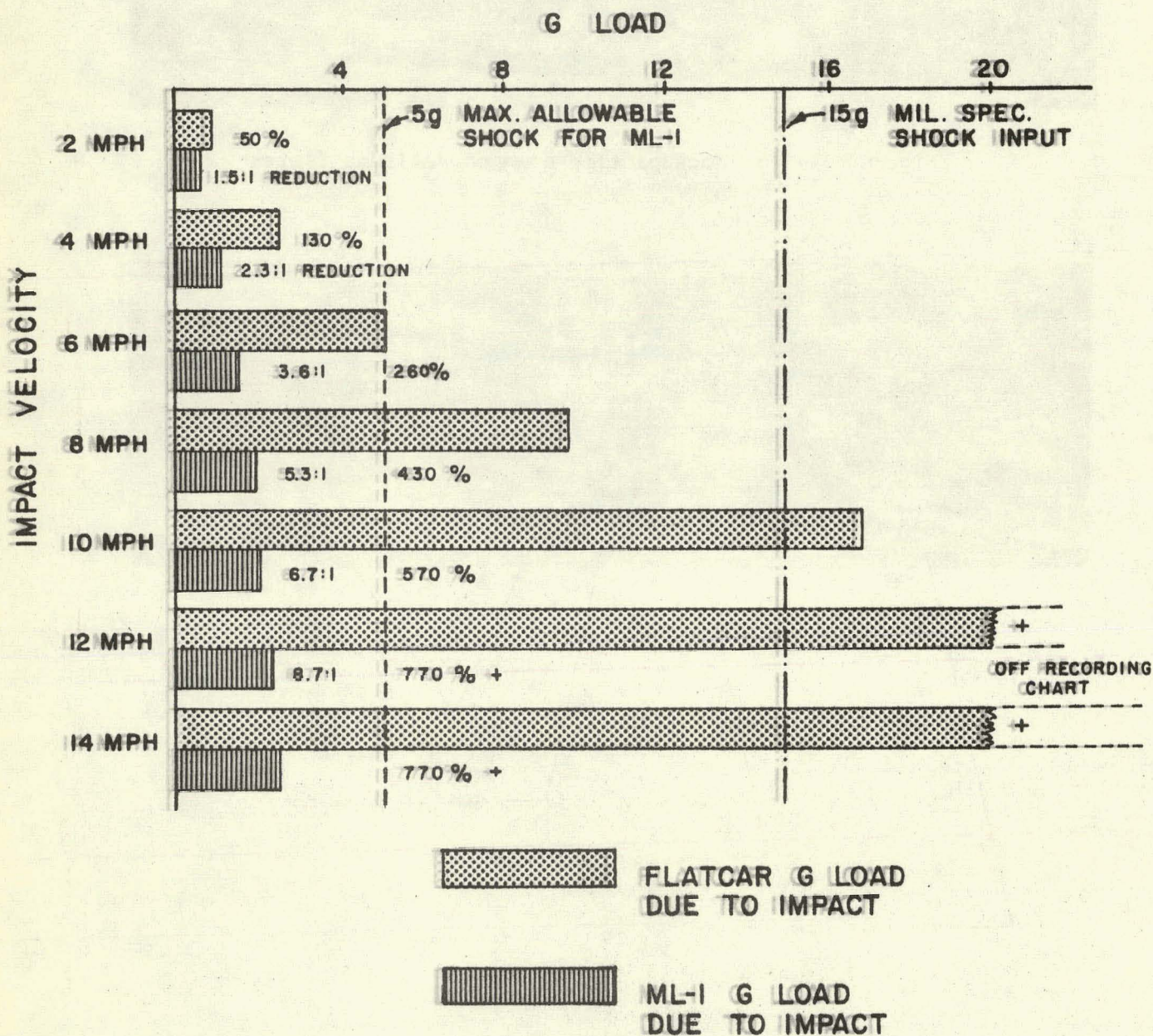
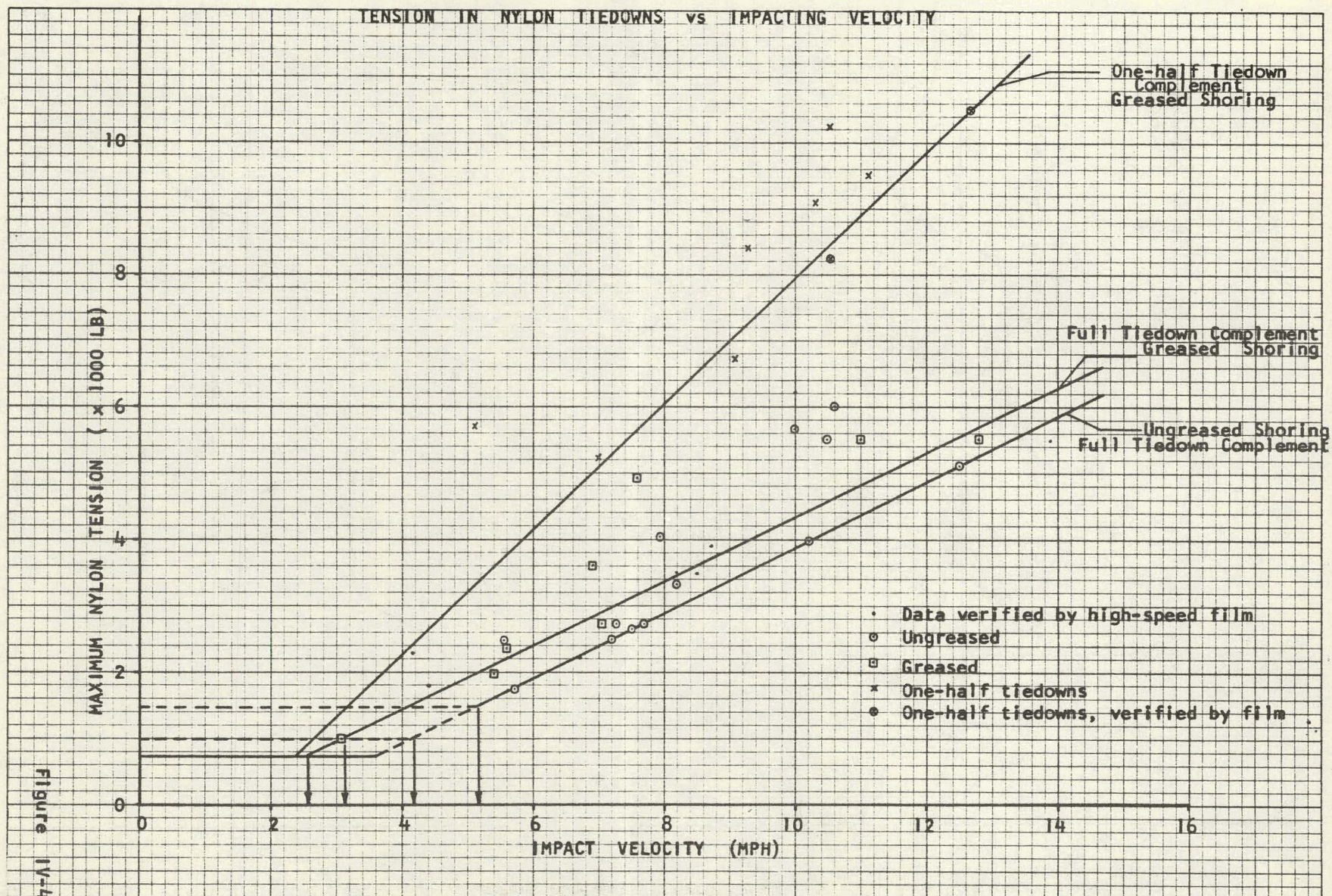


Figure IV-3



TYPICAL LONGITUDINAL DISPLACEMENTS

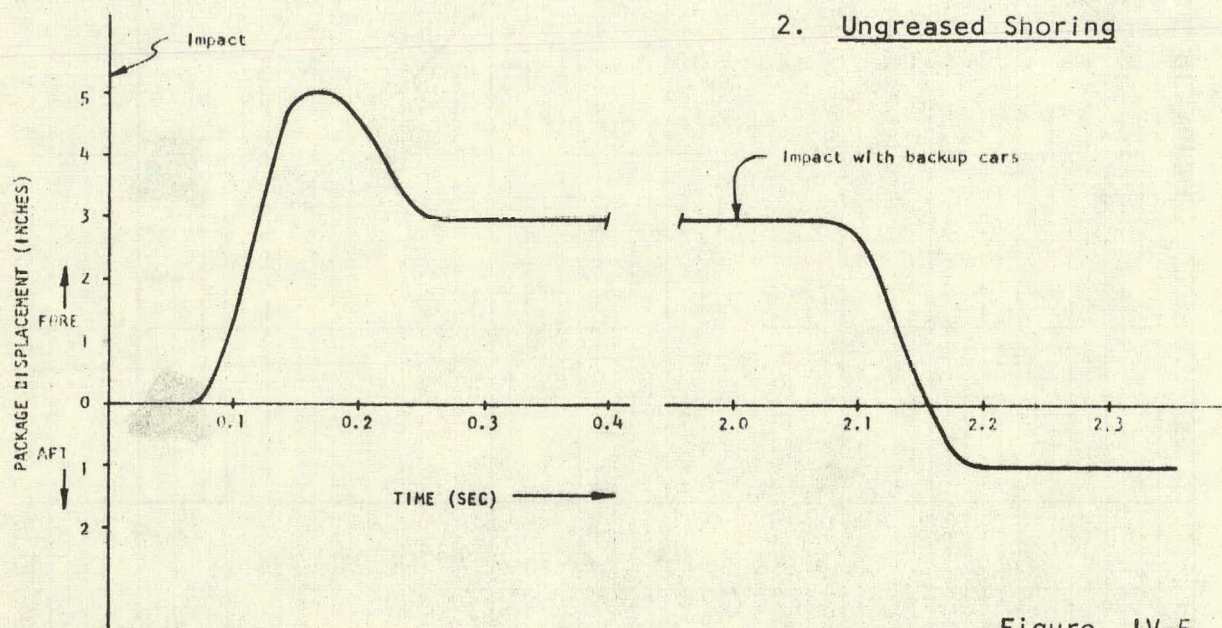
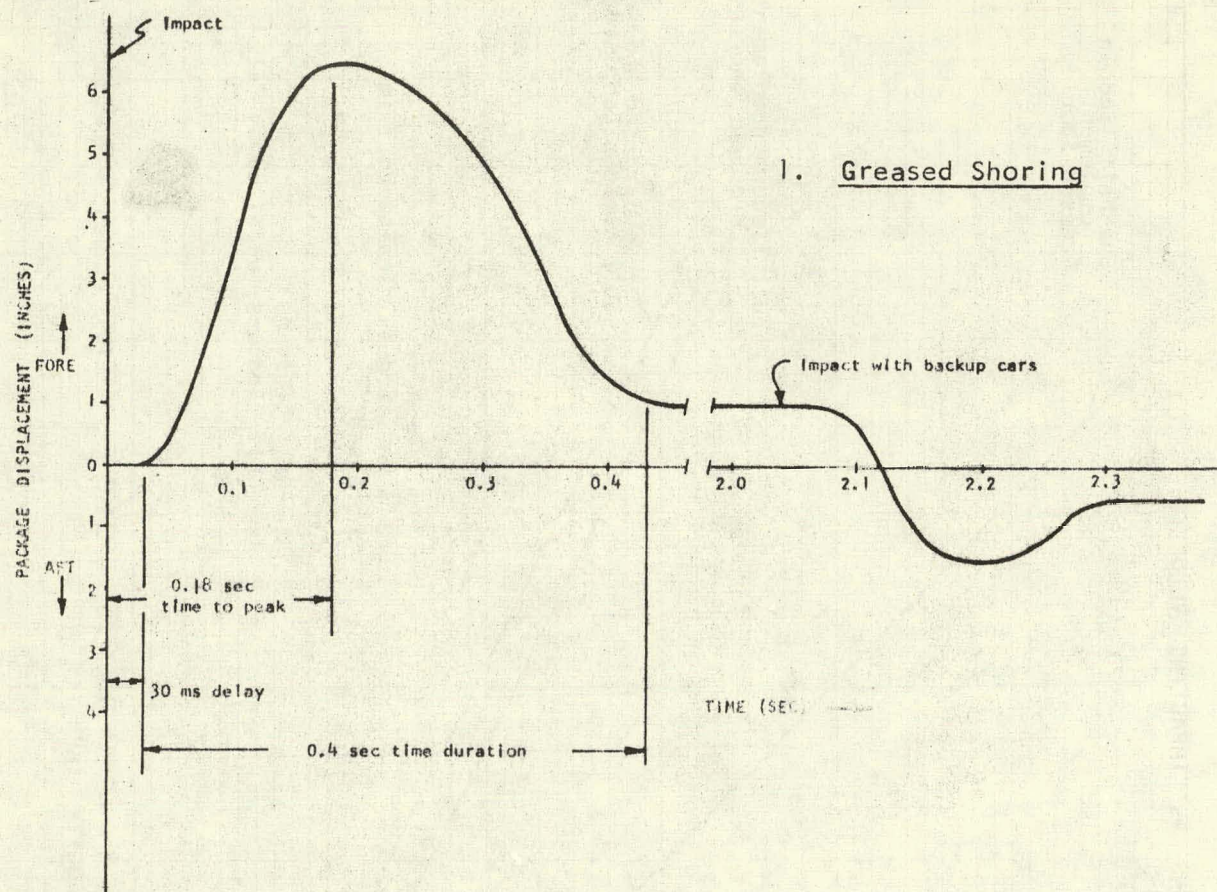
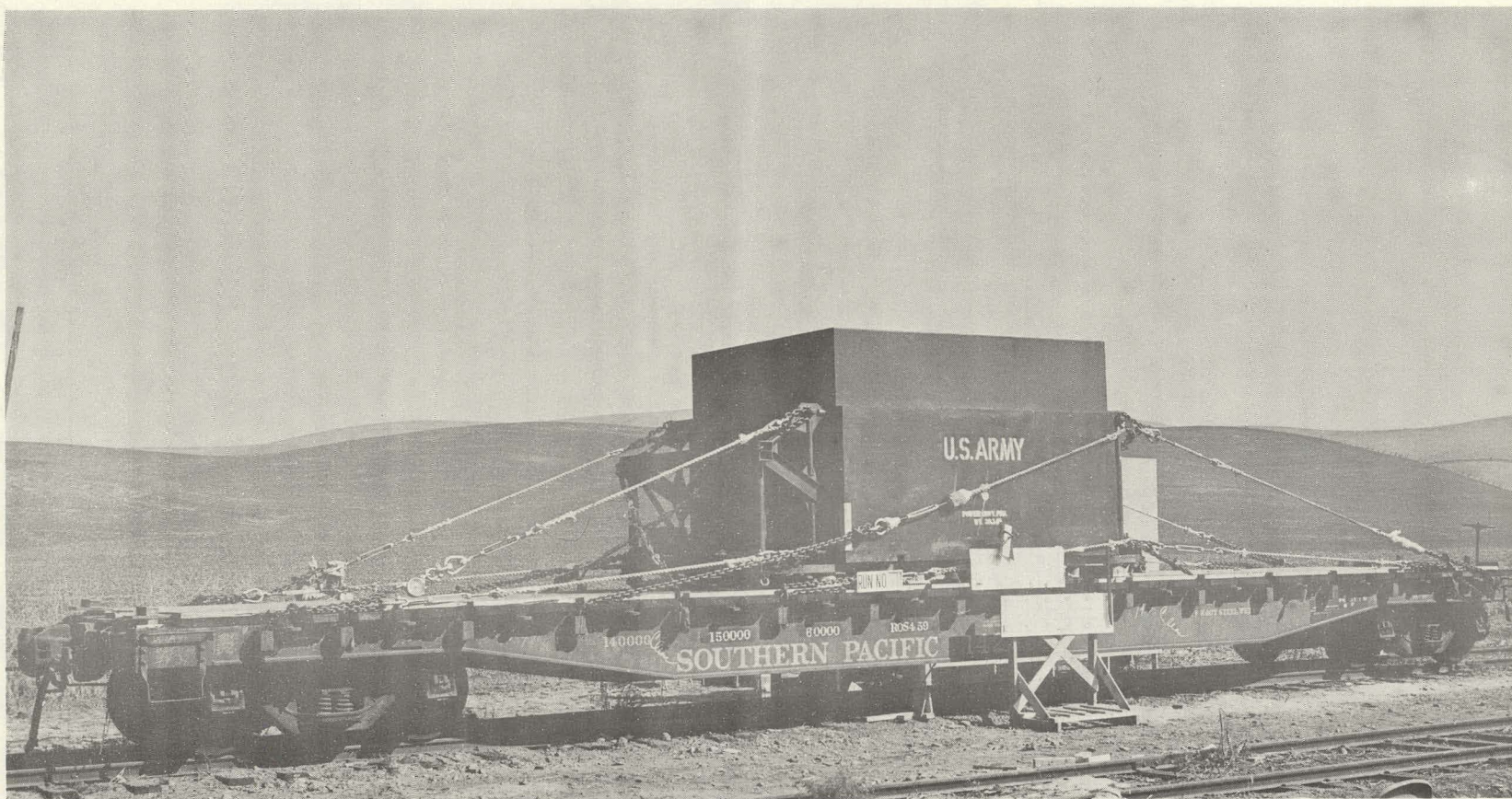


Figure IV-5



Setup for simulated aircraft emergency landing tests

COMPARISON OF SHOCK REDUCTION PROPERTIES — NYLON ROPE AND CHAIN TIEDOWNS

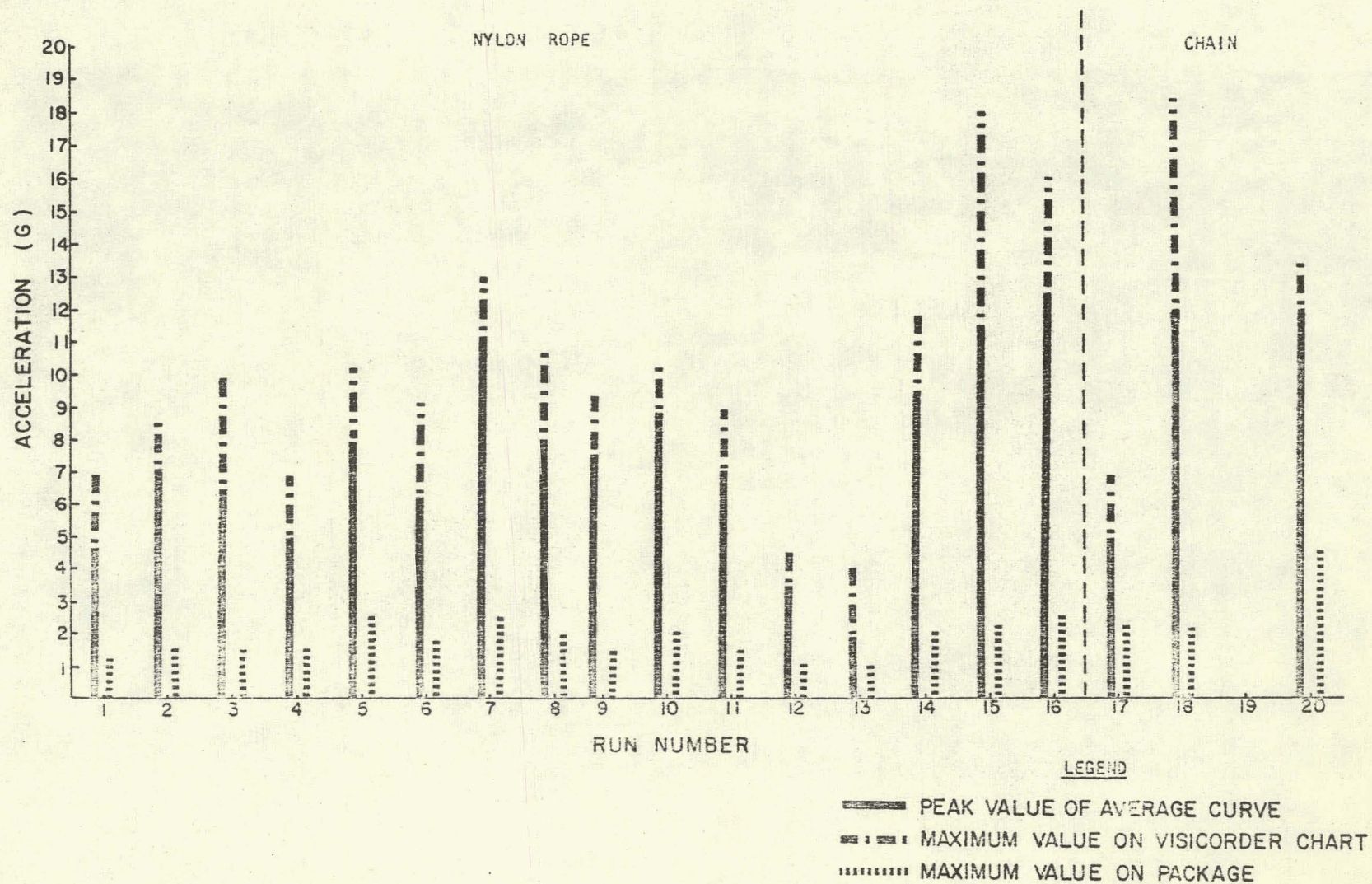


Figure IV-7

V. COMPONENT TESTING

Tests of both the shock mounts and the nylon rope used in the tie-downs were conducted at Aerojet's laboratories in San Ramon, and at Stanford University, Palo Alto, California. These tests were conducted to determine static and dynamic properties under various environmental conditions. The tests began in July 1959 (to obtain data on which to base the shock mount design) and were completed in February 1960.

A. SHOCK MOUNTS

Because limited performance data were available on the silicone rubbers proposed for the shock mounts, it was impossible to select material of appropriate hardness without first carrying out a screening program. Initially, six test pieces, with hardnesses of 40, 50, and 60 durometers, were subjected to static and dynamic tests at an ambient temperature of 75°F. The 60-durometer specimen appeared to have the best properties for the shock mount application, and further tests were made on this material. Eventually, it was selected for use in the shock mounts.

Test procedures and results are described in this section. Several important conclusions drawn from the overall testing program are listed below:

1. Sixty-durometer silicone rubber offers the best shock isolation properties of the samples tested.
2. The shock mounts withstood compressive loads up to 50,000 lb, and shear loads of 2,000 lb (at an initial compression of 1/2 in.).
3. For full-scale dynamic operation, the frequency response of the shock mounts varies from 4-13 cps.
4. Shock mount energy dissipation for first impact of the shock load was 65-70%; this represents an 11% equivalent viscous damping coefficient.

5. Throughout the testing program, both in the field and in the laboratory, the shock mounts did not transmit vertical shock loadings over 3.4 g, although the actual shock inputs were greater than anticipated.

1. Dynamic Tests

- a. Procedures

The shock mounts were first tested dynamically by a special machine (see Figure V-1). A 100-lb weight, dropped from 1- to 10-ft heights, simulated the shock mount action during relatively high shock loads. (During the field tests, the weight of the combined mockups was distributed so that each shock mount experienced about 1875 lb.)

Tests to determine the dynamic properties of the shock mounts in the performance range of -65° to $+150^{\circ}$ F were conducted on the equipment used to test the nylon rope after some modifications were made to accommodate the shock mounts. (See discussion of rope tests, below.) Since the machinery dropped a 332-lb weight (as compared to the 100-lb weight used in the above tests) from various heights, it was possible to correlate variations in strain rate with shock transmitted through the shock mounts to the package. Tests were conducted to determine the amplification of the shock mounts. This amplification is defined as the apparent increase in stiffness of the shock mount from the static response, when a shock is applied at a high strain rate. The shock mount material had a lower deflection at high strain rates for the same load; hence, the total energy absorption was less.

Forty-six drop tests were made on the experimental shock mounts, using a modified test fixture (see Figure V-2). The tests were conducted on shock mounts at temperatures ranging from -65° to $+150^{\circ}$ F.

- b. Test Results

Since the dynamic characteristics of the mounts were easier to analyze with respect to the energy of impact, a static load deflection curve was integrated, plotted, and compared with the dynamic response (see Figure V-3). This figure shows the correlation between the 100- and 380-lb test machines at 75° F. Both curves are compared to the static curve at 75° F. Increased amplification for the larger machine is a result of higher strain rates of testing. The dynamic amplification ranged from 20 to 70%. This means that with a given deflection, in the lower range of the curve 20% more energy can be applied than with a static load. Similarly, in the high range of the curve, 70% more energy can be applied. The amount of shock transmitted would be correspondingly greater. (These amplification ranges and transmissions were determined from the 100-lb drop-weight tests described above.) By comparing the amplification factors and the strain

rates producing these factors, a curve (Figure V-4) was plotted from which package performance was predicted. Actual full-scale operation ranges from no-amplification at low loads to 10% at higher levels. Corresponding data show the effect of temperature on amplification (see Figure V-5). These data were compared with experimental results from the full-scale mockup tests. Anticipated shock loads transmitted to the mockups at all operating temperatures were predicted (see Figure V-6). Data were obtained from component and full-scale mockup tests. The vertical transmitted shock is less than the maximum allowable under all conditions of operation and temperature.

The resonant frequencies of the mounts during component and full-scale tests are compared with the theoretical curve in Figure V-7.

Shock mount amplifications obtained from energy inputs from full-scale mockup tests on the railroad and trailer are compared to the static curve in Figure V-8.

2. Static Tests

Load deflection curves, based on the compression tests, were plotted for the three hardnesses of silicone rubber. When these curves were compared with the theoretical design curve, the 60-durometer material came closest to the curve (see Figure V-9).

The shear strength of the shock mount was determined at various compressive loads. The results are shown in Figure V-10. A comparison of the theoretical and 60-durometer curves shows that the experimental curve had properties superior to those anticipated. The shock mount was softer, and the curve almost linear at lower loads. The slope increased rapidly at higher loads. The mount was operating in shear at low deflections, giving good shock isolation and low-frequency damping. When high-compression loads were encountered (e.g. during the ramp phases of the loading operations) the major shock mechanism changed from shear to compression; thus, the shock mounts offer stiffened resistance to concentrated loads.

Figure V-11 shows that approximately 70% of the input energy was absorbed in the first impact of the falling weight, dropped from 6 ft onto the shock mount.

The shock mounts were subjected to compression and shear tests at ambient temperatures only. The material complied with the military specifications (MIL-R-5847C, Class 1) for low-temperature materials. The shock mounts were judged to have adequate properties in the -65° to $+150^{\circ}$ F range.

B. NYLON ROPE

These tests were conducted to determine the performance characteristics of nylon rope, under widely varying environmental con-

ditions. The important conclusions derived from these tests included:

1. The test results showed that, under all conceivable conditions of temperature and shock, the shock experienced by the ML-1 will never exceed the 5-g maximum allowable.
2. The energy dissipation for first impact of a shock load was 50-55%, an equivalent 8% viscous damping effect.
3. The ultimate strength of 1-1/8-in. nylon rope is within $\pm 5\%$ of 30,000 lb.
4. Dynamic amplification is independent of strain rate for the range tested and is increased with decreasing temperature.

1. Dynamic Tests

A total of 77 test runs was made. Each run consisted of dropping a known mass from a known height onto a platform supported vertically by a nylon rope. (see Figure V-12.)

The platform displacement was measured with scratch gauges and an electronic transducer. The displacement was checked by a high-speed camera. A dynamometer and strain gauges were placed in series with the rope to measure the load as a function of time. The output of all transducers was recorded on a 14-channel oscillograph.

The runs were conducted at rope temperatures which varied from -65° to $+150^{\circ}\text{F}$. The data analysis indicated that the rope had adequate shock absorption properties over the entire temperature range. The nylon rope was in good physical condition after repeated cold temperature runs. The rope pretension decreased from 1000 to 600 lb with a corresponding temperature decrease from 70° to -65°F . Test results showed that the nylon tiedowns will have adequate tension if an aircraft should be loaded in temperate climates and then be flown to arctic regions.

The first series of impacts tested the dynamic response of 1-1/8-in. rope. Figure V-13 shows the amplification due to impact over static load deflection. Similarly, amplification factors were determined for the following temperatures: -65° , -30° , 0° , 25° , 75° , and 150°F .

The dynamic hysteresis curve is shown in Figure V-14.

Dynamic amplifications as a function of ambient temperature for the nylon tiedown system are shown in Figure V-15.

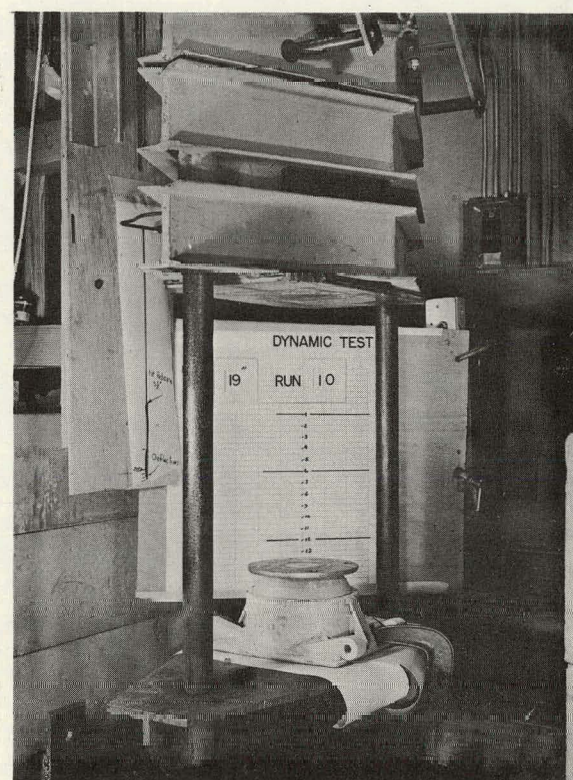
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Figure V-1

Equipment used for testing
shock mounts

Figure V-2
Apparatus for drop tests



DYNAMIC RESPONSE
60-DUROMETER SILICONE RUBBER

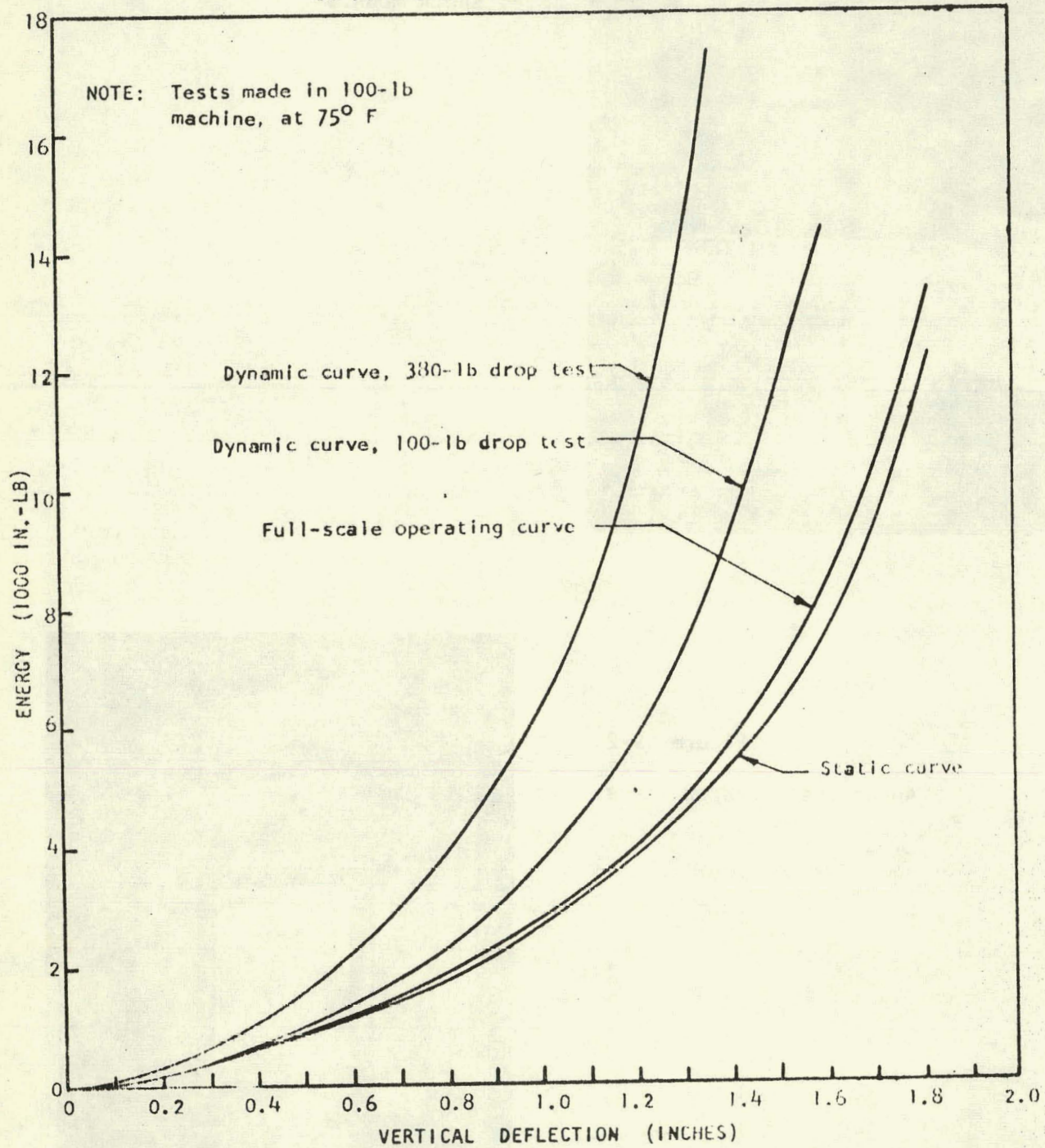


Figure V-3

DYNAMIC AMPLIFICATION vs STRESS RATE
SHOCK MOUNTS @ 75°F

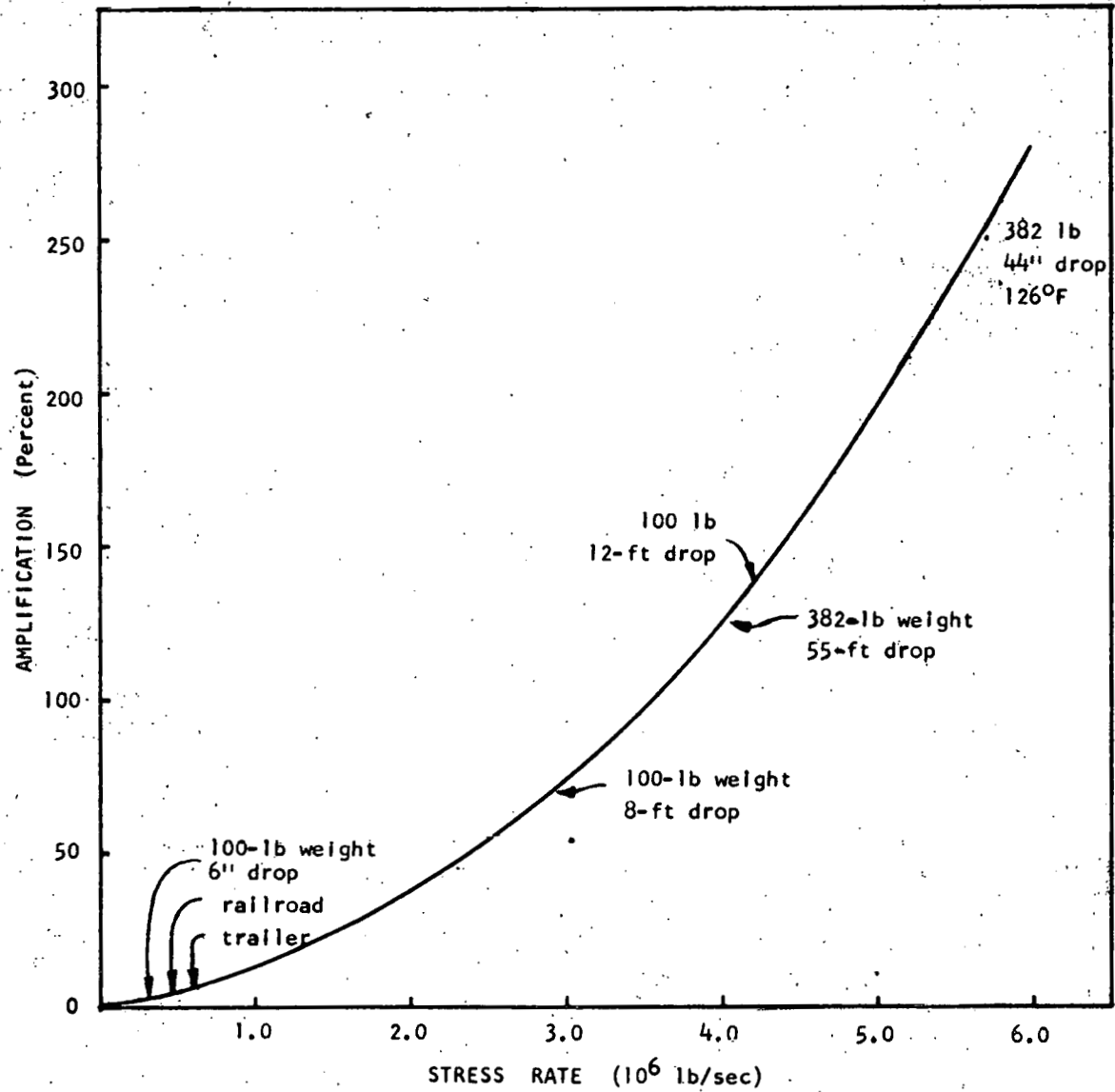


Figure V-4

DYNAMIC AMPLIFICATION vs TEMPERATURE

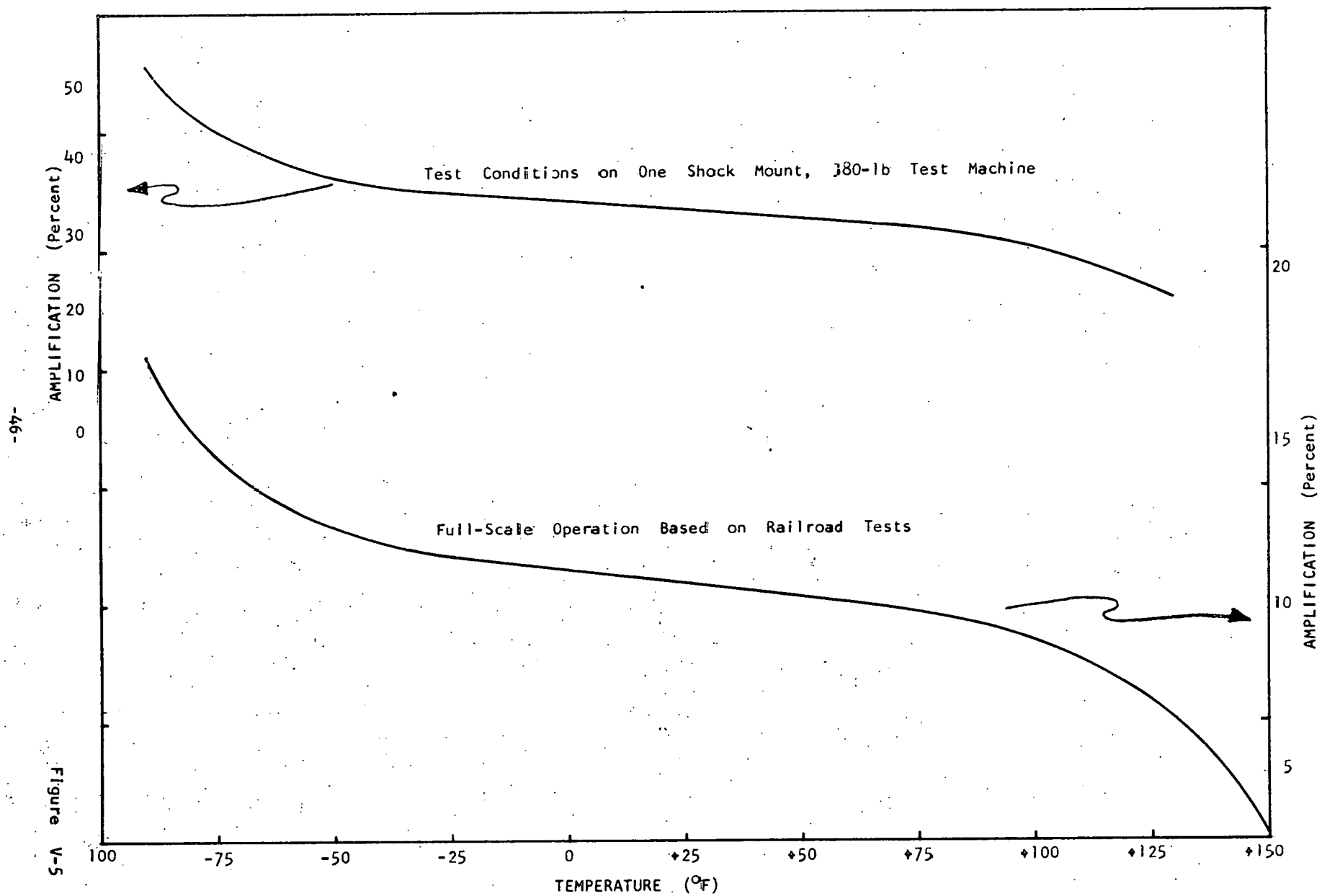


Figure V-5

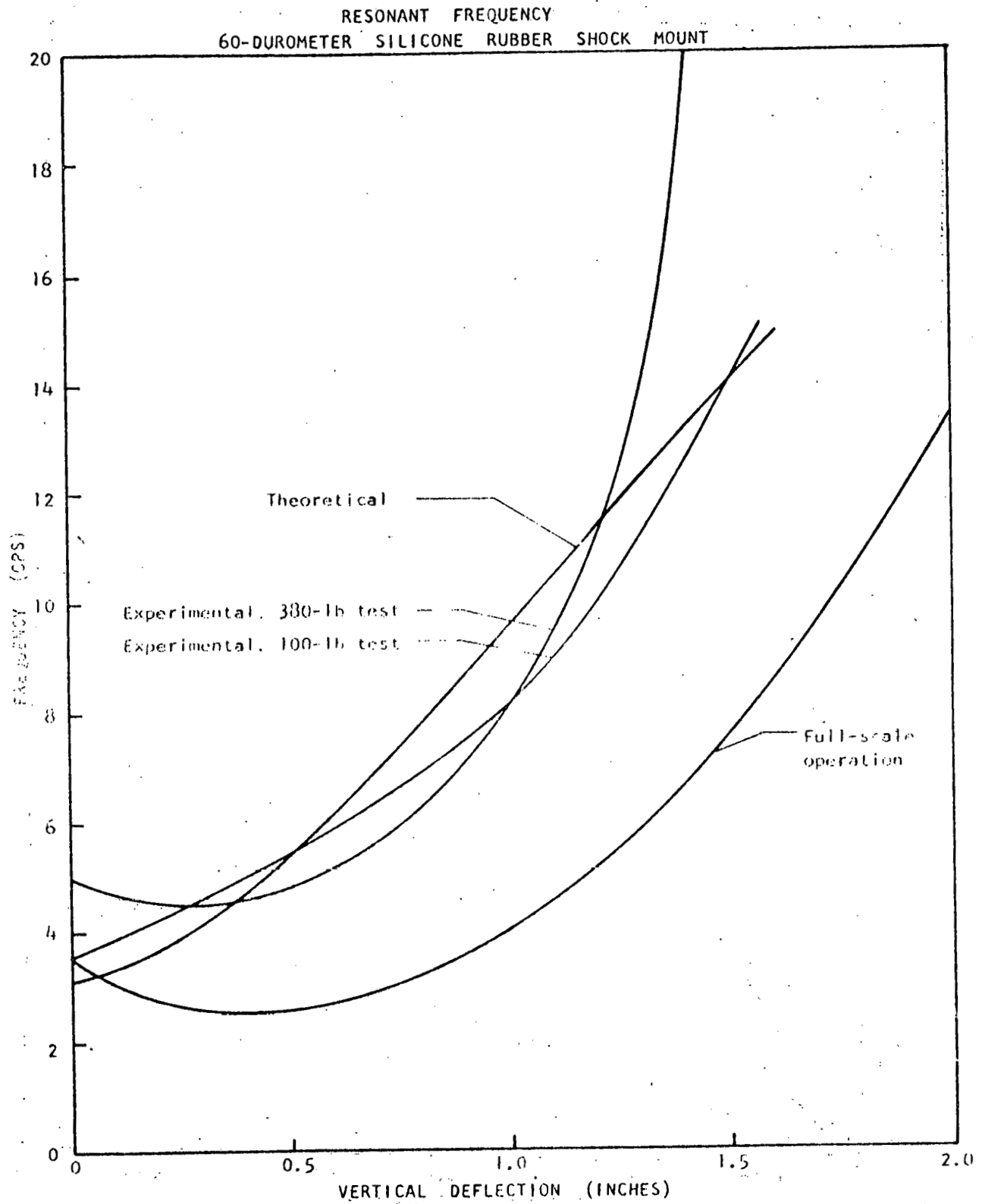


Figure V-6

SHEAR LOADING WITH VERTICAL PRE-SET
60-DUROMETER SILICONE RUBBER

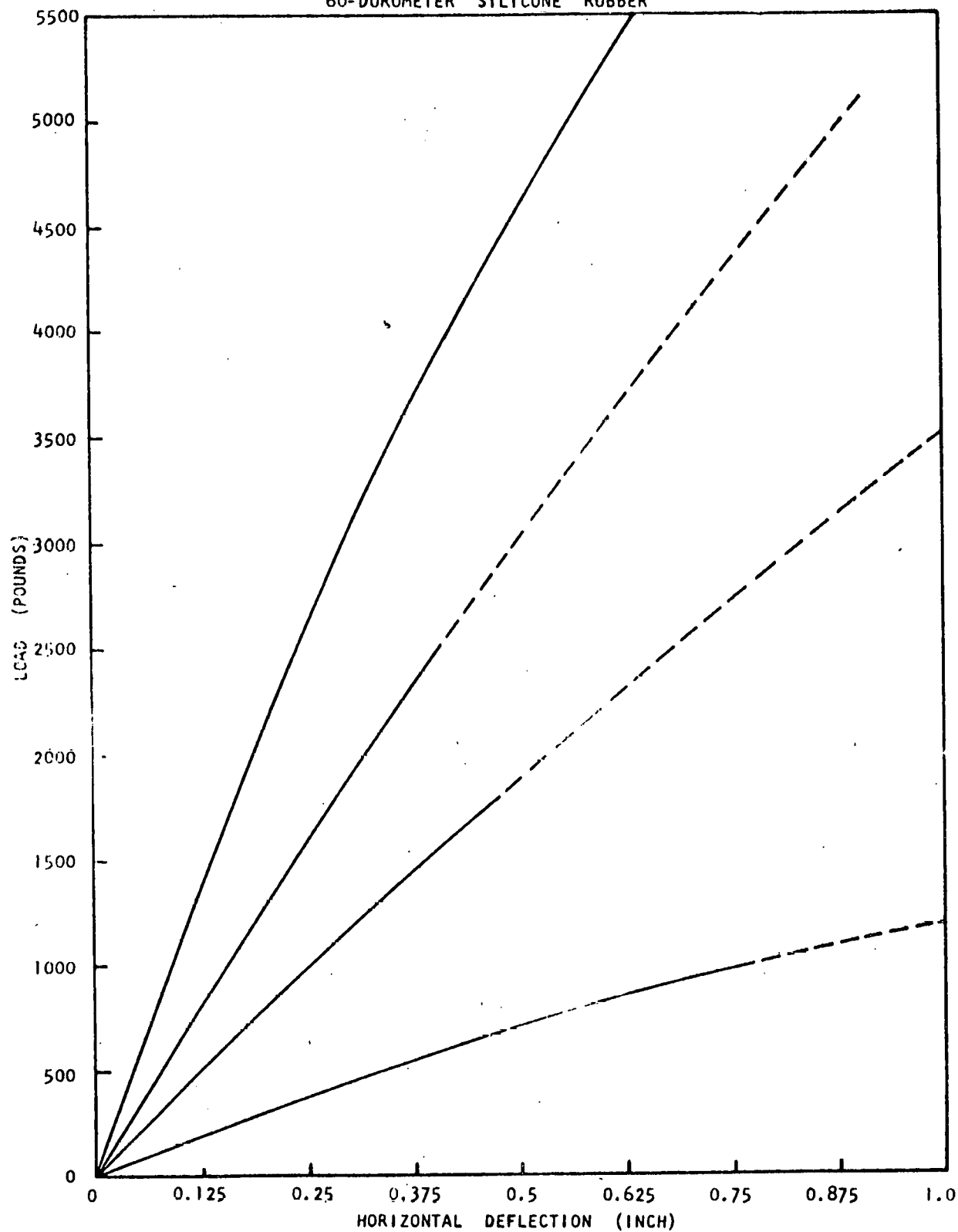
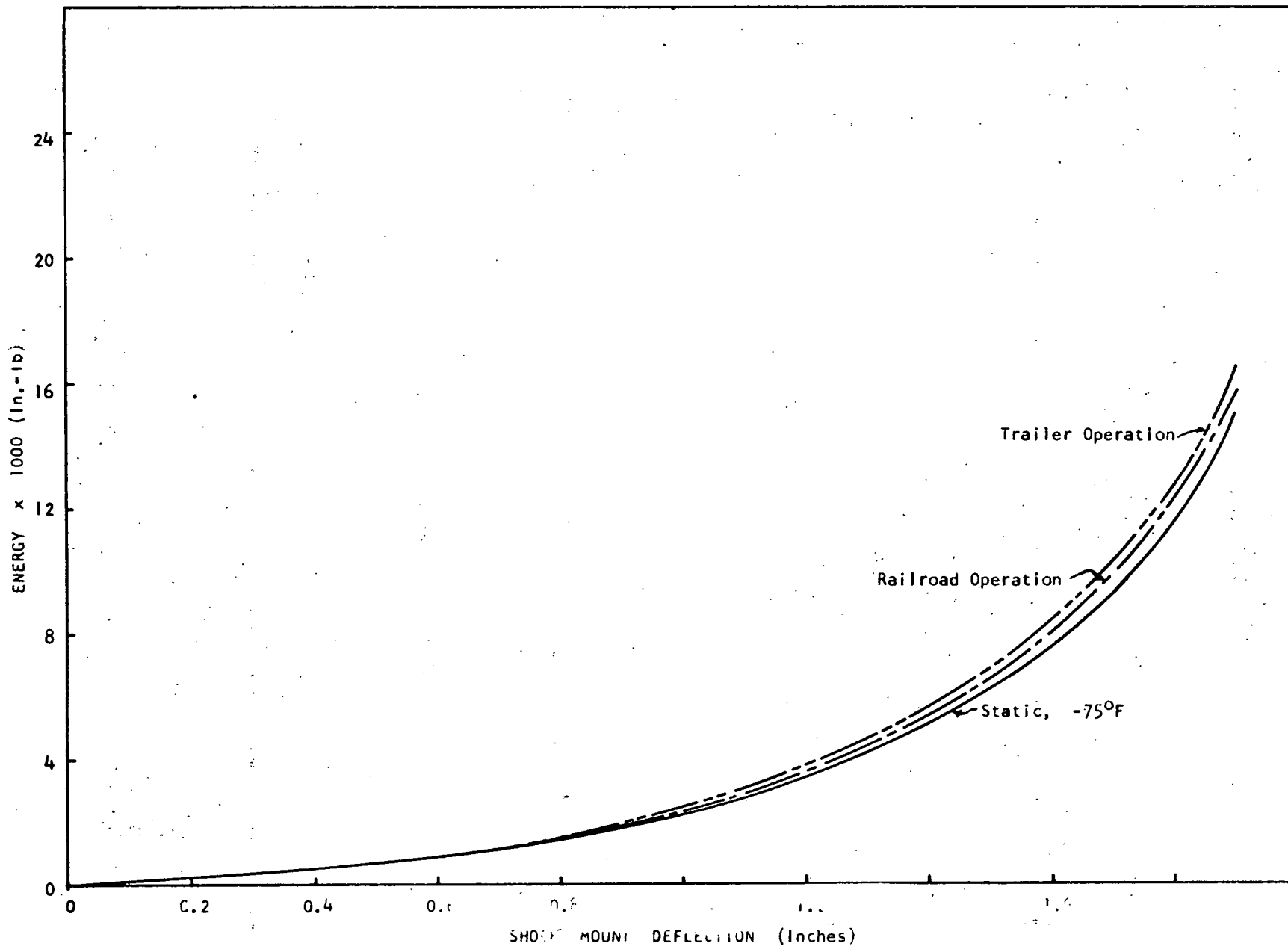


Figure V-7

ENERGY vs DEFLECTION
 SHOWING OPERATING RANGE OF MOUNT FOR RAILROAD & TRUCK HANDLING OPERATION (75° F)



-64-

Figure V-8

LOAD-DEFLECTION CURVES
7.75-in. OD SILICONE RUBBER INSERTS

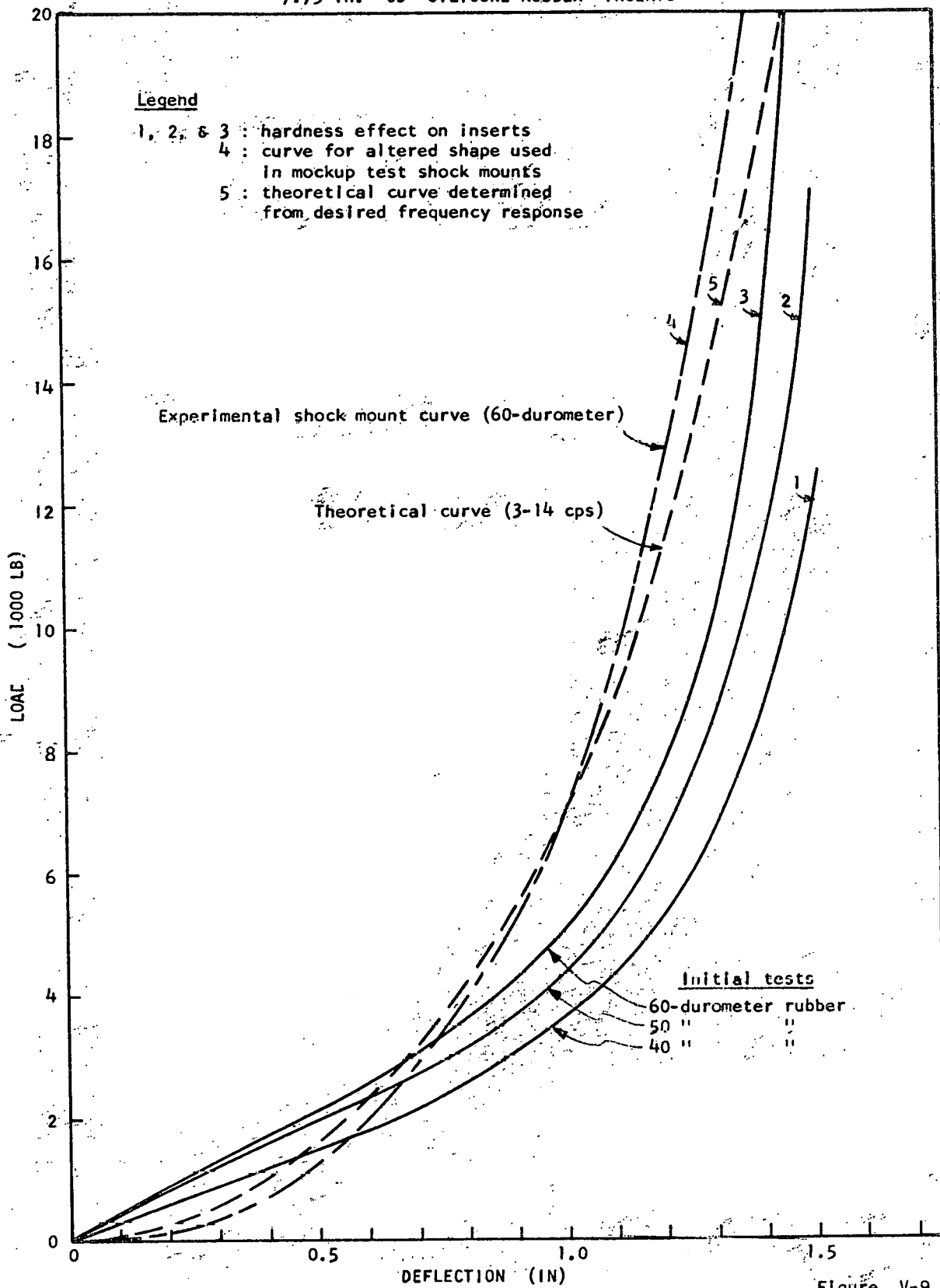


Figure V-9

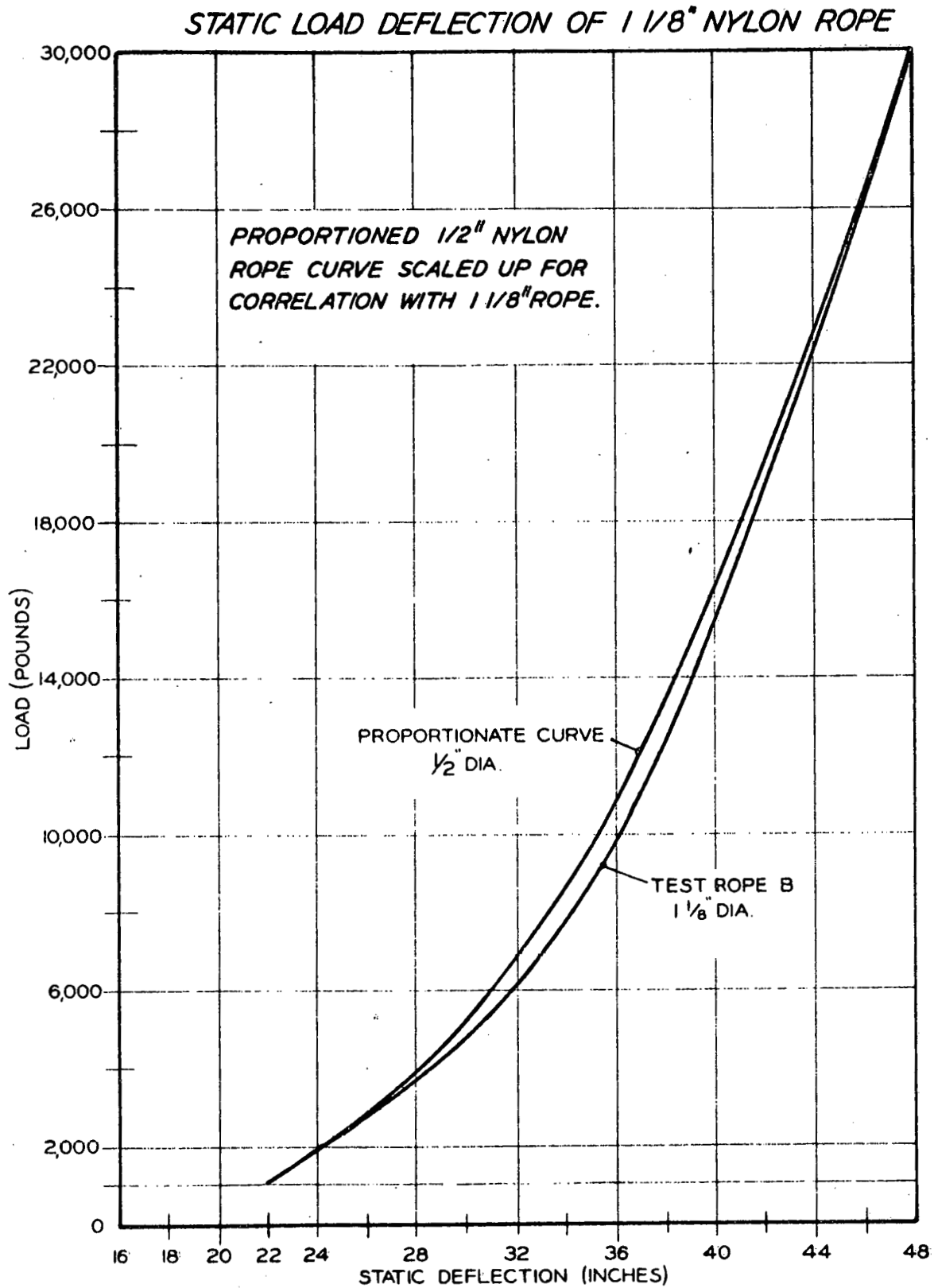


Figure V-10

***SHOCK MOUNT ENERGY ABSORPTION
for Successive Impacts by Free Falling
Weight in Test Machine***

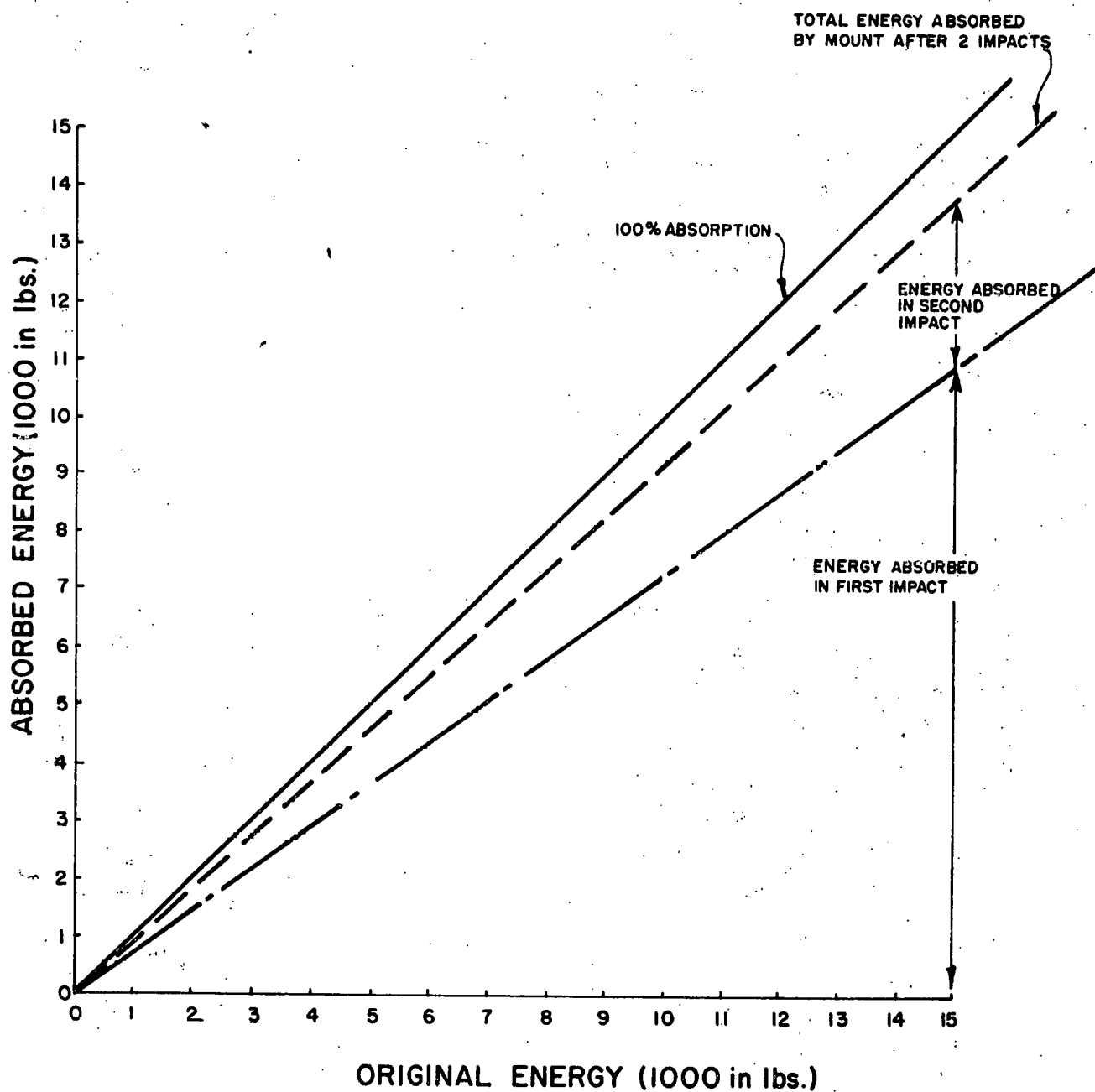
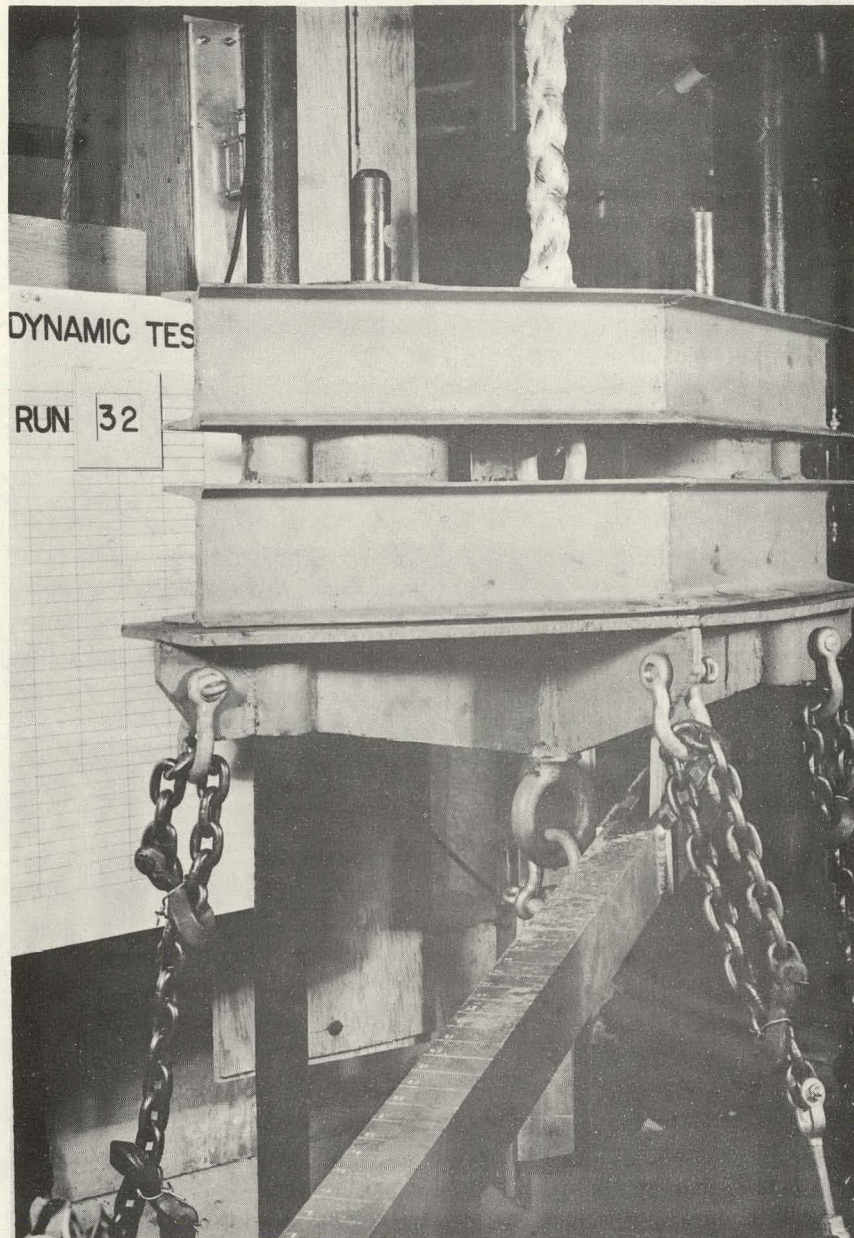


Figure V-11



Apparatus for testing nylon rope

DYNAMIC AMPLIFICATION OF 1-1/8-IN. NYLON ROPE
(Tested by Impacting with 332-lb Weights)

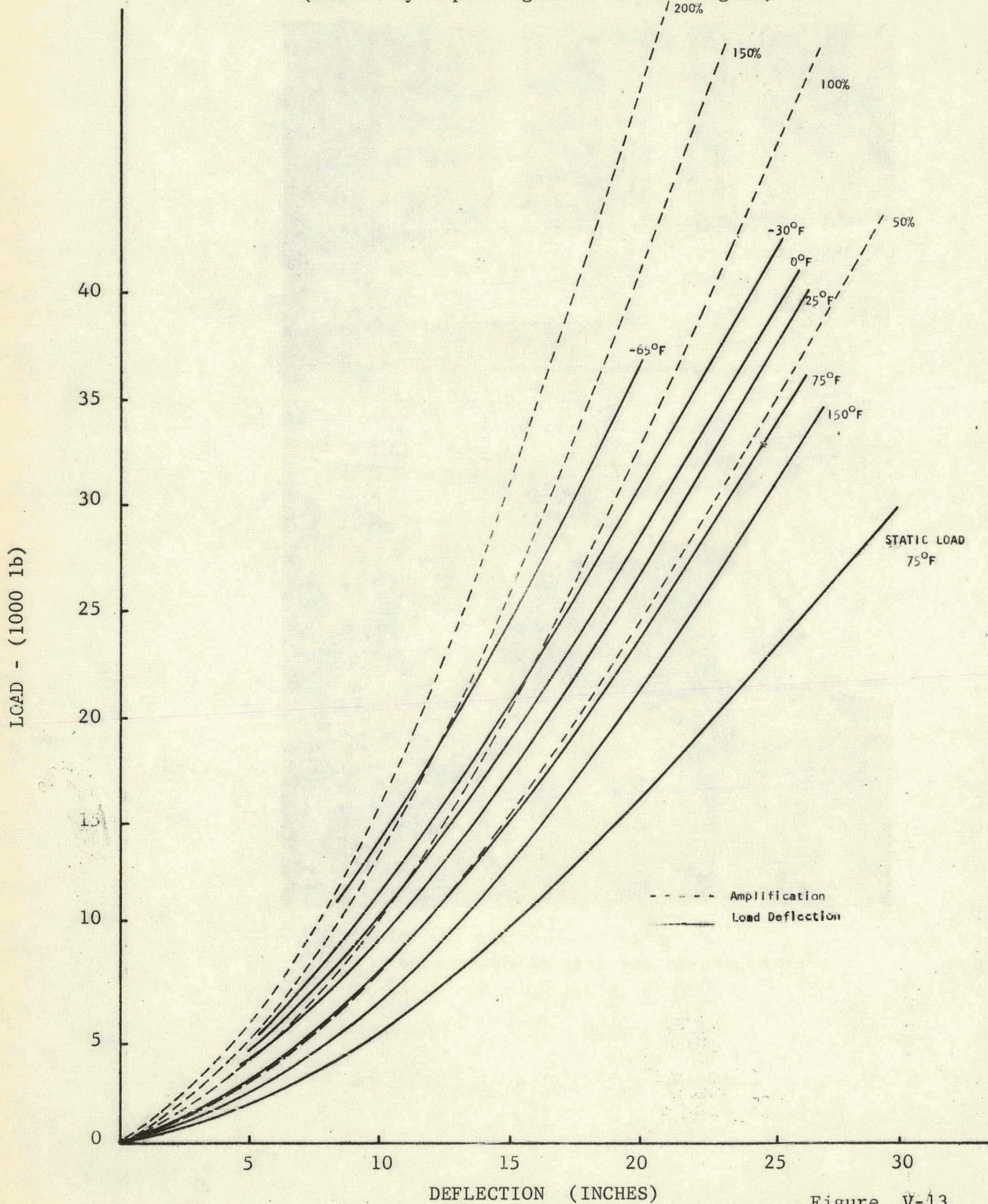
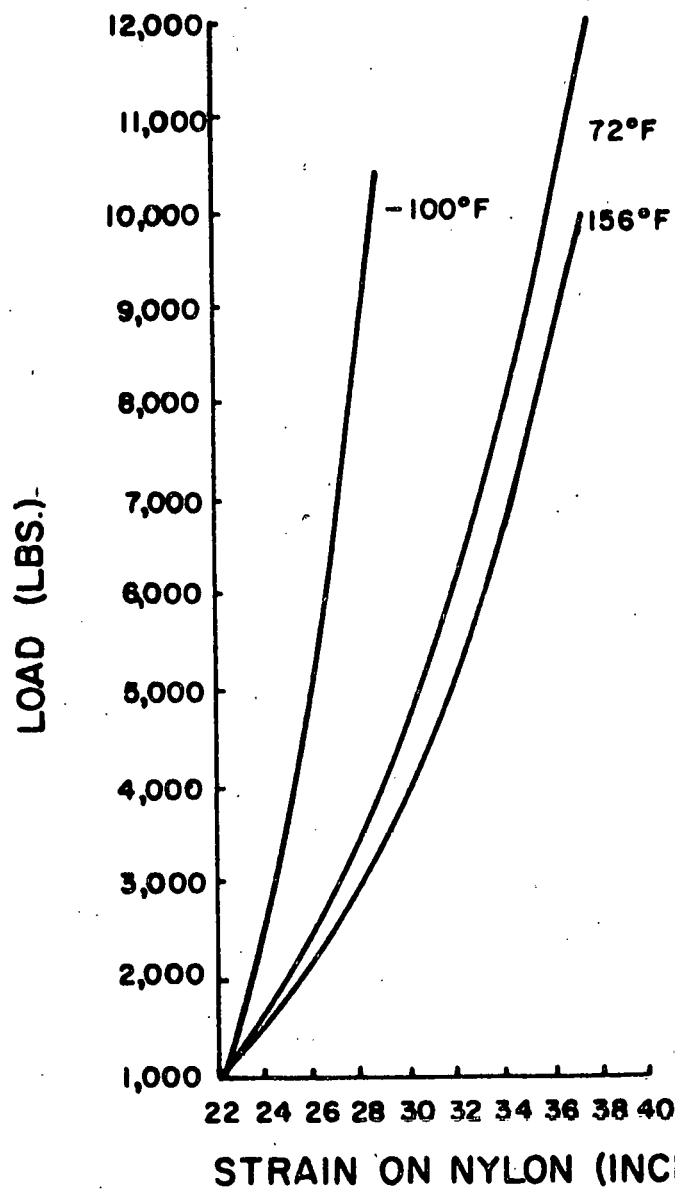


Figure V-13

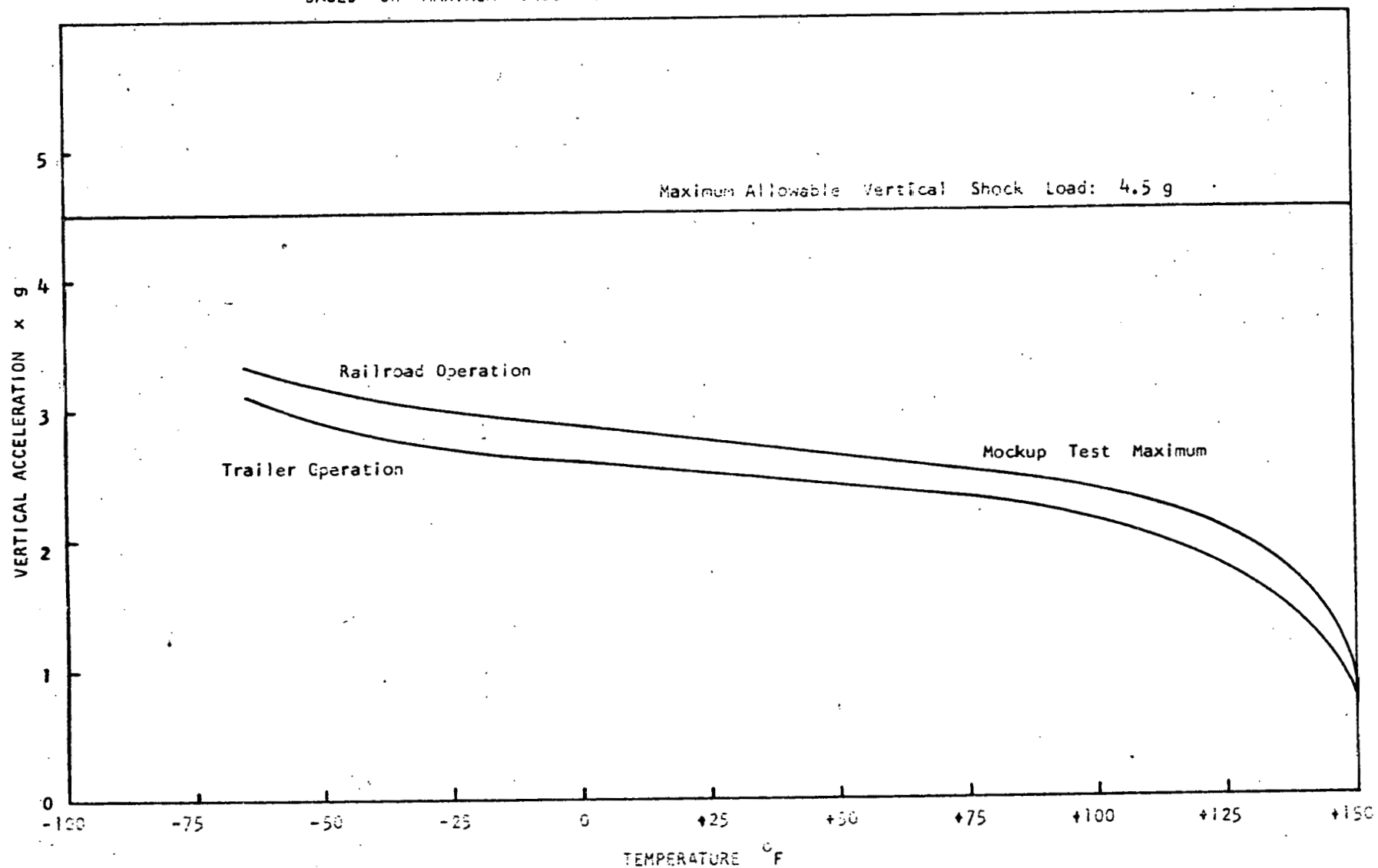
STATIC LOAD-DEFLECTION FOR 1-1/8" NYLON ROPE AT VARIOUS TEMPERATURES



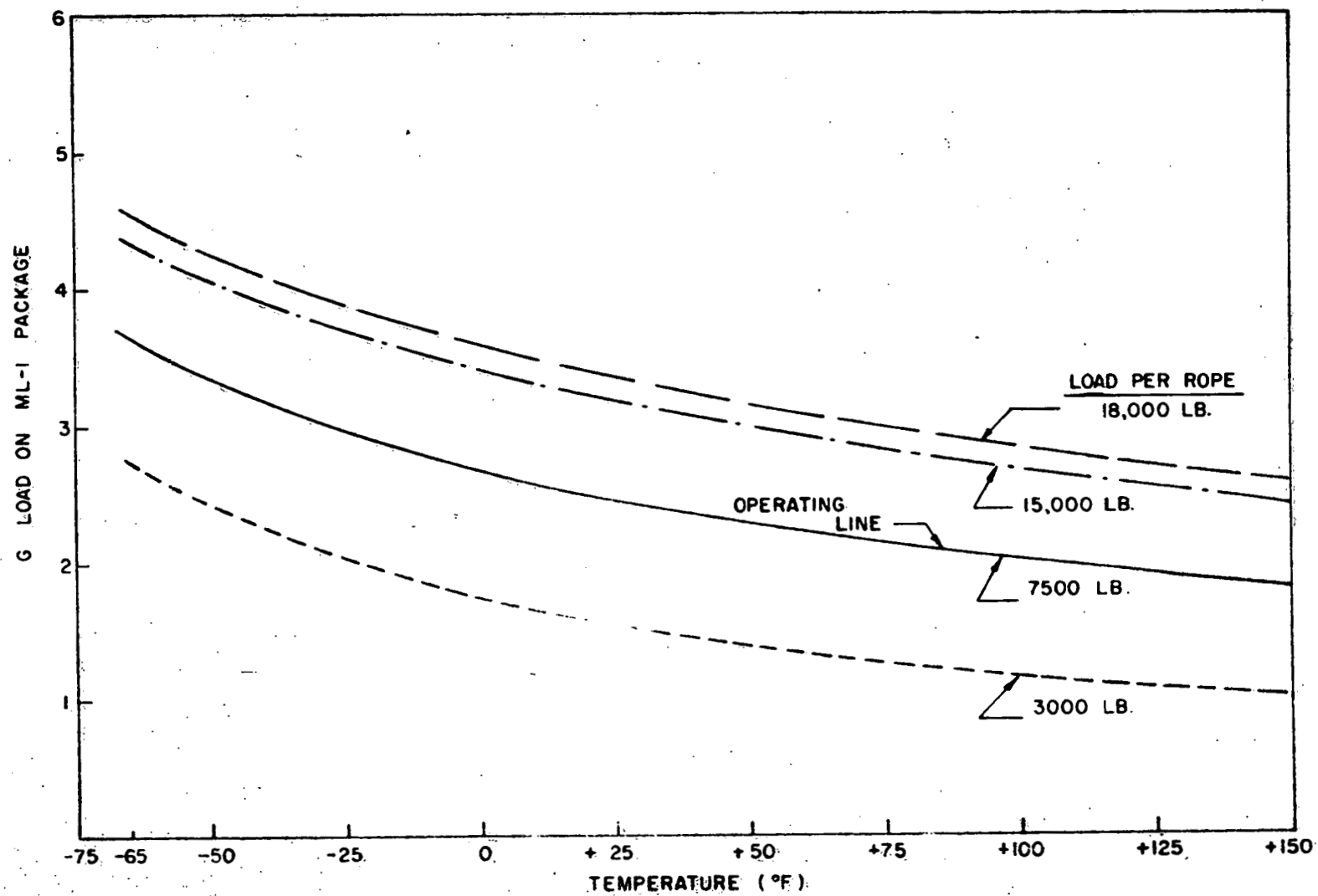
OVERALL RELAXED LENGTH OF TEST ROPE 84"

Figure V-14

MAXIMUM VERTICAL SHOCK LOAD vs OPERATING TEMPERATURE RANGE
 BASED ON MAXIMUM SHOCK FROM FULL-SCALE MOCKUP TESTING AT 75°F



ML-1 SHOCK LOAD AT VARIOUS TEMPERATURES RAILROAD HANDLING



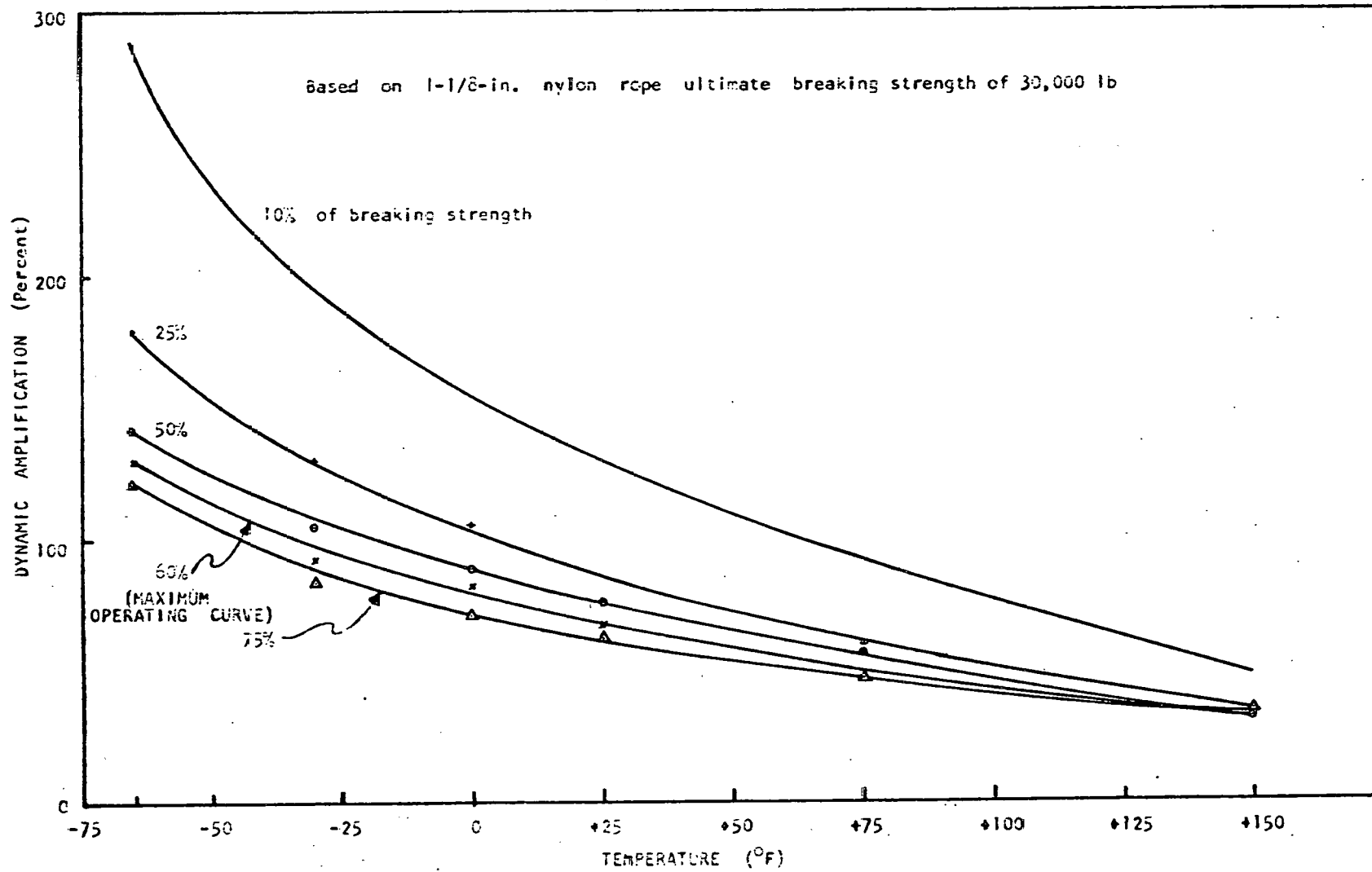
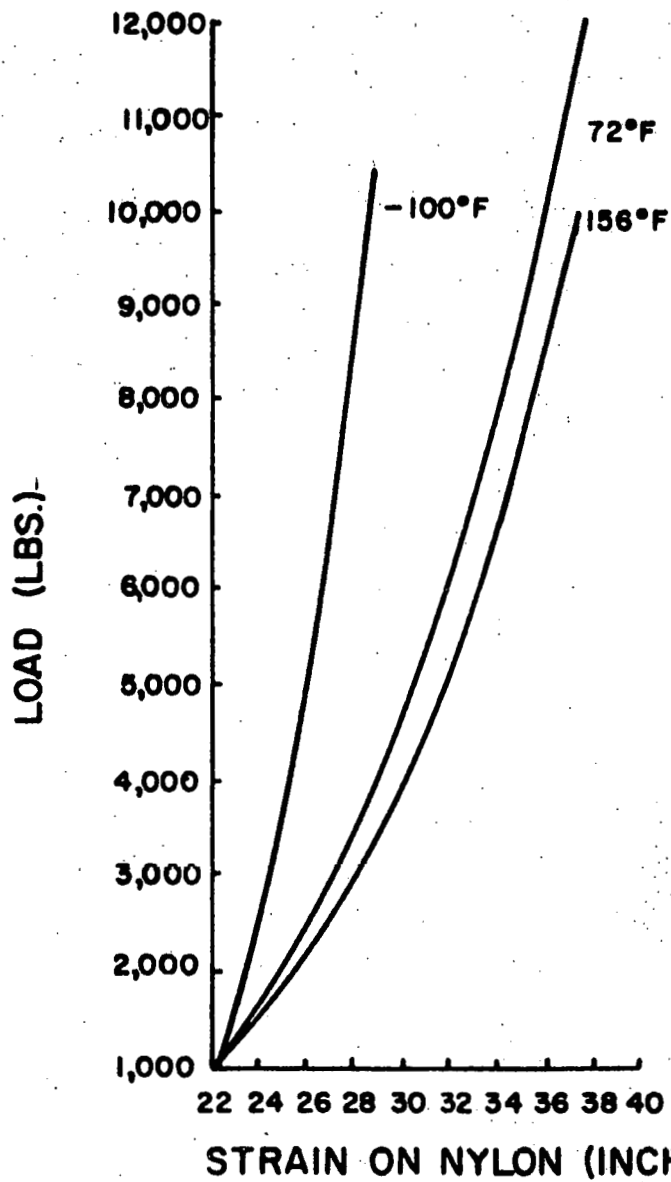
DYNAMIC AMPLIFICATION vs TEMPERATURE
VARIOUS PERCENT LOADS

Figure V-17

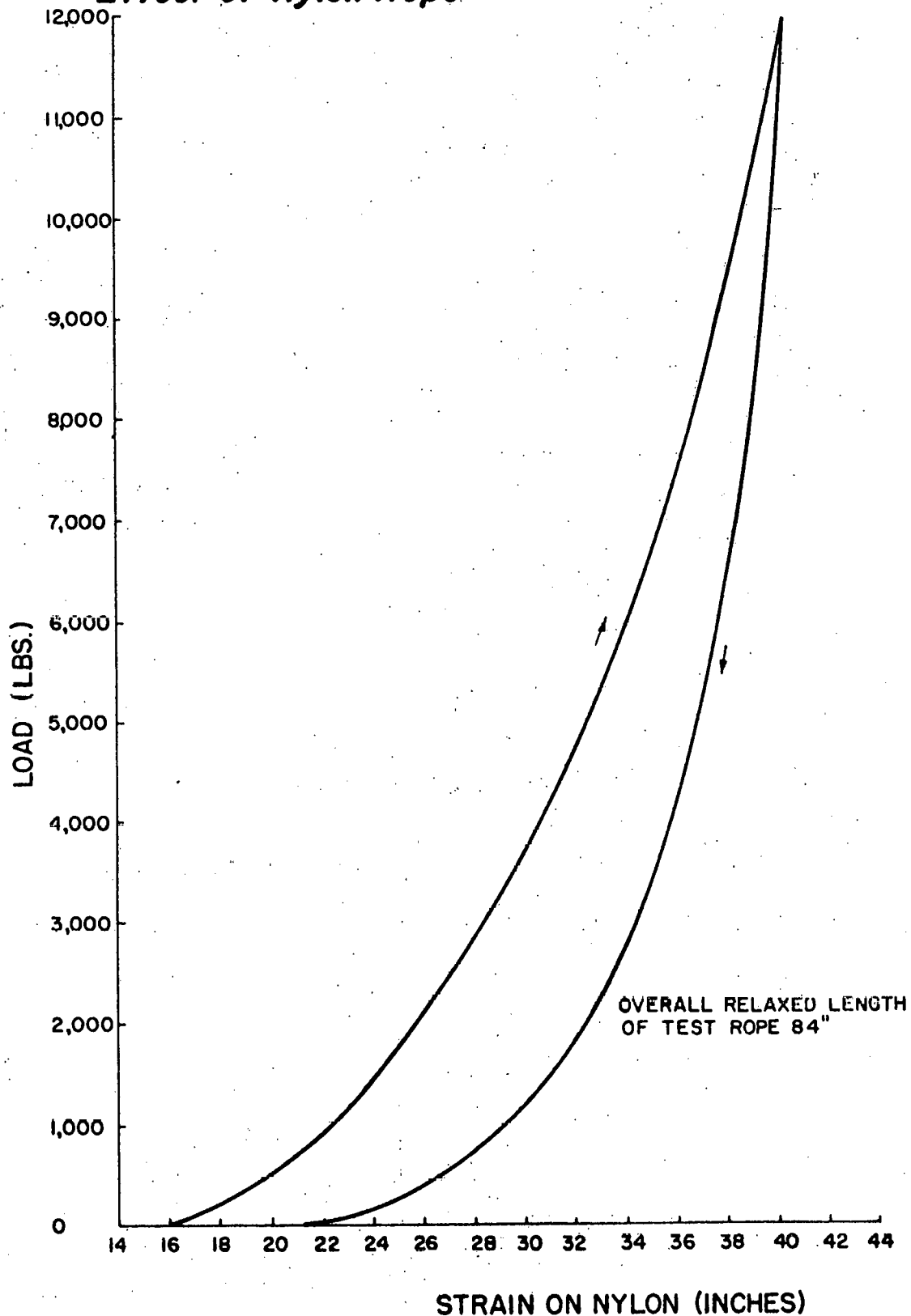
**STATIC LOAD-DEFLECTION FOR
1-1/8" NYLON ROPE
AT VARIOUS TEMPERATURES**



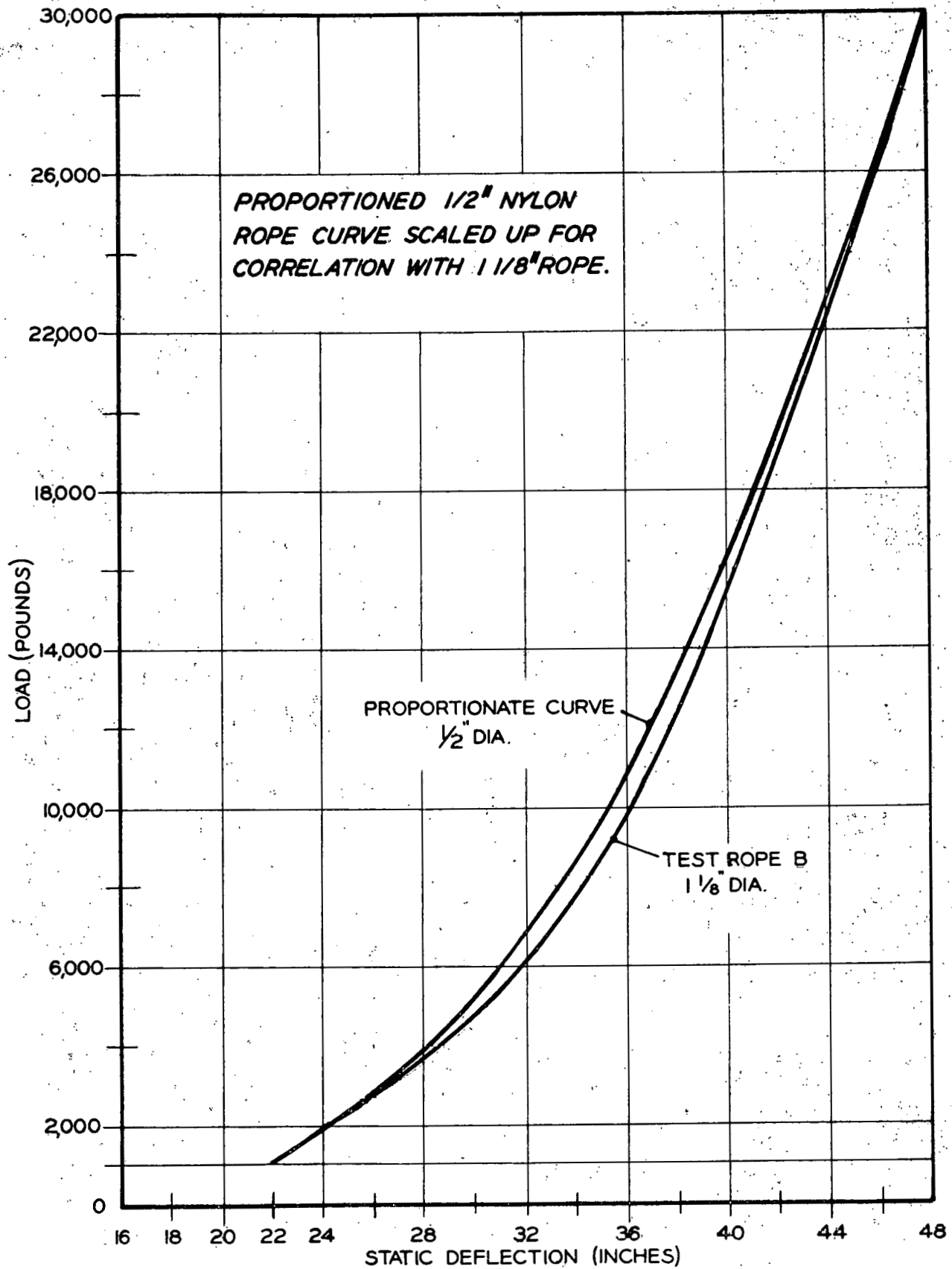
OVERALL RELAXED LENGTH OF TEST ROPE 84"

Figure V-18

1-1/8" NYLON ROPE LOAD-DEFLECTION FOR 1 CYCLE
Demonstrating Energy Absorption or Hysteresis
Effect of Nylon Rope



OVERALL RELAXED LENGTH
OF TEST ROPE 84"

STATIC LOAD DEFLECTION OF 1 1/8" NYLON ROPE

STATIC LOAD DEFLECTION
40,50,60 DUROMETER SILICONE RUBBER
(AT 75 °F)

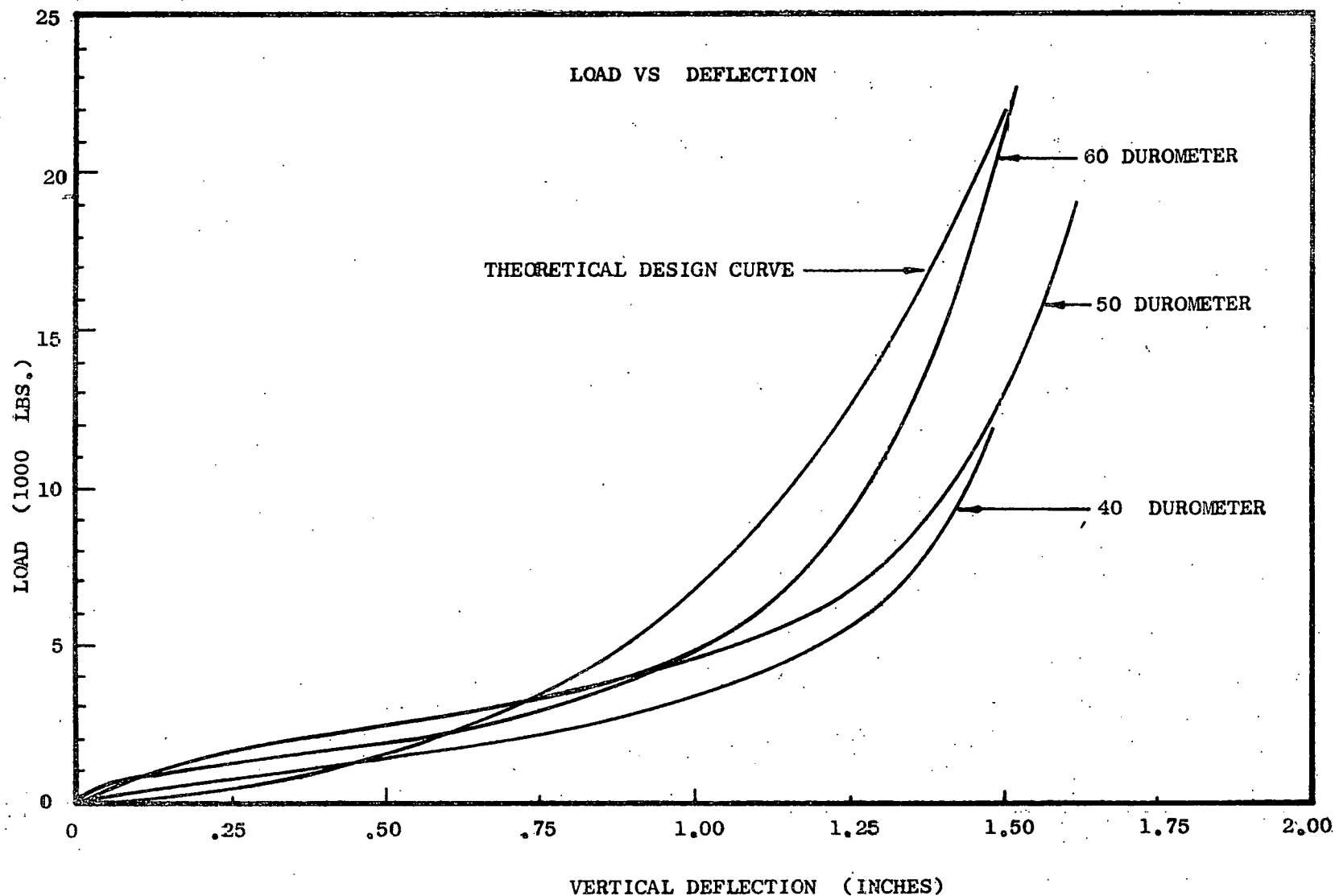


FIGURE V-21

APPENDIX A

RECAPITULATION OF TIME STUDIES
ML-1 MOCKUP TRAILER LOADING TESTS

at

Aerojet-General Nucleonics
San Ramon, California

September 1959

C R E W

Aerojet Representatives

Task Engineer

J. W. Blakley

Mechanical Engineers

J. S. Alcorn

A. K. Shaffer

W. S. Scott

Time Records

D. H. Moran

Mechanics

J. K. Mahanna

A. V. Peloquin

Carpenter

E. R. Finigan

Army Representatives

Fort Baker, California

M/Sgt R. King, NCOIC
2 enlisted men (truck
driver and helper)

Commercial Drayers and Riggers

1 Rigger Foreman

2 Riggers

1 Crane Operator

1 Oiler (Crane Driver)

2. Static Tests

From a correlation of full-scale and laboratory tests, the shock load transmitted to the ML-1 in the environmental temperature range was predicted (see Figure V-16).

Because load deflection information for the rope was available only for ambient temperature tests, static tests were made at 75°, 100°, and 150°F. Data from the manufacturer were furnished for rope with plain ends, i.e., no splices. It was necessary to test the actual tiedown ropes to analyze the effect of the two splices used to form the eye on each end of the rope. The tests were conducted on a tensile machine which loaded the rope to its rupture point. Each rope tested finally ruptured within $\pm 5\%$ of 30,000 lb (see Figure V-17).

Load deflection curves were determined up to the ultimate breaking point at 75°F; at 30% of this point at -100°F, and at 33% of this point at +150°F (see Figure V-18). The slope of the -100°F static curve increased approximately 2.5 times at 6000 lb over that of the 75°F curve. However, no significant change in slope was observed for the 150°F curve. The two ropes that were tested failed at 30,000 and 29,000 lb, respectively. By comparing the elongation of the 5-ft gauge length in the center portion of the rope with the elongation of the total 7 ft length, it was determined that 40% of the total rope stretch occurred in the splices. The amount of stretching was higher than anticipated.

Five or six cycles of loading to 35-40% of maximum were required to obtain a "worked" rope. Figure V-18 indicates the hysteresis (energy dissipation) capacity of a "worked" rope. The amount of energy dissipation was 3680 ft lb; this accounts for the high damping rate of the tiedown arrangement.

Since the test machine capacity was limited to 25% of the breaking strength of 1-1/8 in. rope, a smaller diameter rope (1/2 in.) with a similar length-to-diameter ratio was statically tested. Results were extrapolated and correlated with the 1-1/8 in. rope. (see Figure V-20). Close correlation of static curves, similar size relationships, and similar rope construction justified the use of dynamic data obtained from 1/2 in. dia rope to predict the full range of dynamic operation of the larger rope.

F O R E W A R D

The following is a recapitulation of field notes taken during ML-1 mockup loading tests to determine methods of loading the mockups on an Army M-172 trailer.

Time studies of this nature must be carefully used because they are functions of several factors, most of which can be controlled within reasonable limitations. During experimental tests, all factors cannot be carefully controlled; therefore, the use to which the elemental times is put must be carefully considered.

Operation times are a function of the method used, the crew size, the equipment on hand, the layout of the equipment at the start of the operation, environmental conditions and the state of the crew's training. A time study of experimental operations is the starting point for establishing standard operating times. Standard times must be based on a good statistical sample of the operation. If any of the variables listed above is changed, then the time involved must necessarily also change.

Due to the size of the crew and the experimental nature of this test, many operations were done simultaneously. With only one person recording the times, it was impossible to break simultaneous elements apart.

The times were recorded to the nearest second; and although the reader may consider this spurious accuracy, the fact is that many of the operations which were really important were less than one minute in duration; therefore, they had to be recorded in seconds. The final summary times are rounded off.

During studies for setting time standards, the normal practice is to try to choose elements which are approximately the same length of time. This is not possible during experimental studies which cover a full day's work by a large crew that fluctuates in size.

This report is divided into three parts: Part I is an elemental time summary listing the total times by category for each operation and each package in chronological order; Part II is a tabular listing of each element by number; Part III is the transcription of the field notes. Each element is described in detail and pictures are referenced for clarity.

PART I -- ELEMENTAL TIME SUMMARY
OF M-172 TRAILER LOADING OPERATIONS

	*SU	O	I	D	AD	TOTAL
Package: <u>Power Conversion</u>						
Operation: Load with crane		8 min				8 min
Off-load with crane		17 min			13 min	30 min
Package: <u>Reactor</u>						
Operation: Load with crane		14 min				14 min
Off-load with crane		4 min			3 min	7 min
Load with winch	9 min	58 min		49 min	5 min	2 hr 1 min
Off-load with winch	29 min	25 min				54 min
Load with winch and rollers (rigger's method).	39 min	22 min			2 min	1 hr 3 min
Package: <u>General</u>						
(for any package)						
Operation: Set up 20-ton crane	5 min					5 min
Package: <u>Power Conversion</u>						
Operation: Load with winch as follows:						
a) Load with crane	13 min					13 min
b) Chain down and transport	8 min					8 min
c) Off-load with crane	6 min					6 min
d) Winch aboard	29 min	12 min			12 min	53 min
					Total:	1 hr 20 min
Operation: Off-load with winch	26 min	16 min		4 min		46 min
Package: <u>Combined Power Conversion & Reactor</u>						
Operation: Load with winch:		25 min	2 min	55 min		1 hr 22 min

LEGEND :

- *SU = Set up and tear down.
O = Operation -- any element which makes the job progress.
I = Inspection
D = Unavoidable delays due to method of operation.
AD = Avoidable delays -- wait for tools, coffee breaks, taking pictures, etc.

TABULATION OF ELEMENTAL TIMES
M-172 TRAILER LOADING OPERATIONS

PART II

SU				O				I				D				AD			
Op.				Op.				Op.				Op.				Op.			
No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S

LOAD POWER CONVERSION PACKAGE MOCKUP USING CRANE

1	6	33
2	1	12
Total	7	45
Rounded		
Total	8	

UNLOAD POWER CONVERSION PACKAGE USING CRANE

3	5		5	13
4	5	55		
6	2	6		
7		39		
8	1	55		
9		50		
10	1			
Total	17	25		13
Rounded				
Total	17			13

TRANSPORT REACTOR PACKAGE FROM CONCRETE PAD TO SHORING

Load on M-172 Using Crane

1	1	5
2		40
3	2	
4		45
5	4	45
6	1	5
7	2	25
8	1	
9		30
Total	14	15
Rounded		
Total	14	

Off-Load From M-172 to Greased Shoring

11	1	20	10	3	5
12	2	40			
Total	4			3	5
Rounded					
Total	4			3	

TABULATION OF ELEMENTAL TIMES
M-172 TRAILER LOADING OPERATIONS

(Continued)

SU				O				I				D				AD			
Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S
WINCH REACTOR PACKAGE ABOARD EMPTY M-172 TRAILER																			
13		6	10													15		55	
14			40																
16		4																	
17		15	50																
18		7	20																
19		5	5	20		3	40	32		1		24		3	15	30		4	30
27		4		21		3	40					25		11	15				
				22		6	10					26		5	30				
				23			10					29		2	10				
				28			10					31		18	10				
				33		4	15					34		6	15				
				35		4	10					36		2	40				
				37		1	40												
Total		9	5	Total		57	55	Total		1		Total		49	5	Total		5	25
Rounded				Rounded								Rounded				Rounded			
Total		9		Total		58						Total		49		Total		5	

OFF-LOAD REACTOR PACKAGE USING WINCH

38	28	30	39	24	30
Rounded					
Total	29			25	

LOAD REACTOR PACKAGE USING METHOD SUGGESTED BY COMMERCIAL RIGGERS

1	39	3	22	5	2	2	17
Rounded							
Total	39		22			2	

SET UP 20-TON CRANE

1	5	25
Rounded		
Total	5	

LOAD AND OFF-LOAD POWER CONVERSION PACKAGE USING WINCH

Load Aboard Trailer Using Crane -- Chain Down

1	3	20
2	1	10
3		10
4		15
5	1	20
6	2	6
7	2	9
8		30
9	1	26
10		12
Total	12	38
Rounded		
Total	13	

TABULATION OF ELEMENTAL TIMES
M-172 TRAILER LOADING OPERATIONS
(Continued)

SU				O				I				D				AD			
Op.				Op.				Op.				Op.				Op.			
No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S

CHAIN DOWN PACKAGE AND TRANSPORT 50 FT TO TEST SITE

11	4	47
12	3	40
Total	8	27
Rounded	8	

OFF-LOAD FROM TRAILER TO GROUND USING CRANE

13	4	5
14		50
15		55
Total	5	50
Rounded		
Total	6	

WINCH PACKAGE ABOARD TRAILER

16	12	20	6	21	4
17	4	55	22	55	23
18	13	5	24	1	30
19	10	25	26	1	35
			28	1	15
			30	1	
Total	28	37	12	15	11
Rounded					50
Total	29		12		12

OFF-LOAD USING WINCH

31	25	25	32	1	35	33	1	40
34		30	35	1	8	36		42
			37		50	38		50
			39	5	10	42		30
			40	3	10			
			41	4	30			
Total	25	55	16	23		3	42	
Rounded								
Total	26		16			4		

TABULATION OF ELEMENTAL TIMES
M-172 TRAILER LOADING OPERATIONS

(Continued)

SU				O				I				D				AD			
Op.				Op.				Op.				Op.				Op.			
No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S
WINCH COMBINED REACTOR AND POWER CONVERSION PACKAGES ABOARD M-172 TRAILER																			
1				1	30	2				30	4			1	21				
3				3	4	15				10	6			4	40				
5				2	35	25		2	2	8				1	50				
7					50	27		1	40	9				18	50				
10					45	29				5	13			2	45				
11				2	35	31				27	19			14	1				
12					10	35				15	21			5	5				
14				2	35	37				23	23				50				
16				2	5	39				15	33			5	11				
17				2	21														
18					24														
20					10														
22					45														
24					25														
26					17														
28				1	40														
30					12														
32				1	32														
34					12														
36					12														
38					10														
40					15														
Total				24	44			1	47			54	33						
Rounded																			
Total				25				2				55							

RECAPITULATION OF TIME STUDIES
ML 1 MOCKUP TRAILER LOADING TESTS
PERFORMED AT
AEROJET-GENERAL NUCLEONICS
SAN RAMON, CALIFORNIA

PART III

Operation Dated 9 September 1959: Load, take static deflection measurements, and off-load power conversion package mockup using crane.

Equipment: ML-1 Power Conversion Package Mockup (mounted on wooden runners)
M-52 Army tractor
M-172 Army trailer
20-ton commercial crane
Spreader bar (commercial design)

Crew: 1 rigger foreman
2 riggers
1 crane operator
1 oiler
M-52 tractor driver
1 NCO in charge of M-52 tractor

Setup: The M-172 trailer bed had been modified on 8 September 1959, as shown in Figures A-1, A-2, A-3 and A-4. The modifications consisted of placing 3-inch lumber on the bed, and steel bridges over the wheel wells. These modifications were made in order to allow for the protrusion of the tires through the wheel wells so that there would be no interference with the load. Figure A-5 shows the steel well bridge detail. Figure A-6 shows the front and floor modifications in detail. Figure A-7 shows the trailer looking toward the rear. Figure A-8 shows the ramps with 3-inch shoring in place.

At the start of this operation the power conversion mockup was resting on wooden blocks, placed on a concrete pad as shown in Figure A-9. The crane was in position with slings attached to the package at each corner and supported by the pulleys on the spreader bar.

Element 1 (0)*

Hoist load, back trailer under load, position trailer (2-min conference between the rigger foreman and M/Sgt as to proper position for the trailer), lower load to trailer bed.

Elapsed Time: 6 min 33 sec

L E G E N D :

*SU = Set up and tear down.
O = Operation -- any element which makes the job progress.
I = Inspection
D = Unavoidable delays due to method of operation.
AD = Avoidable delays -- wait for tools, coffee breaks, taking pictures, etc.

Element 2 (0)

Uncouple clevis pins two per corner, one man on each corner. Hoist spreader bars and cable clear. Reference Figure A-10.

Elapsed Time: 1 min 12 sec

Static Deflection Measurements (no time values taken)

The power conversion package was then transported to the site which had been prepared for static load deflection measurements. Unloaded trailer bed heights had been previously recorded. See Figure A-11. The bed height measurements were recorded. See Figure A-12.

Unload

Element 3 (0)

Transport power conversion package 60 feet from static deflection measurement site to position under crane spreader bar as shown in Figures A-13 and A-14.

Elapsed Time: 5 min

Element 4 (0)

Attach cable to package at each corner. One rigger is stationed on top of the package. One rigger and rigger foreman are stationed on the ground. The top is attached first. One of the lower clevis pins was bent and therefore was hammered into place, losing 30 seconds.

Elapsed Time: 5 min 55 sec

Element 5 (AD)

Flame cut clevis with bent pin and replace with missing link. This was a safety precaution.

Elapsed Time: 13 min

Element 6 (0)

Hoist load and pull trailer closer.

Elapsed Time: 2 min 6 sec

Element 7 (0)

Position wooden support block.

Elapsed Time: 39 sec

Element 8 (0)

Lower load and reposition blocks.

Elapsed Time: 1 min 55 sec

Element 9 (0)

Set load on blocks.

Elapsed Time: 50 sec

Element 10 (0)

Disassemble clevises and clear cables.

Elapsed Time: 1 min

Operation Dated 9 September 1959: Transport Reactor Package Mockup from concrete pad to skids. Winch reactor package aboard empty trailer. Off load reactor package using winch.

Element 1 (0)

At the beginning of this element the crane was located as shown in Figure A-15 with cables attached to the reactor package. Hoist reactor package and back M-172 trailer under package.

Elapsed Time: 1 min 5 sec

Element 2 (0)

Position trailer and lower load to trailer bed, as shown in Figures A-16 and A-17.

Elapsed Time: 40 sec

Element 3 (0)

Remove cables from reactor package.

Elapsed Time: 2 min

Element 4 (0)

Hoist cable and spreader bar clear of load.

Elapsed Time: 45 sec

Element 5 (0)

Transport truck to location beside wooden shoring laid out on the ground for loading operations.

Elapsed Time: 4 min 45 sec

Element 6 (0)

Position crane beside trailer and lower cables into position for attaching to the package.

Elapsed Time: 1 min 5 sec

Element 7 (0)

Attach all cables for hoisting from trailer.

Elapsed Time: 2 min 25 sec

Element 8 (O)

Hoist load clear of trailer.

Elapsed Time: 1 min

Element 9 (O)

Pull trailer clear.

Elapsed Time: 30 sec

Element 10 (AD)

Swing load from position directly over shoring and grease shoring as shown in Figure A-18.

Elapsed Time: 3 min 5 sec

Element 11 (O)

Lower reactor package to greased shoring as shown in Figure A-19.

Elapsed Time: 1 min 20 sec

Element 12 (O)

Reposition reactor package on shoring.

Elapsed Time: 2 min 40 sec

Element 13 (SU)

Position M-172 trailer in front of reactor skid.

Elapsed Time: 6 min 10 sec

Element 14 (SU)

Lift 4 M-172 trailer ramps into position by means of crane.

Elapsed Time: 40 sec

Element 15 (AD)

Relocate M-172 Trailer in line with reactor package. Relocate the 4 loading ramps. This took two soldiers, 2 riggers and the crane. Reference Figure A-20.

Elapsed Time: 55 sec

Element 16 (SU)

Lower 5th wheel into position on a piece of shoring.

Elapsed Time: 4 min

Element 17 (SU)

Turn M-52 tractor around and put in proper location for winching. Two soldiers prepared the winch for service; shoring was greased. Reference Figure A-21.

Elapsed Time: 15 min 50 sec

Element 18 (SU)

Rig pulleys on the front of the reactor package as shown in Figures A-22 and A-23, and hook winch cable (5/8 diameter steel cable) to pulley on reactor package.

Elapsed Time: 7 min 20 sec

Note: Name plate data on M52 winch; 20,000 lbs rated pull at 15 fpm on a bare drum. Ordnance #K-1411122.

Element 19 (SU)

Complete cable setup. Note that no deadman was used during this operation. The setup for winching aboard was completed; reference Figure A-24, A-25, and A-26.

Elapsed Time: 5 min 5 sec

Element 20 (O)

Winch aboard. Forward motion was stopped due to right hand shock mount binding on the inside ramp.

Elapsed Time: 3 min 40 sec

Element 21 (O)

Winch forward.

Elapsed Time: 3 min 40 sec

Element 22 (D)

Free shock mount.

Elapsed Time: 6 min 10 sec

Element 23 (O)

Winch forward.

Elapsed Time: 10 sec

Element 24 (D)

Use sledge hammer to knock shock mount into line.

Elapsed Time: 3 min 15 sec

Element 25 (D)

Pull load back to free cleat which was catching on center ramp (recommended no center ramps be used in future operations).

Elapsed Time: 11 min 15 sec

Element 26 (D)

Remove center ramps.

Elapsed Time: 5 min 30 sec

Element 27 (SU)

Place triangular blocks on top of bolts holding trailer showing place.

Elapsed Time: 4 min

Element 28 (O)

Winch forward.

Elapsed Time: 10 sec

Element 29 (D)

Push shoring back into place.

Elapsed Time: 2 min 10 sec

Element 30 (AD)

Discussed whether or not to remove inboard elastomers which were binding on shoring and trailer.

Elapsed Time: 4 min 30 sec

Element 31 (D)

Remove inboard elastomers.

Elapsed Time: 18 min 10 sec

Element 32 (I)

Check cables.

Elapsed Time: 1 min

Element 33 (O)

Winch forward.

Elapsed Time: 4 min 15 sec

Element 34 (D)

Adjust shoring.

Elapsed Time: 6 min 15 sec

Element 35 (O)

Winch forward.

Elapsed Time: 4 min 10 sec

Element 36 (D)

Adjust cable.

Elapsed Time: 2 min 40 sec

Element 37 (O)

Winch forward.

Elapsed Time: 1 min 40 sec

Note: Load was in final position at the end of this element.

Element 38 (SU)--Off Loading

Part of the crew took a break while the cable was re-rigged for off loading. Cables were attached on each side of the reactor package for side thrust. A winch truck was placed on one side and the crane winch was used on the other side. Bolts holding the ramp shoring together were reversed so that the nut was on the outside and the bolt heads were on the inside. This was done to avoid binding between the nuts and the load.

Elapsed Time: 28 min 30 sec

Element 39 (O)

Off load to the ground.

Elapsed Time: 24 min 30 sec

Operation dated 10 September 1959: Load Reactor Package Using Method Suggested by Commercial Riggers. Extra equipment necessary: 2 ten-ton jacks, (4" dia x 6' long) oak rollers.

Element 1 (SU)

Jack up reactor package, insert planks and rollers under the shock mounts, position Army M-172 trailer.

Elapsed Time: 39 min

Element 2 (AD)

Take pictures of setup. Pictures of the setup are as follows: Figures A-27, A-28, A-29, A-30, A-31, and A-32..

Elapsed Time: 2 min 17 sec

Element 3 (O)

Winch load aboard, position load at gooseneck: Reference Figures A-33, A-34, and A-35.

Elapsed Time: 22 min 5 sec

Operation Dated 10 September 1959: Setup 20 Ton Crane.

Element 1 (SU)

This element begins with the crane in motion 15' from position. The spreader bar is already located on the crane hook. Drive crane into position on dirt in front of the concrete pad. Lower spreader bar and attach cables to load. Position blocks under crane.

Elapsed Time: 5 min 25 sec

Operation Dated 10 September 1959: Winch Power Conversion Package Mockup Aboard M-172 Trailer

Element 1 (SU)

Crane is in position for hoisting load onto trailer. Place blocks under crane outriggers.

Elapsed Time: 3 min 20 sec

Element 2 (SU)

Lower spreader bar to load.

Elapsed Time: 1 min 10 sec

Element 3 (SU)

Position outriggers on spreader bar.

Elapsed Time: 10 sec

Element 4 (SU)

Raise spreader bar to position over package.

Elapsed Time: 15 sec

Element 5 (SU)

Attach cables to load.

Elapsed Time: 1 min 20 sec

Element 6 (SU)

Hoist load, remove support blocks.

Elapsed Time: 2 min 6 sec

Element 7 (SU)

Back M-172 trailer under load.

Elapsed Time: 2 min 9 sec

Element 8 (SU)

Lower package to position on trailer.

Elapsed Time: 30 sec

Element 9 (SU)

Unhook cables from package.

Elapsed Time: 1 min 26 sec

Element 10 (SU)

Clear spreader bars and cables.

Elapsed Time: 12 sec

Element 11 (SU)

Chain down load on trailer to prevent shifting due to grease on shoring on trailer bed.

Elapsed Time: 4 min 47 sec

Element 12 (SU)

Transport load to location where loading is to take place. (approx. 50 ft).

Note: Crane also moved into position at the same time that the load was repositioned.

Elapsed Time: 3 min 40 sec

Element 13 (SU)

Attach cables to load.

Elapsed Time: 4 min 5 sec

Element 14 (SU)

Hoist load and pull trailer clear.

Elapsed Time: 50 sec

Element 15 (SU)

Lower load to ground.

Elapsed Time: 55 sec

Element 16 (SU)

Put additional grease on shoring.

Elapsed Time: 12 sec

Element 17 (SU)

Back trailer, with the ramps attached, up to the package.

Elapsed Time: 4 min 55 sec

Element 18 (SU)

Uncouple tractor, lower 5th wheel on trailer, position tractor for winching operation, back out cable from winch and rig cables for loading. Reference Figures A-36 and A-37.

Elapsed Time: 13 min 5 sec

Element 19 (SU)

Position crane on one side of package and additional winch truck on opposite side and attach cables at right angles to load for application of side thrusts during loading operations.

Elapsed Time: 10 min 25 sec

Element 20 (O)

Winch forward, to a point where the starboard rear end of the load comes off the shoring. Crane was used to hoist load back on to the shoring.

Elapsed Time: 6 min

Element 21 (D)

Reposition on the shoring.

Elapsed Time: 4 min

Element 22 (O)

Winch forward.

Elapsed Time: 55 sec

Element 23 (D)

Reposition the cable attached to the crane for side thrust.

Elapsed Time: 1 min 10 sec

Element 24 (O)

Winch forward.

Elapsed Time: 1 min 30 sec

Element 25 (D)

Change position of cable attached to crane from the front of the package to the rear of the package. At this point the package was located as shown in Figure A-38.

Elapsed Time: 2 min 20 sec

Element 26 (O)

Winch forward to point shown in Figure A-39.

Elapsed Time: 1 min 35 sec

Element 27 (D)

Relocate crane and winch truck so that the angle between the cables and the longitudinal center line of the package is smaller than before.

Elapsed Time: 2 min 5 sec

Element 28 (O)

Winch forward to a point shown in Figure A-40.

Elapsed Time: 1 min 15 sec

Element 29 (D)

Reposition side thrust cables.

Elapsed Time: 2 min 15 sec

Element 30 (O)

Winch forward.

Elapsed Time: 1 min

At this point the power conversion package was 6'-6" from the gooseneck of the trailer as can be seen in Figure A-41.

Element 31 (SU) - Off Loading Operations

Rig for off loading. Reattach the 4 shock mounts which had been removed on September 9. Figures A-42 and A-43 show the setup immediately before off loading. See Figure A-44 which shows a detail of one of the shock mounts. Figure A-45 shows the package with the cables taut as at the beginning of the off loading operations.

Elapsed Time: 25 min 25 sec

Element 32 (O)

Off load.

Elapsed Time: 1 min 35 sec

Element 33 (D)

Block ramp shoring from moving.

Elapsed Time: 1 min 40 sec

Element 34 (SU)

Place plates on aft end of package so that they will slide on shoring more easily.

Elapsed Time: 30 sec

Element 35 (O)

Off load.

Elapsed Time: 1 min 8 sec

Element 36 (D)

Adjust shoring.

Elapsed Time: 42 sec

Element 37 (O)

Off load.

Elapsed Time: 50 min

Element 38 (D)

Apply more pressure to hold shoring in place.

Elapsed Time: 50 sec

Element 39 (O)

Off load to a point about 2 feet from the reactor skid which had been resting on shoring on the ground.

Elapsed Time: 5 min 10 sec

Element 40 (O)

Pull power conversion package toward reactor package to a point where the holes and pins of the two packages become lined up. At this point the packages were approximately 1/2" apart.

Elapsed Time: 3 min 10 sec

Element 41 (O)

Back up the reactor skid, shift the power conversion skid 1/8" and pull power conversion skid closer.

Elapsed Time: 4 min 30 sec

Element 42 (D)

Pull power conversion package away from reactor package in order to grind dowel pins which do not fit.

Elapsed Time: 30 sec

Operation Dated September 11, 1959 -- Winch combined reactor and power conversion package mockups aboard M-172 trailer.

Element 1 (O)

Winch forward.

Note: Dowel pins were ground, packages were bolted together; the general setup can be seen in Figures A-46 and A-47.

Elapsed Time: 1 min 30 sec

Element 2 (I)

Check side slippage.

Elapsed Time: 30 sec

Element 3 (O)

Winch forward.

Elapsed Time: 3 min 4 sec

Element 4 (D)

Stop forward motion. There was a loud report from the chains at the gooseneck of the trailer. Investigation disclosed that there was no damage, the rings had merely shifted under tension. At this point the front of the package was half-way up the incline. During this element the rear of the package had to be jacked up to get one of the rear shock mounts over the edge of a piece of shoring.

Elapsed Time: 1 min 21 sec

Element 5 (O)

Winch forward.

Elapsed Time: 2 min 35 sec

Element 6 (D)

Attach crane line to starboard end of load for lateral thrust.

Elapsed Time: 4 min 40 sec

Element 7 (O)

Winch forward.

Elapsed Time: 50 sec

Element 8 (D)

At this point the front end of the package was 2 feet from the top of the incline. The rear starboard shock mount on the reactor package was digging into the shoring as can be seen in Figure A-48. Crow bars had to be used to help the load along.

Elapsed Time: 1 min 50 sec

Element 9 (D)

Slack off on cable and put 10-ton jacks under the loading ramps at the point where they connect to the trailer. This operation can be seen in Figure A-49. It is recommended that careful consideration be given to keeping the end of the trailer level.

Note: At this point it became evident that the channel which covered the wheel wells should extend out to the edge of the trailer bed and that the channels should be bolted in place to prevent shifting. In Figure A-50 the additional width needed on the channel is pointed out.

Elapsed Time: 18 min 50 sec

Element 10 (O)

Winch forward.

Elapsed Time: 45 sec

Element 11 (O)

Apply side pull to the starboard.

Elapsed Time: 2 min 35 sec

Element 12 (O)

Winch forward. At this point the front shocks are engaging with the steel channel over the wheel wells.

Elapsed Time: 10 sec

Element 13 (D)

Ten ton jack had to be used to push a shock mount up over the edge of the channel.

Elapsed Time: 2 min 45 sec

Element 14 (O)

Winch forward.

Elapsed Time: 2 min 35 sec

Element 15 (I)

Check alignment.

Elapsed Time: 10 sec

Element 16 (O)

Winch forward. At the beginning of this element the package tipped to a position where it was parallel with the bed of the trailer, i.e., it had passed beyond the incline of the ramps.

Elapsed Time: 2 min 5 sec

Element 17 (O)

Attach a cable to the port side of the package at the rear in order to apply lateral tension by means of winch truck.

Elapsed Time: 2 min 21 sec

Element 18 (O)

Winch forward. During this element the 10-ton jack on the starboard side slipped out from under the trailer. Load shifted to the starboard side.

Elapsed Time: 24 sec

Element 19 (D)

Conference was held to determine the best way to shift the load back to the proper alignment. The jack was replaced on the starboard side.

Elapsed Time: 14 min 1 sec

Element 20 (O)

Winch forward.

Elapsed Time: 10 sec

Element 21 (D)

Apply port thrust on the front of the power conversion package by means of the winch truck.

Elapsed Time: 5 min 5 sec

Element 22 (O)

Applied tension both by the M-52 tractor winch and the winch truck on the port side in an effort to straighten the load.

Elapsed Time: 45 sec

Element 23 (D)

Insert block in a void in the shoring.

Elapsed Time: 50 sec

Element 24 (O)

Winch forward.

Elapsed Time: 25 sec

Element 25 (I)

Inspect alignment.

Elapsed Time: 2 min 2 sec

Element 26 (O)

Winch forward.

Elapsed Time: 17 sec

Element 27 (I)

Inspect alignment.

Elapsed Time: 1 min 7 sec

Element 28 (O)

Winch forward.

Elapsed Time: 1 min 40 sec

Element 29 (I)

Inspect alignment.

Elapsed Time: 5 sec

Element 30 (O)

Winch forward.

Elapsed Time: 12 sec

Element 31 (I)

Inspect alignment.

Elapsed Time: 27 sec

Element 32 (O)

Winch forward.

Elapsed Time: 1 min 32 sec

Element 33 (D)

At this point all observers at the test came forward to inspect the operation.

Elapsed Time: 5 min 11 sec

Element 34 (O)

Winch forward.

Elapsed Time: 12 sec

Element 35 (I)

Inspect alignment.

Elapsed Time: 15 sec

Element 36 (O)

Winch forward.

Elapsed Time: 12 sec

Element 37 (I)

Inspect alignment.

Elapsed Time: 23 sec

Element 38 (O)

Winch forward.

Elapsed Time: 10 sec

Element 39 (I)

Inspect alignment.

Elapsed Time: 15 sec

Element 40 (O)

Winch forward.

Elapsed Time: 15 sec

At this point the package was in a position which can be seen in Figure A-51.

Note: Figure A-51 shows the package after it had been tied down with chains prior to cross country testing and had been transported over to the testing site on a concrete pad.

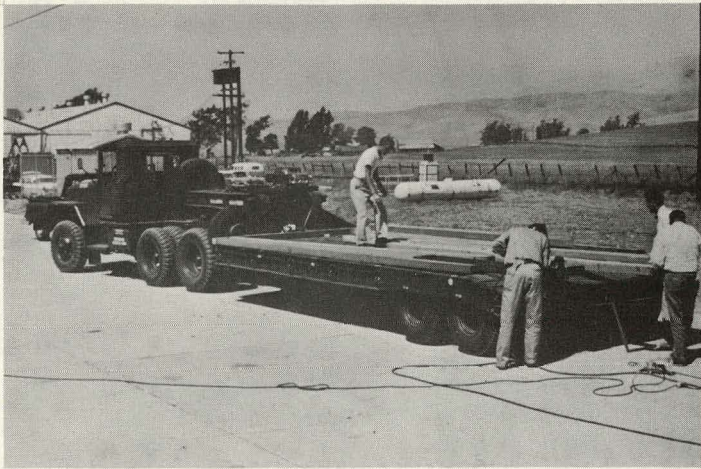


Figure A-1

M-172 trailer bed modifications, laying flooring

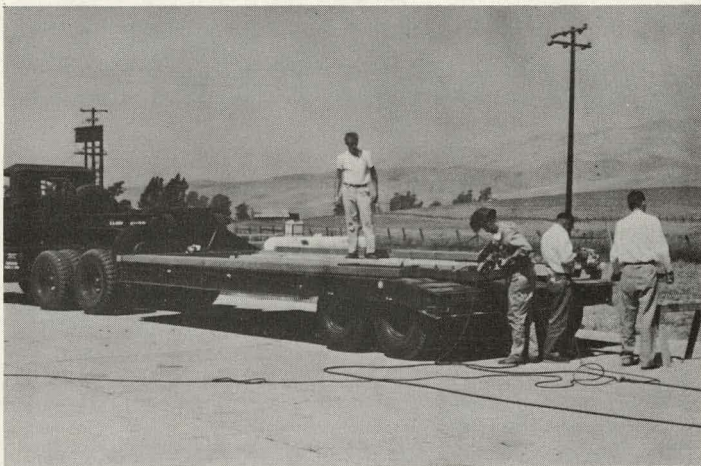


Figure A-2

M-172 trailer bed modifications, welding wheel well channel in place

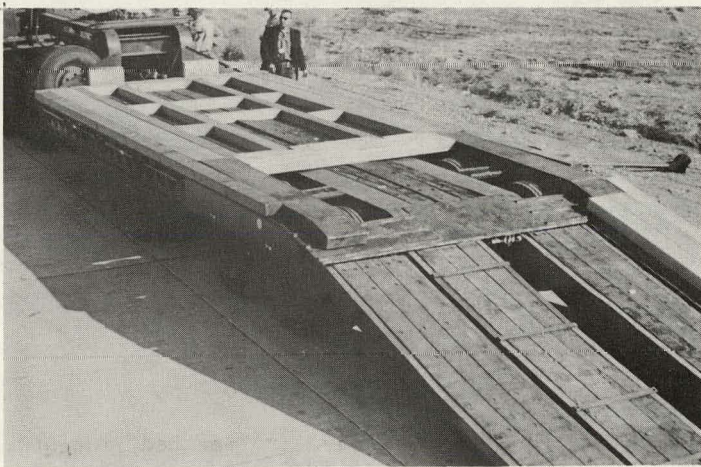


Figure A-3

M-172 trailer bed completely modified, showing flooring in place and wheel well channel details

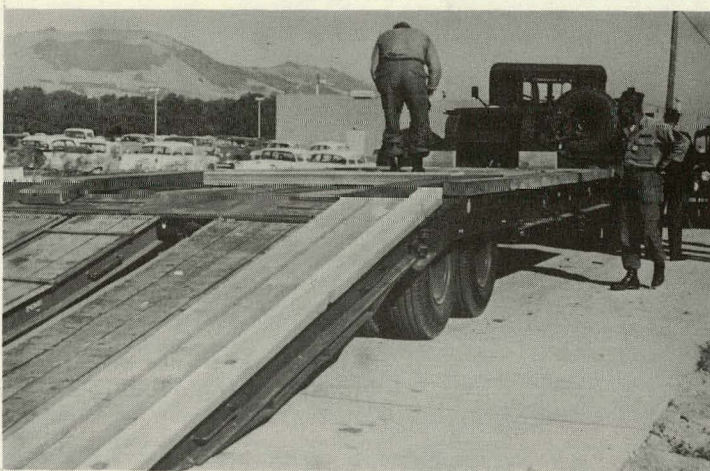


Figure A-4

M-172 trailer ramp being
shored with lumber

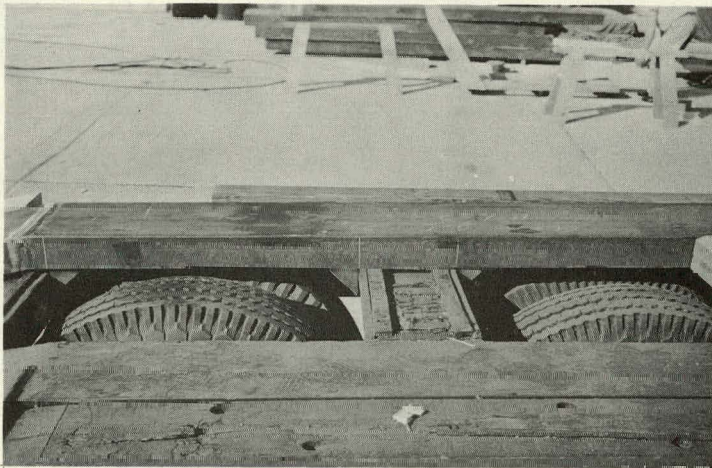


Figure A-5

M-172 trailer wheel well

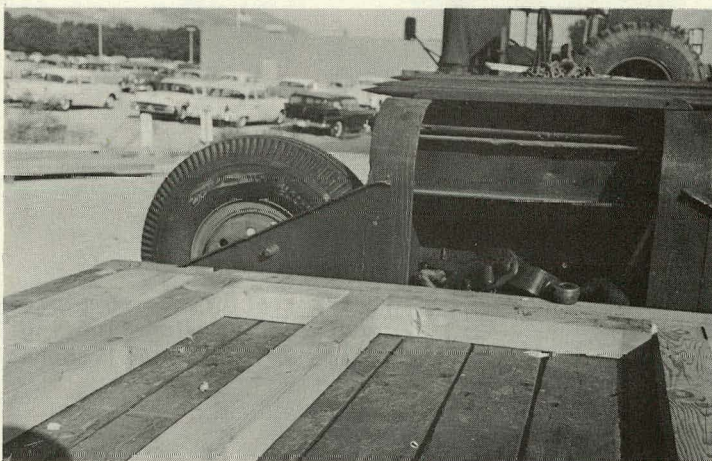


Figure A-6

M-172 trailer bed, forward,
toward gooseneck and M-52
tractor

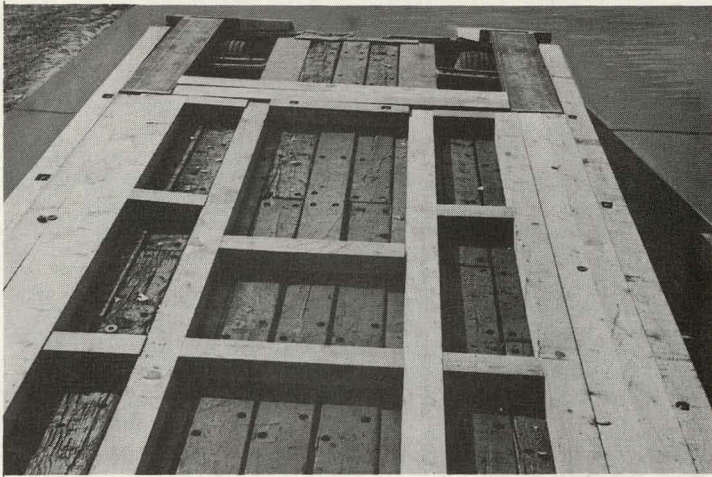


Figure A-7

M-172 trailer bed completely modified, aft end

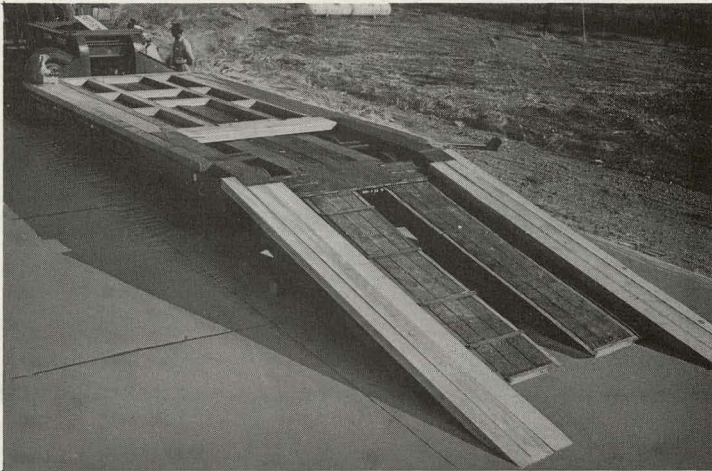


Figure A-8

M-172 trailer bed completely modified, showing ramp shoring meeting wheel well bridges



Figure A-9

ML-1 power conversion and reactor mockups in place prior to crane loading



Figure A-10

Power conversion mockup after loading onto M-172 trailer, using 20-ton crane and spreader bars



Figure A-11

Static, no-load trailer bed height measurement; sighting measuring tape



Figure A-12

Static, loaded trailer bed height measurement



Figure A-13

Positioning power conversion
mockup under crane



Figure A-14

Positioning power conversion
mockup under crane

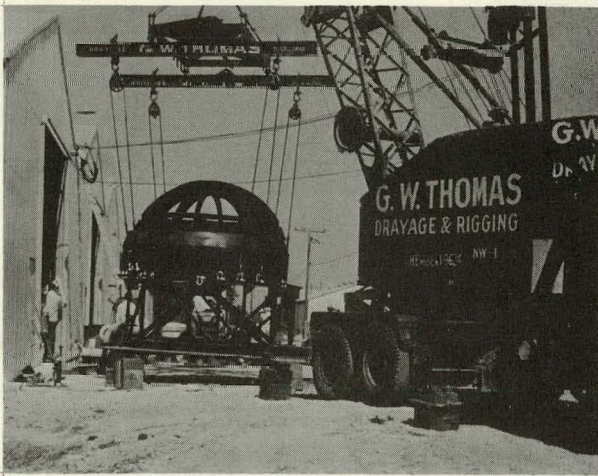


Figure A-15

Preparing to lift reactor mockup onto M-172 trailer

Figure A-16

Hoisting reactor mockup onto M-172 trailer

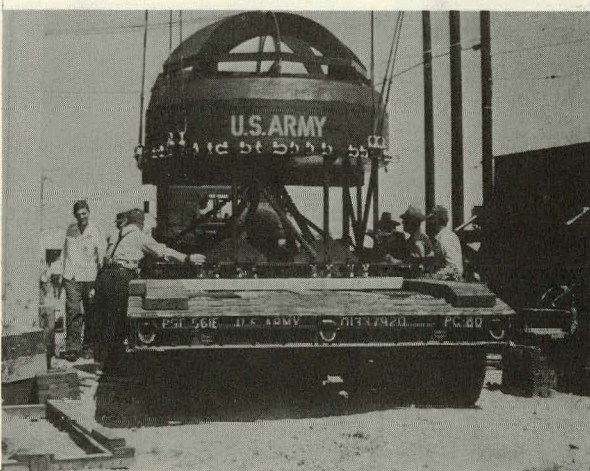
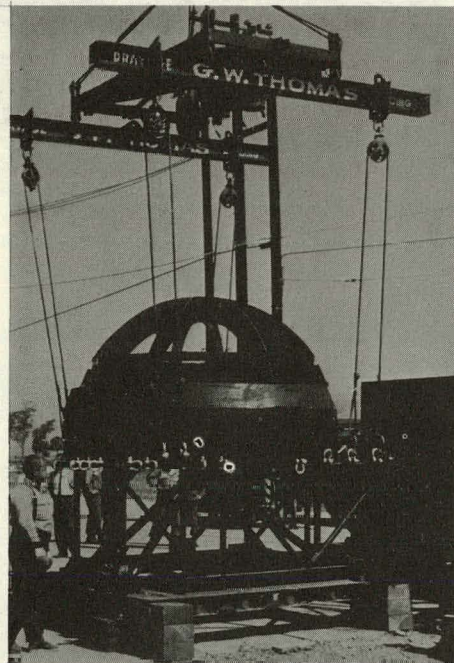


Figure A-17

Lowering reactor mockup onto trailer bed



Figure A-18

Applying grease to shoring

Figure A-19

Lowering reactor mockup onto greased shoring

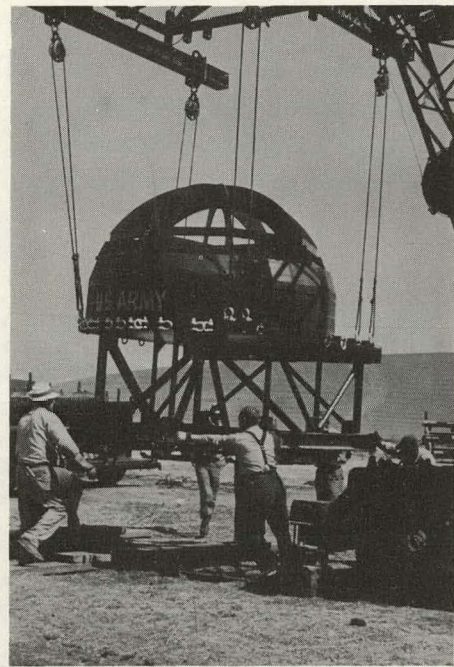


Figure A-20

Trailer and loading ramps re-aligned with reactor mockup

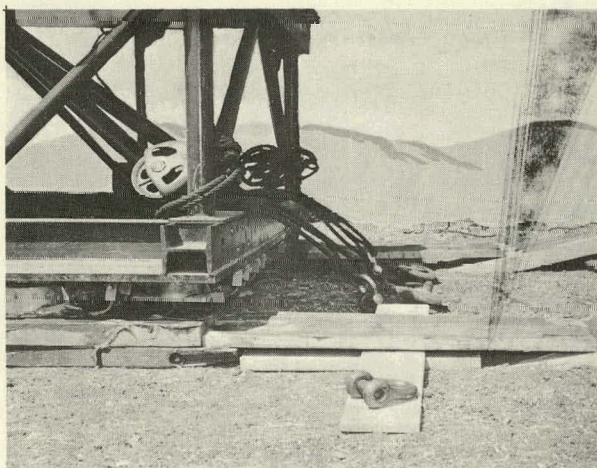


Figure A-22

Pulleys rigged on forward end
of reactor mockup

Figure A-21

Grease being applied to lum-
ber on loading ramps

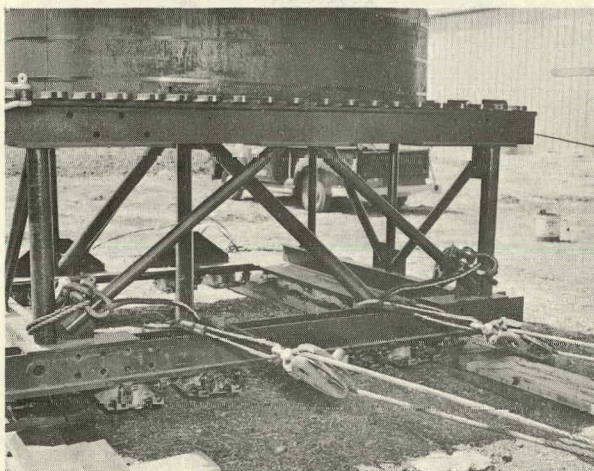


Figure A-23

Pulley arrangement on forward
end of reactor mockup

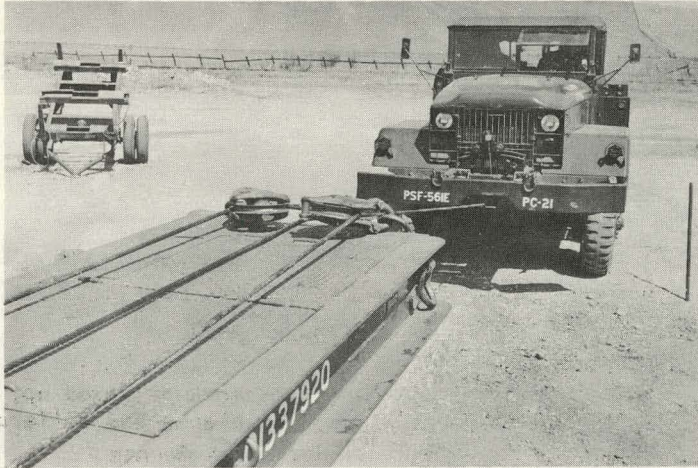


Figure A-24

Setup prior to winching reactor mockup aboard trailer, showing M-52 tractor winch in position

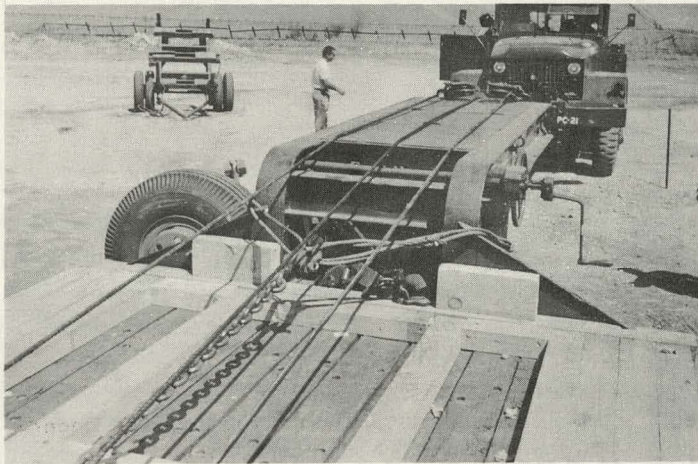


Figure A-25

Cable arrangement prior to winching reactor mockup aboard trailer, showing dead-end attachment to trailer gooseneck

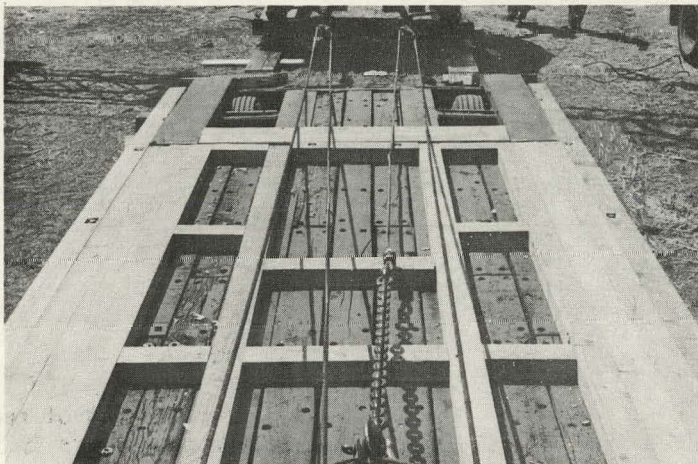


Figure A-26

Cable arrangement, cables attached to reactor mockup (at top of photograph)

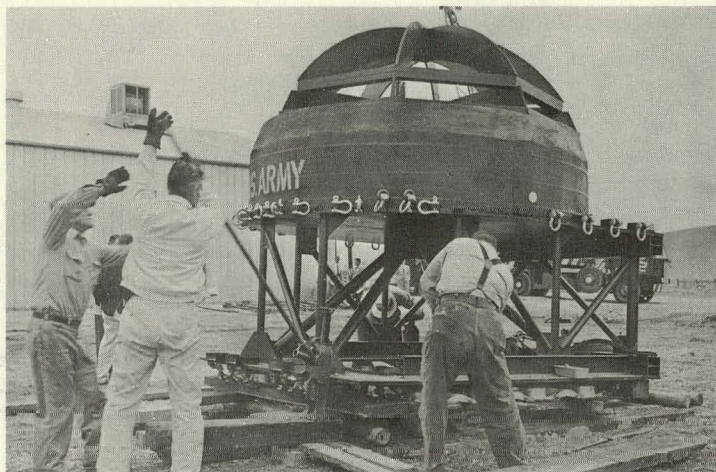


Figure A-27

Reactor mockup jacked up, inserting planks and rollers under shock mounts

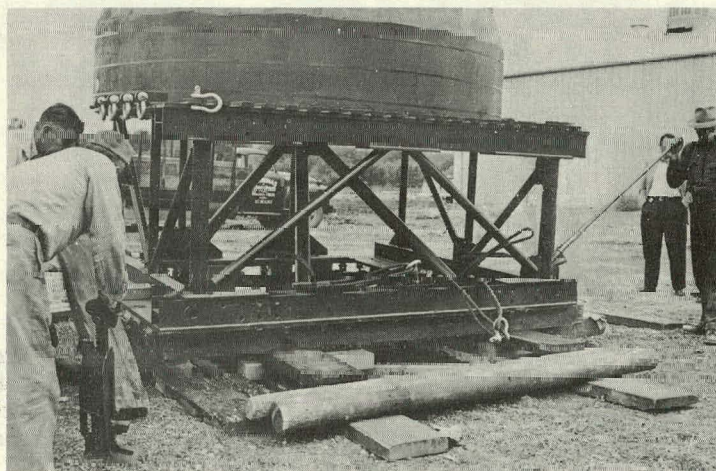


Figure A-28

Inserting rollers under reactor mockup

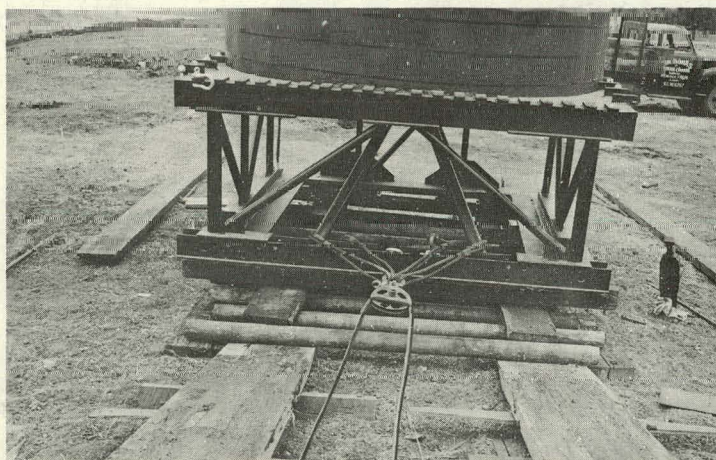


Figure A-29

View of forward end of reactor mockup on rollers

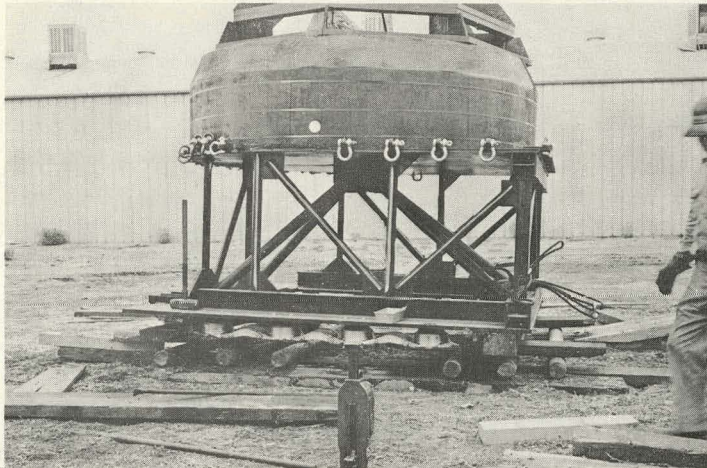


Figure A-30

**Reactor package on rollers,
prior to being winched aboard
trailer**

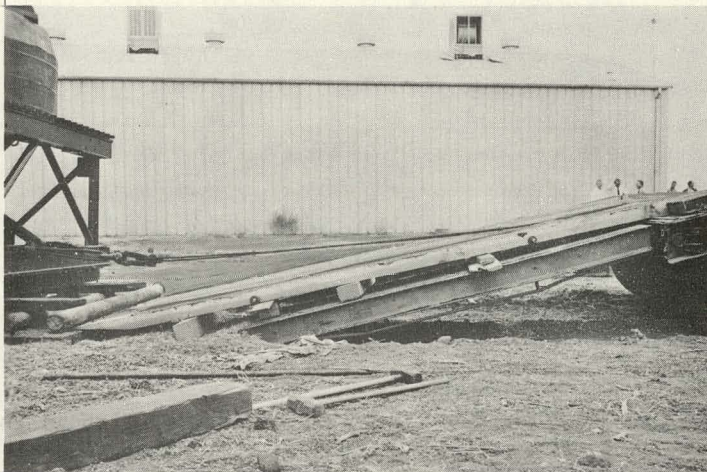


Figure A-31

**Cable attachment, loading ramp
setup prior to winching reac-
tor mockup aboard trailer**

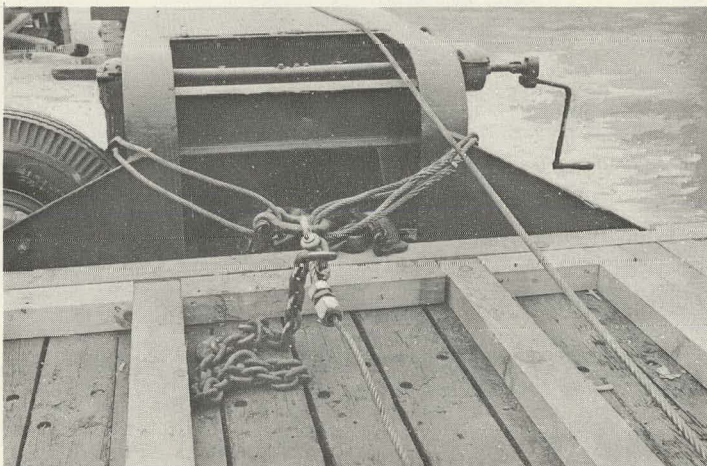


Figure A-32

**Dead end of cable attached to
trailer gooseneck**

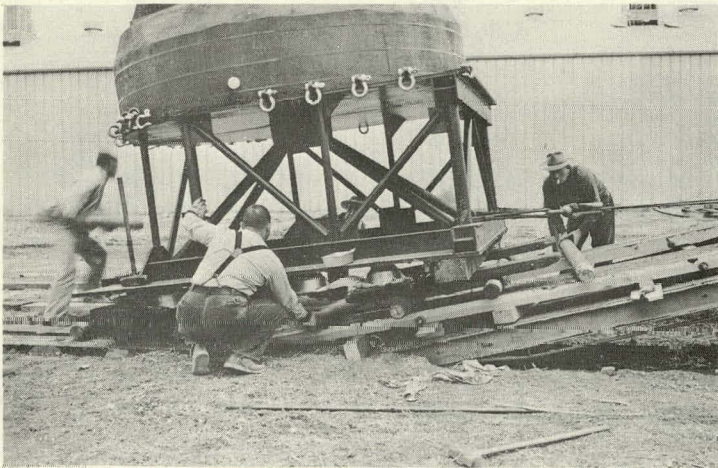


Figure A-33
Start of winching operations

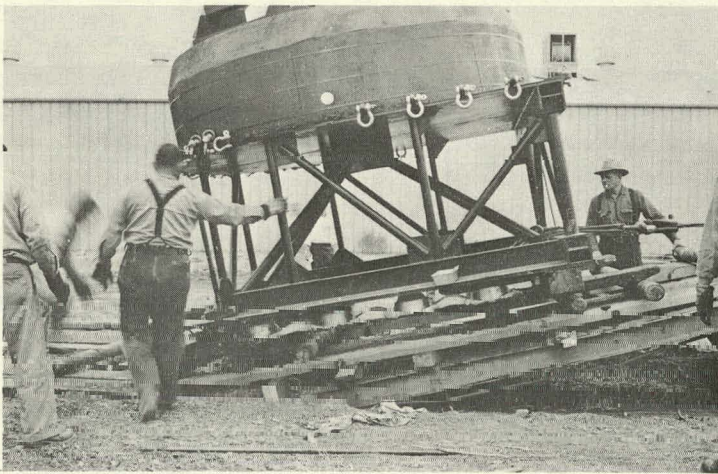


Figure A-34
Reactor mockup being winched
aboard trailer

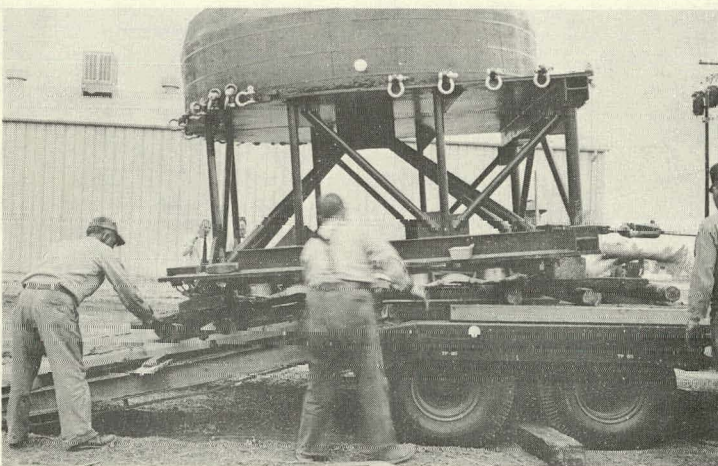


Figure A-35
Reactor mockup at crest of
loading ramp

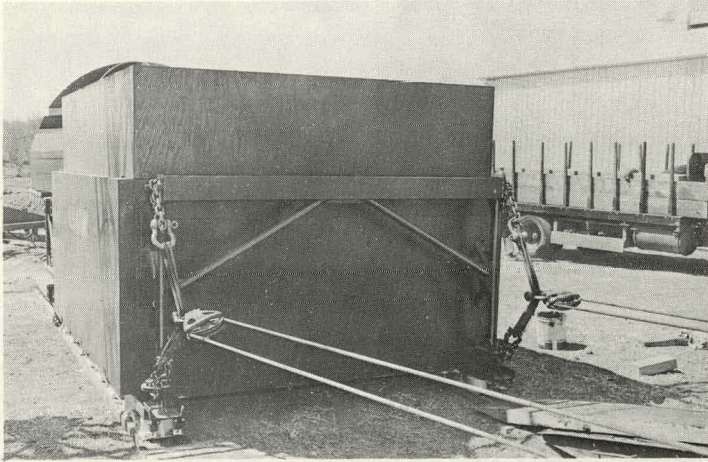


Figure A-36

Cables attached to forward end of power conversion mock-up, at foot of loading ramp

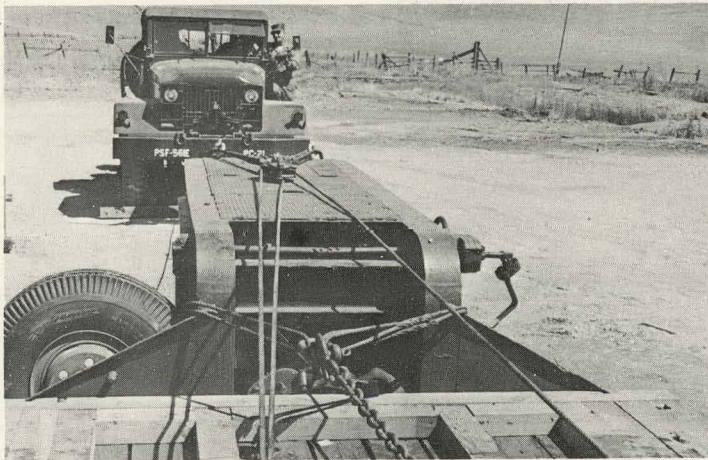


Figure A-37

M-52 tractor positioned for winching power conversion mockup aboard trailer

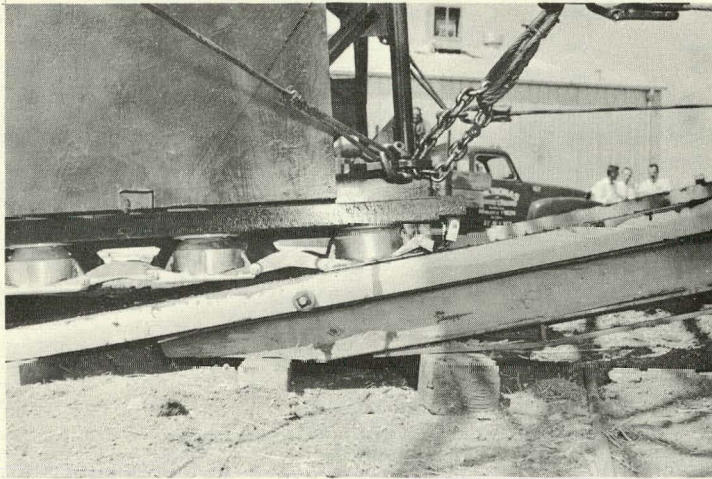


Figure A-38

Power conversion mockup being winched up loading ramp

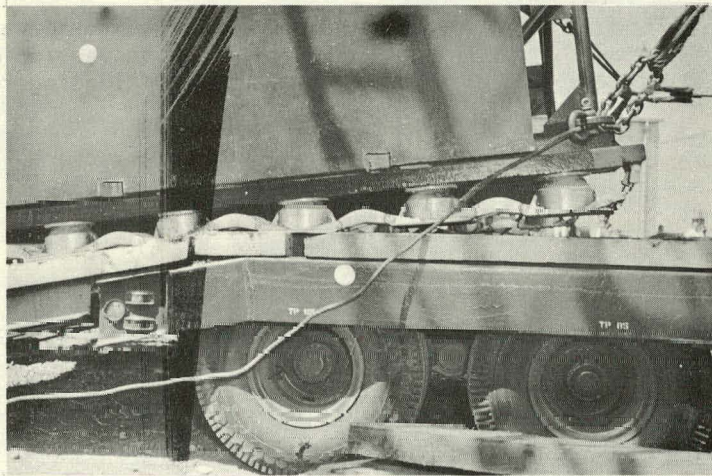


Figure A-39

Power conversion mockup at point immediately before tipping to trailer bed level

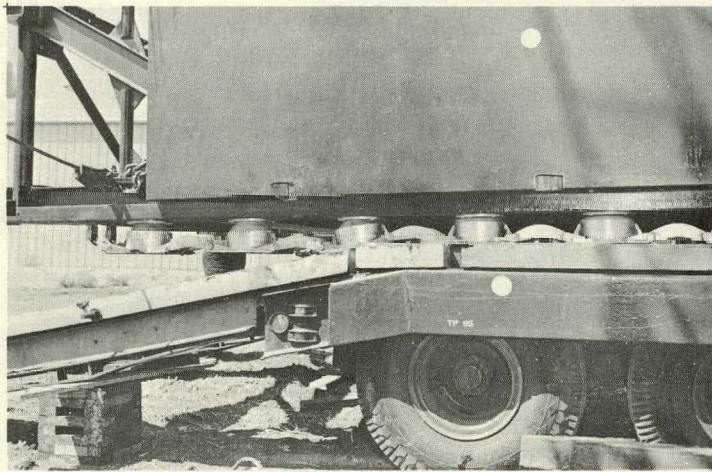


Figure A-40

Power conversion mockup fully supported by trailer bed. Note method of supporting ramps and cable attached for lateral thrust at end of mockup

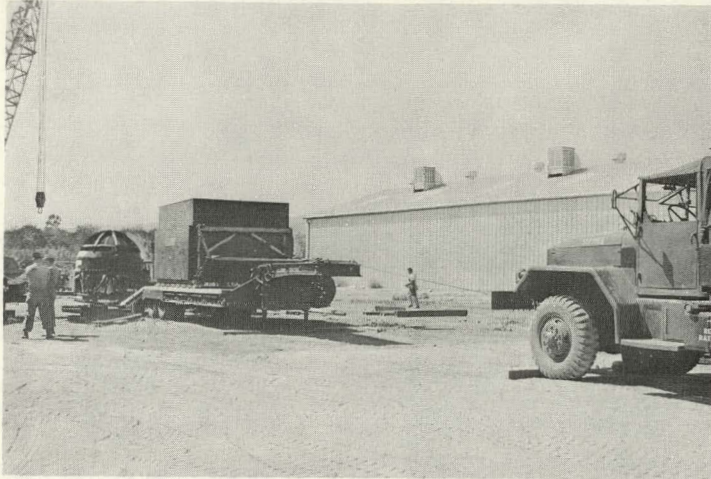


Figure A-41

Power conversion mockup, at point 6' 6" from trailer gooseneck

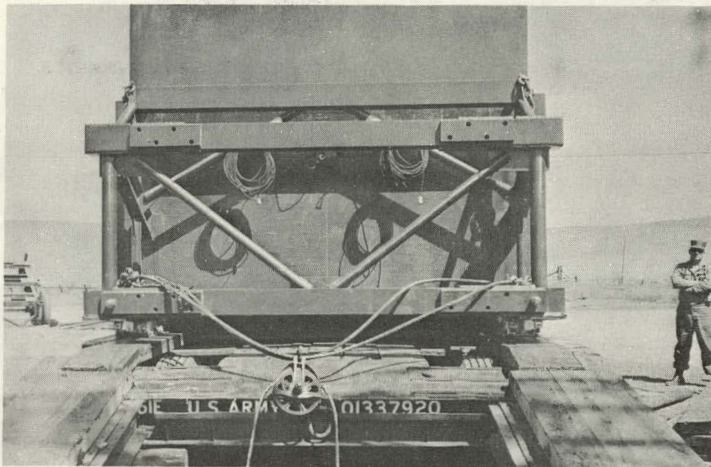


Figure A-42

Cable arrangement prior to off-loading

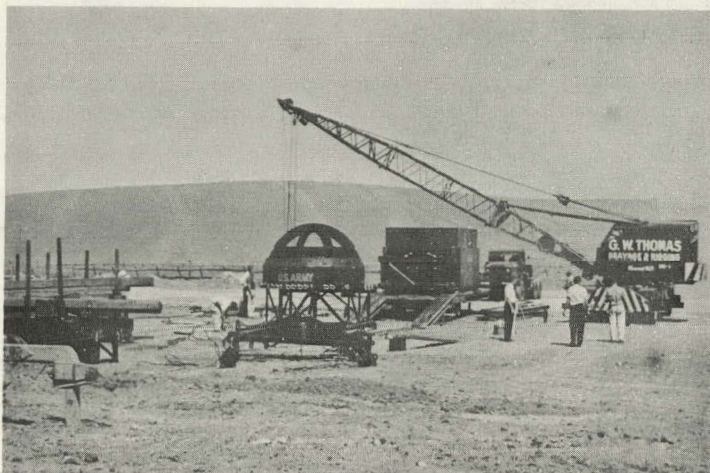


Figure A-43

General equipment setup, immediately prior to off-loading power conversion mockup. Note: Deadman (heavy construction earth roller) not shown

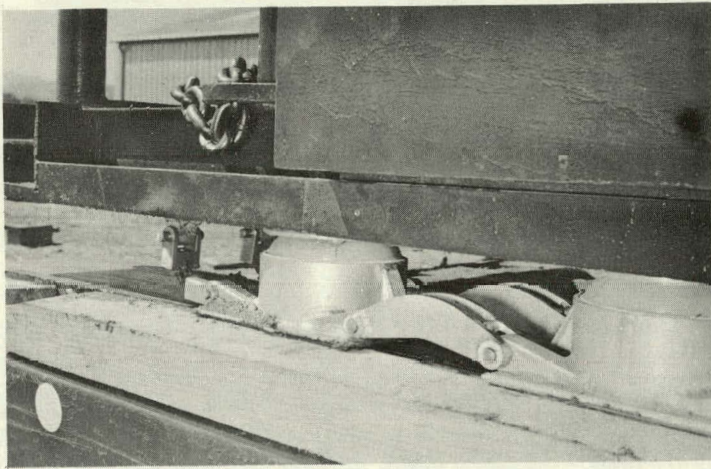


Figure A-44

Detail of shock mounts

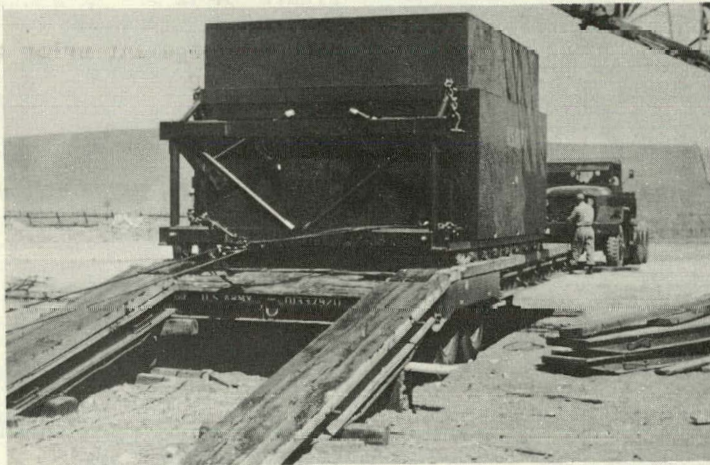


Figure A-45

Start of off-loading operation

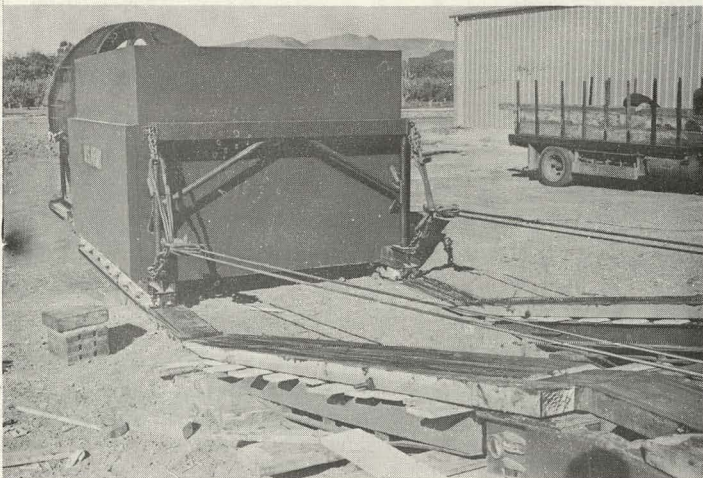


Figure A-46

Reactor and power conversion mockups bolted together and ready for loading as single unit



Figure A-47

Cable arrangement prior to winching combined mockups



Figure A-48

Rear starboard shock mounts digging into shoring during loading of combined mockups. Note side thrust cables attached at rear of mockup.

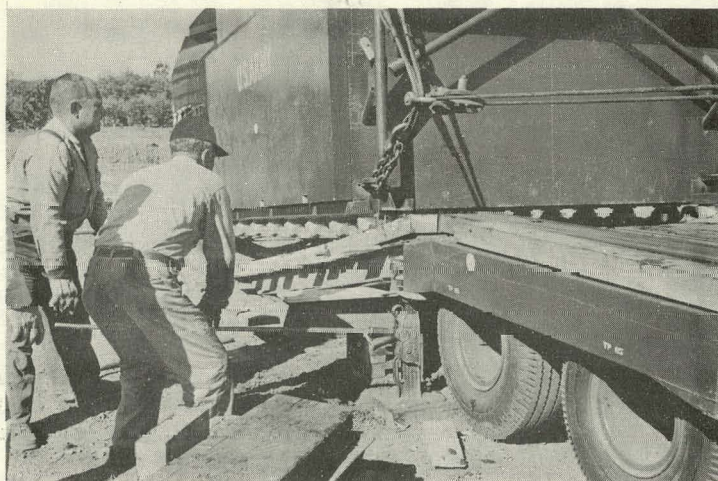


Figure A-49

Placing 10-ton jack on starboard board side of trailer in effort to level ramp and trailer



Figure A-50

Tape indicates where wheel well channels should extend flush with edge of trailer bed

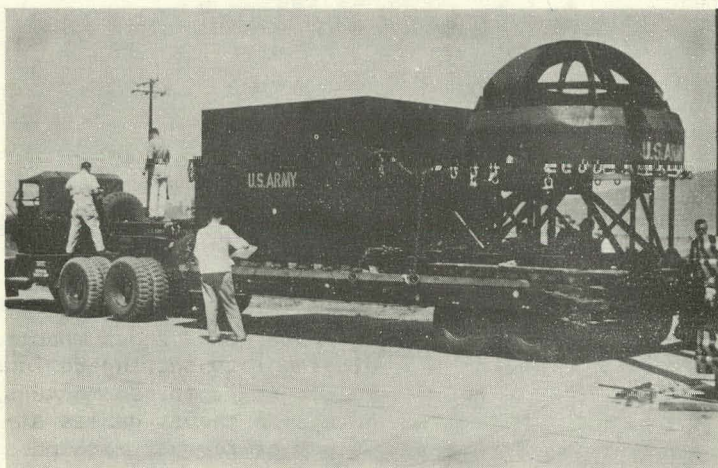


Figure A-51

Measurements of trailer bed deflection, after combined mock-ups winched aboard trailer by the M-52 tractor winch

F O R E W A R D

This material is a recapitulation of field notes taken during ML-1 mockup loading tests at Travis Air Force Base, Fairfield, California. Time studies of this nature must be carefully used because they are functions of several factors, most of which can be controlled within reasonable limitations. During experimental tests, all factors cannot be carefully controlled; therefore, the use to which the elemental times is put must be carefully considered.

Operation times are a function of the method used, the crew size, the equipment on hand, the layout of the equipment at the start of the operation, environmental conditions and the state of the crew's training. A time study of experimental operations is the starting point for establishing standard operating times. Standard times must be based on a good statistical sample of the operation. If any of the variables listed above is changed, then the time involved must necessarily also change.

Due to the size of the crew and the experimental nature of this test, many operations were done simultaneously. With only one person recording the times, it was impossible to break simultaneous elements apart. For example, the setup for off-loading was partially accomplished during the tiedown operations in some instances.

The times were recorded to the nearest second, and although the reader may consider this spurious accuracy, the fact is that many of the operations which were really important were less than one minute in duration; therefore, they had to be recorded in seconds. The final summary times are rounded off.

During studies for setting time standards, the normal practice is to try to choose elements which are approximately the same length of time. This is not possible during experimental studies which cover a full day's work by a large crew that fluctuates in size.

The report is presented in four main sections:

- 1) C-130 loading tests with the power conversion mockup,
- 2) C-130 tests with the reactor mockup,
- 3) C-133 tests with both packages, and
- 4) C-124 tests with the power conversion mockup.

Each section is further subdivided into two parts:

- 1) A tabular listing of each element by number, and
- 2) the transcription of the field notes. Each element is described in detail and pictures are referenced for clarity.

THE LOADING TESTS

The purposes of these aircraft loading tests were to:

- 1) Prove that the ML-1 reactor and power conversion packages could be loaded aboard C-130, C-133 and C-124 aircraft.
- 2) Determine the method of loading the ML-1.

In general, the crew operated in the following manner:

Mr. Blakley and Colonel Snodgrass acted as supervisors of the loading effort. The aircraft load master acted as an Air Force technical representative giving advice and direction on the loading of the aircraft in his charge. The Army enlisted men under Colonel Snodgrass acted as loading crew, and general laborers, moving lumber, adjusting cable, performing tiedown operations, etc. All necessary mechanical work was performed by the Aerojet mechanical engineers and mechanic. Carpentry work was performed by the Aerojet carpenter. The Army personnel from Fort Baker, California, operated the M-52 tractor with its 20,000 lb winch and the M-172 trailer used for transporting the packages to and from the aircraft. A commercial 20 ton crane was on full time standby during this operation. The crew for the commercial crane consisted of a crane operator, and an oiler, who also acted as the driver for the vehicle.

PART I

ELEMENTAL TIME SUMMARY
OF OPERATIONS ON
C-124, C-130 AND C-133 AIRCRAFT

Package	Operation	SU*	O	I	D	Sub Total	AD	Total	Plane
Power Conv.	Load	3 hr 49 min	19 min	8 min	3 hr 10 min	7 hr 26 min	26 min	7 hr 52 min	C130
"	Off Load	20 min	6 min	25 min		49 min		49 min	C130
Reactor	Load	2 hr 18 min	9 min	26 min	19 min	3 hr 12 min		3 hr 12 min	C130
"	Tie Down		1 hr 54 min			1 hr 54 min		1 hr 54 min	C130
"	Off Load		45 min			45 min		45 min	C130

Power Conv. & Reactor	Load	5 hr 44 min	28 min	35 min	1 hr 48 min	7 hr 55 min		7 hr 55 min	C133
"	Tie Down		6 hr 25 min			6 hr 25 min		6 hr 25 min	C133
"	Off Load	38 min	18 min	6 min	25 min	1 hr 25 min		1 hr 25 min	C133

Power Conv.	Load	2 hr 1 min	1 hr 7 min	1 min	1 hr 23 min	4 hr 32 min		4 hr 32 min	C124
"	Tie Down		2 hr 17 min			2 hr 17 min		2 hr 17 min	C124
"	Off Load	1 hr 2 min	9 min	2 min	32 min	1 hr 45 min	4 min	1 hr 49 min	

LEGEND :

*SU = Set up and tear down.

O = Operation -- any element which makes the job progress.

I = Inspection

D = Unavoidable delays due to method of operation.

AD = Avoidable delays -- wait for tools, coffee breaks, taking pictures, etc.

C-130 AIRCRAFT

LOADING TESTS WITH POWER CONVERSION MOCKUP

PART II
TABULATION OF ELEMENTAL TIMES

C-130 POWER CONVERSION PACKAGE MOCKUP

LOADING OPERATIONS

SU				O				I				D				AD			
Op. No.	*H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S
1		6		15		3		22		2	15	16		10	10	14		12	
2		7		17			30	43		1	10	18		8	25	35		3	50
3		5		19			20	50		4	25	20		4	30	48		10	
4		9		21								23		2					
5		21		25		3						24		23					
6		48		36		2	40					26		3	20				
7		23		38			50					27		3	50				
8		7		40			30					28		3	50				
9		18		42			10					29		3	10				
10		1	30	44			15					30			20				
11		3		46		1	25					31		18					
12		3	3	49		2						37			55				
13		13		51		1	20					39		1	50				
32		52	30	54			4					41		1	10				
33		3	50	57			43					45		2	45				
34		7	40	59		1	25					47		46					
												52		35	15				
												53		4	54				
												55		3	32				
												56			2				
												58		6	30				
												60		6	15				
												61			5				
Total	3	48	33		18	57			7	50			3	9	48		25	50	
Rounded																			
Off	3	49			19				8				3	10			26		

OFF-LOADING OPERATIONS (FROM STATION 600)

62	16	35	63		59	66		55			
64		46	65	2	20	68		50			
71		3	67	1	25	70	21	40			
			69		20						
			72	1	16						
Total	20	21		6	20		23	25			
Rounded											
Off	20			6			23				

*H = hours

M = minutes

S = seconds

C-130 AIRCRAFT
LOADING TESTS WITH POWER CONVERSION MOCKUP
ELEMENTAL DESCRIPTION AND ELAPSED TIME

September 15, 1959

Operations began at 1415 hours. Equipment was located near the aircraft, in positions similar to those shown in Figures B-1 and B-2.

The remainder of the afternoon of 9/15/59 was spent in the crew familiarizing themselves with the operation at hand. The gear was spotted at the side of the airplane; excess gear was removed from inside the aircraft. Installation of roller conveyors on the inside of the plane was begun. Plans were made for on-loading the next morning at 0800. Operations ceased for the day at approximately 1700 hours.

September 16, 1959

Loading crew arrived at the airplane at 0830. Loadmaster and three soldiers had prepared aircraft by opening the rear cargo door and laying shoring and roller conveyors on the cargo door. Thus, the airplane was in the same condition as it had been at 1700 hours the previous day.

First operation: Load and off-load ML-1 power conversion package mockup.

Equipment involved: ML-1 power conversion mockup
 C-130 aircraft
 M-172 Army trailer
 Army jeep
 M-52 Army tractor, equipped with 20,000# winch
 Commercial 20-ton crane equipped with 10,000# winch
 2 x 10 in. wood shoring
 4 x 8 in. plywood
 Tools: hammer, hatchet, hand saw, skill saw,
 carpenter's square, carpenter's level, wood
 chisel and mallet.
 Mechanics tool chest containing general hand tools.

The M-52 tractor winch was equipped with 5/8 in. diameter steel cable.

Element 1 (SU)*

Lay C-133 type Douglas Aircraft Co. magnesium-glass fiber roller conveyor inside of plane and down rear cargo loading ramp. Air Force part number on this conveyor is 5585909-1 (this roller conveyor is shown in Figure B-3, which shows the break in shoring at the hinge of the rear cargo loading door of the C-130.) During this operation the crane, which had been parked in front of the airplane overnight, was set up. (See Figure B-7 for conveyor setup).

Elapsed Time: 6 min

Element 2 (SU)

The 20 ton crane was relocated for off-loading the power conversion package from the M-172 trailer. It moved into position as shown in Figure B-5, with the boom high and no spreader bar, using long cable slings. It was noted at this point that the C-130 aircraft has twelve 25,000# fittings. (Earlier models had only 8).

Elapsed Time: 7 min

LEGEND:

*SU = Set up and tear down.
O = Operation -- any element which makes the job progress.
I = Inspection.
D = Unavoidable delays due to method of operation.
AD = Avoidable delays -- wait for tools, coffee breaks, taking pictures, etc.

Element 3 (SU)

A piece of 2 x 10 with beveled ends was placed on the rollers at the beginning of the incline in order to pick up the nose of the skid and avoid high point loadings on the rollers. This piece of wood is called a "bogie". (See Figure B-6).

Elapsed Time: 5 min

Element 4 (SU)

Skate-wheel type rollers (as shown in Figure B-7) were installed in two layers of 10' long by 1' wide, 3-3/8" high.

Elapsed Time: 9 min

Element 5 (SU)

Carpenter aided by three soldiers measured plywood, sawed the proper widths, and placed them on the roller conveyors, as shown in Figure B-7. Note: The bar rollers shown in Figure B-8 have the following dimensions: 27" wide x 10' long x 4" high, laid on 2 x 12 shoring; the bar rollers are 2-1/4" in diameter and 23" long.

Elapsed Time: 21 min

Element 6 (SU)

Move 172 trailer into position as shown in Figure B-5.

Elapsed Time: 48 min

Element 7 (SU)

Hook crane sling to power conversion package.

Elapsed Time: 23 min

Element 8 (SU)

M-52 tractor put in winching position. Hoist power conversion package off of M-52 trailer, swing around to pallet, and position on pallet as shown in Figure B-10. Note: The M-172 trailer can be seen in its winching position in Figure B-9. The cable is shown passing through a pulley inside the port forward cargo door.

Elapsed Time: 7 min

Element 9 (SU)

Stop operations -- remove power conversion package from pallet on

roller conveyors, recut the pallet to proper size, pallet having been cut too wide previously. Reposition the pallets on the roller conveyor as shown in Figure B-7.

Elapsed Time: 18 min

Element 10 (SU)

Lower power conversion package to pallet. (See Figure B-10).

Elapsed Time: 1 min 30 sec

Element 11 (SU)

Raise and reposition power conversion package on pallet.

Elapsed Time: 3 min

Element 12 (SU)

Rig two 10" #410 McKissick 15 ton pulleys on the front end of the power conversion package (this requires two men). These pulleys may be noted in Figure B-11.

Time Elapsed: 3 min 3 sec

Element 13 (SU)

Rig cable and snatch blocks for winching aboard. Carpenter covered the conveyors with plywood so the cable would slide freely. (See Figure B-12). The hook end of the M-52 winch cable is hooked into a 24,000# fitting at the forward end of the airplane as shown in Figure B-13. The rigging of the snatch block through which the cable passes from the power conversion skid into the M-52 winch is shown in Figure B-9.

Time Elapsed: 13 min

Element 14 (AD)

Took pictures of the setup.

Elapsed Time: 12 min

Element 15 (O)

Pull power conversion package toward airplane. This element was very smooth, no stops until the power conversion skid arrived at the first incline as shown in Figures B-14, B-15, and B-16.

Elapsed Time: 3 min

Note: Port and starboard, with respect to the airplane, are used instead of left and right.

Figure B-6 showed that the first incline was actually the last roller conveyor resting on the ground just before the loading ramp was reached. This was about a 4° incline. This element ends at a point just before we reach the second incline which is the beginning of the loading ramp.

Elapsed Time: 3 min

Element 16 (D)

The vertical clearance at this time was measured and found to be adequate. At this point it was determined that a starboard lateral pull on the cable was necessary. A D-1 tie down fitting was used to pull the cable to the starboard, as shown in Figure B-17.

Elapsed Time: 10 min 10 sec

Element 17 (O)

Winch load aboard to a point where the base channel hits the wooden "bogie."

Elapsed Time: 30 sec

Element 18 (D)

Check side clearance and re-rig for side thrust.

Elapsed Time: 8 min 25 sec

Element 19 (O)

Pull to clear starboard side.

Elapsed Time: 20 sec

Element 20 (D)

Re-rig for straight pull, pulleys rigged as shown in Figure B-14.

Elapsed Time: 4 min 30

Element 21 (O)

Winch load aboard until point reached as shown in Figure B-18, where the magnesium conveyors began to break due to heavy point loading.

Elapsed Time: 45 sec

Element 22 (I)

Inspect broken rollers.

Elapsed Time: 2 min 15 sec

Element 23 (D)

Back Army jeep in place for pulling load out of aircraft and rig chain to rear end of power conversion skid.

Elapsed Time: 2 min

Element 24 (D)

Pull load back out of airplane to a point as shown in Figure B-8. Inspect and replace conveyors on ramp and door with roller skate wheel type conveyors shown in Figures B-19 and B-20. (At this point most of the crew went to lunch, returning to the airplane at 1320 hours; however, two men remained in order to complete replacement of the rollers with aluminum skate wheel type. Lunch took approximately 1 hour.)

Elapsed Time: 23 min

Element 25 (O)

Pull load aboard until starboard clearance is too small; check clearance. This clearance measured on the port side 5", on the starboard side 5/8".

Elapsed Time: 3 min

Element 26 (D)

Tie down the rear end of the power conversion skid to a tie down fitting on the loading ramp using a D-1 fitting and a chain in an effort to straighten out the load.

Elapsed Time: 3 min 20 sec

Element 27 (D)

Change the method of purchase on the two corners of the power conversion package from 2 pulleys to the use of one pulley in the center and 2 D-1 aircraft type fittings as shown in Figure B-8.

Elapsed Time: 3 min 50 sec

Element 28 (D)

Bring jeep to rear and pull load clear of plane.

Elapsed Time: 3 min 50 sec

Element 29 (D)

Change cable to straighten load.

Elapsed Time: 3 min 10 sec

Element 30 (D)

Pull with cable on starboard side only.

Elapsed Time: 20 sec

Element 31 (D)

Back out load, attach crane winch, pull completely out to attach crane cables.

Elapsed Time: 18 min

Element 32 (SU)

Put crane in position (transverse to plane center line). Attach cables to power conversion skid, hoist skid from the conveyors, swing load around and set down on runway. Front ends of the pallet were beveled. The empty pallets were run up the ramp inside the aircraft to check the edge distance, i.e., the distance from the centerline of the airplane to the outer edge of each of the pallets. (This distance had to be 4'8"). Then the two pallets were run back outside the aircraft and nailed together with plywood on top of the pallets instead of on the bottom.

Elapsed Time: 52 min 30 sec

Element 33 (SU)

Place power conversion skid on pallet so that the shock mounts are 2" from the outside edge of the pallet.

Elapsed Time: 3 min 50 sec

Element 34 (SU)

Adjust D-1 fittings connected to chain and McKissick 10", #419, 50 ton pulleys, as shown in Figure B-8.

Elapsed Time: 7 min 40 sec

Element 35 (AD)

Take pictures of setup.

Elapsed Time: 3 min 50 sec

Element 36 (O)

Pull power conversion package toward aircraft. Stop before reaching incline. (Time at this point was 1455 hours).

Elapsed Time: 2 min 40 sec

Element 37 (D)

Power conversion skid was slipping to the starboard; therefore, the starboard D-1 fitting attached to the front end of the power conversion package was tightened.

Elapsed Time: 55 sec

Element 38 (O)

Pull load to the beginning of the first incline.

Elapsed Time: 50 sec

Element 39 (D)

Tightened starboard D-1 fitting since the load was shifting to starboard.

Elapsed Time: 1 min 50 sec

Element 40 (O)

Pull load to within 4' of the beginning of the ramp extensions.

Elapsed Time: 30 sec

Element 41 (D)

Remove the port side D-1 fitting so that the pulley is exerting force on the starboard of the front end of the power conversion skid.

Elapsed Time: 1 min 10 sec

Element 42 (O)

Pull only on starboard side applying crowbar to straighten load.

Elapsed Time: 10 sec

Element 43 (I)

Check clearance between aircraft and power conversion package on both sides.

Elapsed Time: 1 min 10 sec

Element 44 (O)

Pull load only on starboard side.

Elapsed Time: 15 sec

Element 45 (D)

Re-attach the port side D-1 fittings so that the pulley exerts force equally on either side of the power conversion skid front end.

Elapsed Time: 2 min 45 sec

Element 46 (O)

Pull load so that rear end is at the beginning of the extension. This position is shown approximately in Figure B-21.

Elapsed Time: 1 min 25 sec

Element 47 (D)

Remove rear "bullnoses" from power conversion skid. Note: As seen in Figure B-21 these "bullnoses" are pieces of pipe which are attached to the ends of the support channel. These pipes began to dig in, resulting in heavy point-loading on the conveyor.

Elapsed Time: 46 min

Element 48 (AD)

Ten minute break for the crew.

Elapsed Time: 10 min

Element 49 (O)

Winch ahead.

Elapsed Time : 2 min

Element 50 (I)

Check clearance by measurements both sides.

Elapsed Time: 4 min 25 sec

Element 51 (O)

Pull load to point where it is almost level in aircraft, as seen in Figure B-22, through the starboard rear access door.

Elapsed Time: 1 min 20 sec

Element 52 (D)

Check clearance then attempt to move rear end of load to the port side, using a jeep attached to the power conversion package by chain and using a "come-a-long".

Elapsed Time: 35 min 15 sec

Element 53 (D)

Pull to port side using jeep and "come-a-longs".

Elapsed Time: 4 min 54 sec

Element 54 (O)

Winch aboard.

Elapsed Time: 4 sec

Element 55 (D)

Change location of cables to starboard side.

Elapsed Time: 3 min 32 sec

Element 56 (D)

Pull load on starboard side only.

Elapsed Time: 2 sec

Element 57 (O)

Winch aboard.

Elapsed Time: 43 sec

Element 58 (D)

Re-connect cables to both corners of power conversion skid as shown in Figure B-16.

Elapsed Time: 6 min 30 sec

Element 59 (O)

Winch aboard.

Elapsed Time: 1 min 25 sec

Element 60 (D)

Attempt to replace rollers under front end by using crowbar. Attempt failed.

Elapsed Time: 6 min 15 sec

Element 61 (D)

Take up slack on rear cable.

Elapsed Time: 5 sec

Element 62 (SU) -- Off Loading - Power Conversion Package Mockup

Hook up the jeep to pull load back out of aircraft. Re-adjust rear conveyors for off loading. Note: At this point the front end of the power conversion skid was located at station 600 in the aircraft. At this point it was noted that the shock mounts must be moved at least 1' closer inboard on each side in order to have the weight of the power conversion skids distributed properly over the treadway of the aircraft.

Elapsed Time: 16 min 35 sec

Element 63 (O)

Pull starboard aft end of power conversion package with a crane winch in an effort to straighten.

Elapsed Time: 59 sec

Element 64 (SU)

Re-rig crane winch for off loading.

Elapsed Time: 46 sec

Element 65 (O)

Off load.

Elapsed Time: 2 min 20 sec

Element 66 (I)

Check clearance.

Elapsed Time: 55 sec

Element 67 (O)

Off load.

Elapsed Time: 1 min 25 sec

Element 68 (I)

Check clearance.

Elapsed Time: 50 sec

* See tiedown diagrams (Figures B-27, B-52, B-118, and B-119)

Element 69 (O)

Off load.

Elapsed Time: 20 sec

Element 70 (I)

Check clearance and show by pictures how load is slipping to starboard. Hook up crane winch for pull to port. This slipping to starboard can be seen in Figures B-23 and B-24.

Elapsed Time: 21 min 40 sec

Element 71 (SU)

Re-position crane for pulling aft to off load.

Elapsed Time: 3 min

Element 72 (O)

The off loading was accomplished at 6:10 pm. The crew locked up for the day.

Elapsed Time: 1 min 16 sec

This ends the time study recapitulation for loading and off loading the power conversion skid C-130 aircraft. The power conversion skid was not used again because of two reasons: (1) Time limitations and (2) Shock mounts would have to be moved inboard, as noted above, 1 foot on each side in order to distribute the load properly on the treadways; therefore, only the reactor package was properly loaded into the C-130 aircraft, tied down and off loaded.



Figure B-1

General equipment layout, showing C-130, M-52 tractor, M-172 trailer with power conversion mockup loaded, and commercial 20-ton crane



Figure B-2

Equipment arrangement prior to loading power conversion mockup into aircraft

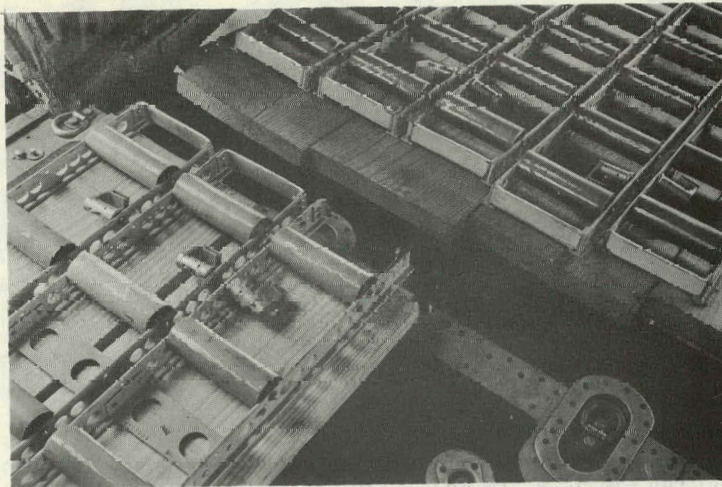


Figure B-3

Magnesium/glass fiber roller
conveyor (Douglas Aircraft Co.)
carried by C-133

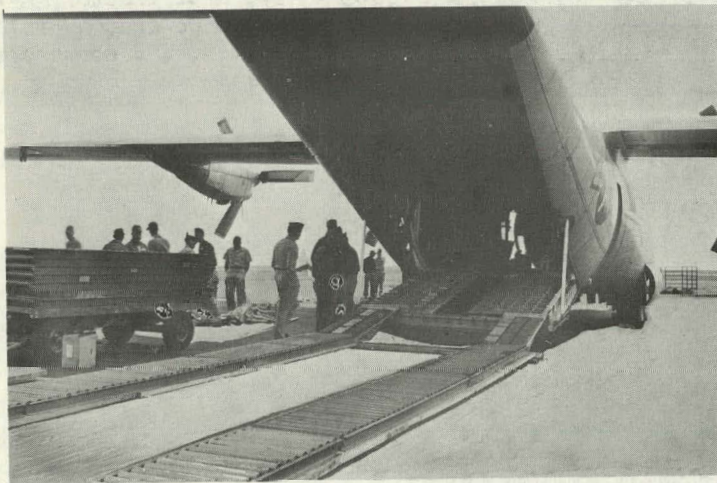


Figure B-4

C-130 aircraft loading ramp

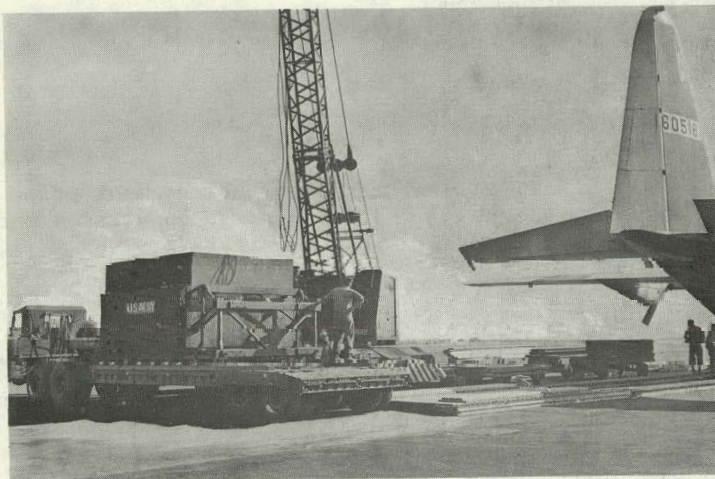


Figure B-5

M-172 trailer and 20-ton crane
in position for unloading power
conversion mockup onto convey-
or pallet

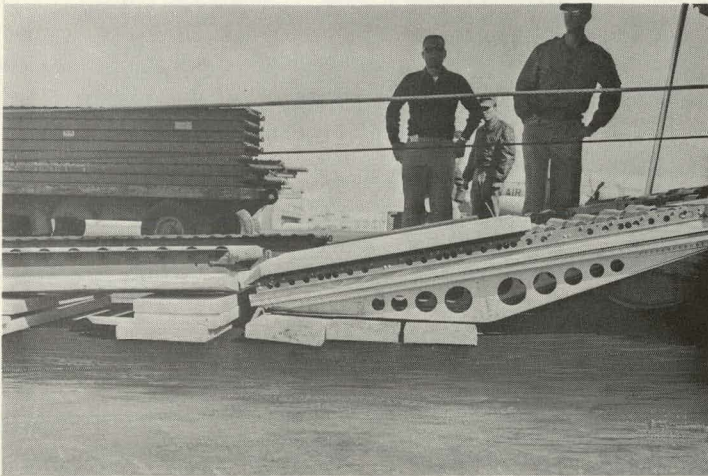


Figure B-6

Wood bogie with beveled ends
in place on roller conveyor

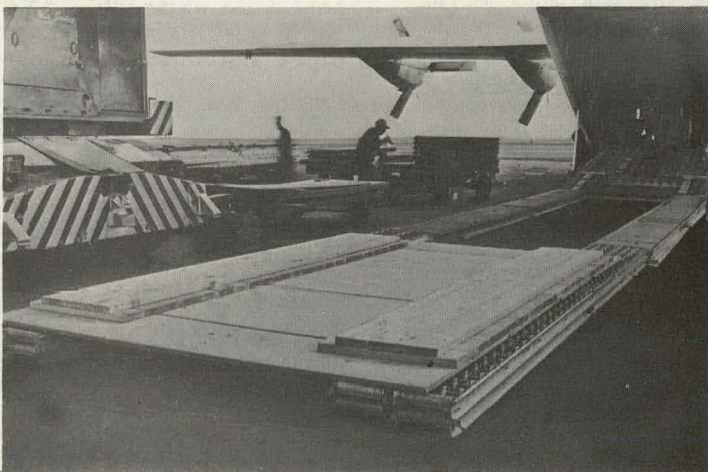


Figure B-7

Detail of a pallet. Each
roller section is 10 ft
long, 1 ft wide, and 3-3/8
inches high

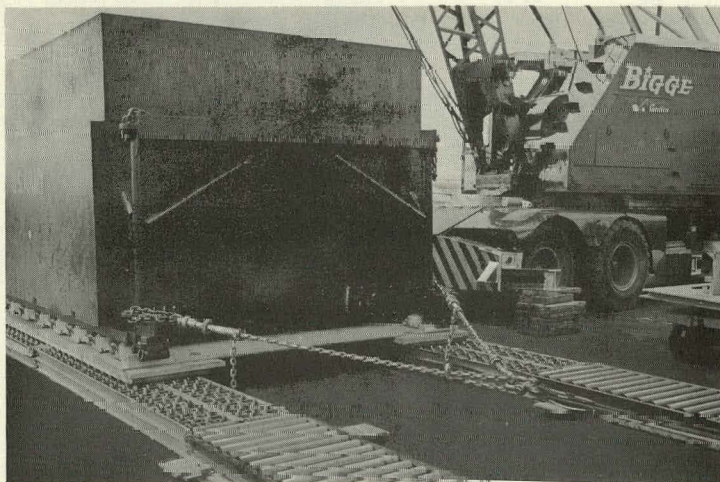


Figure B-8

Power conversion mockup on pallet immediately prior to winching aboard aircraft

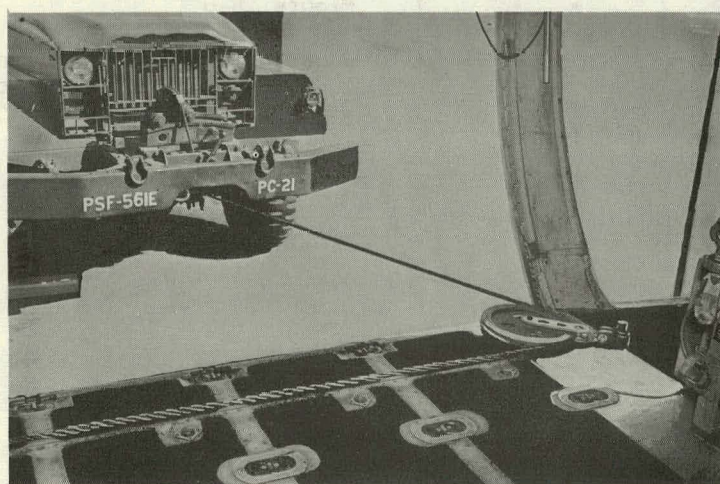


Figure B-9

M-52 tractor in position, port side of C-130. Note cable passing through snatch block and forward cargo door

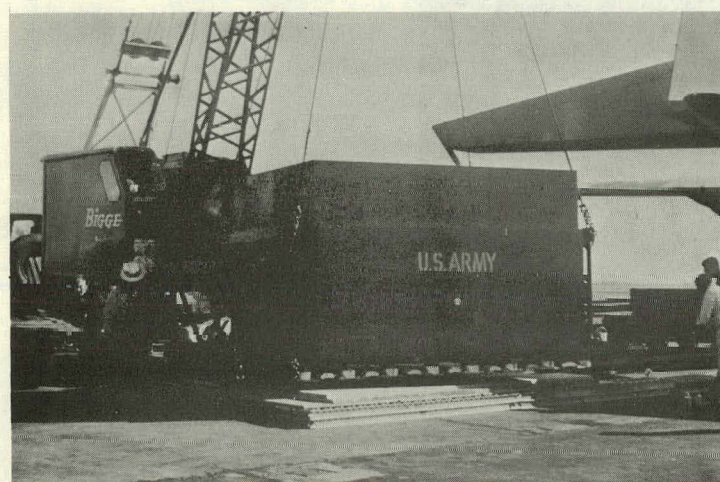


Figure B-10

Power conversion mockup being positioned on pallet prior to loading

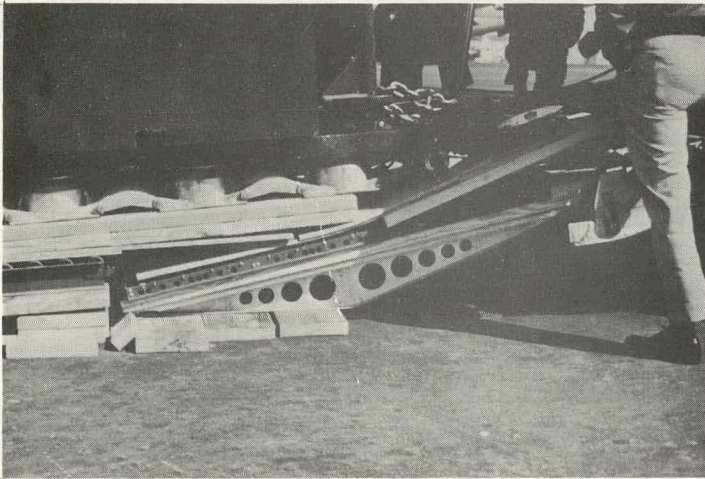


Figure B-11

Wood bogie in use. Note
15-ton pulleys attached to
forward end of mockup

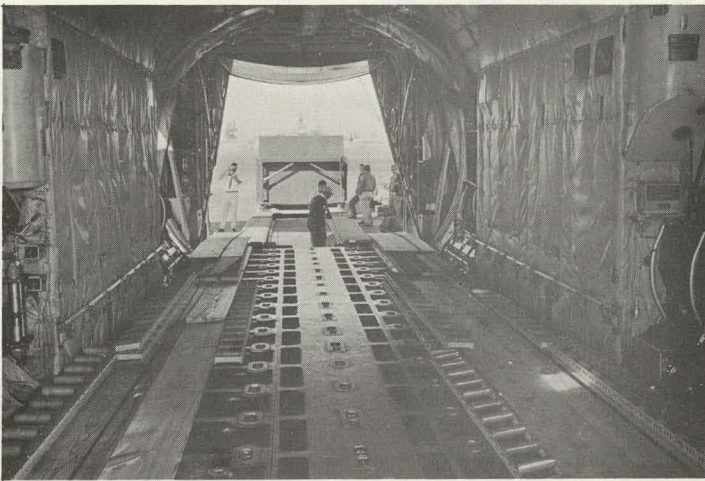


Figure B-12

Interior of C-130. Note
plywood under cable.

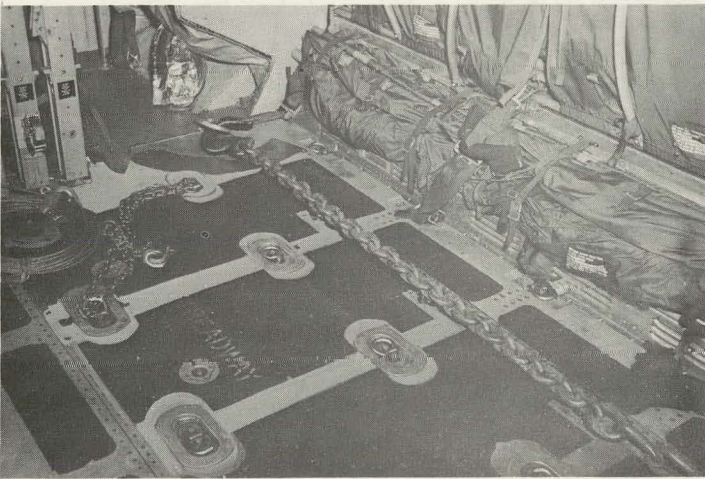


Figure B-13

Hook end of cable from M-52
winch; cable attached to
24,000-lb tiedown fitting at
forward end of C-130

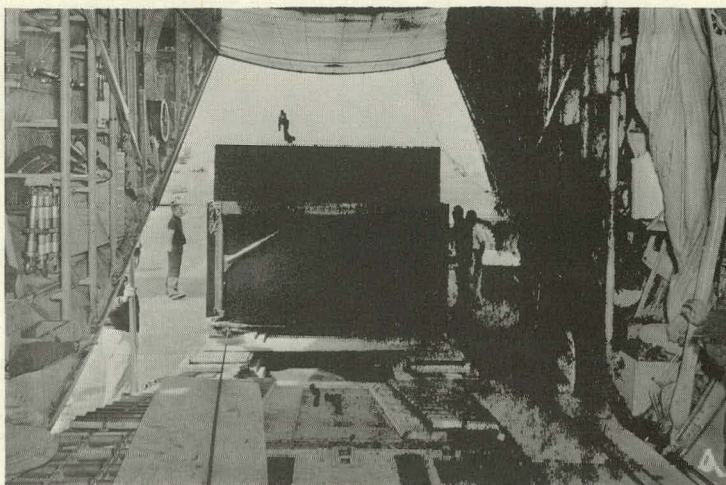


Figure B-14

View of power conversion
mockup from inside aircraft



Figure B-15

Prior to loading power con-
version mockup



Figure B-16

Mockup near end of rear load-
ing door ramps

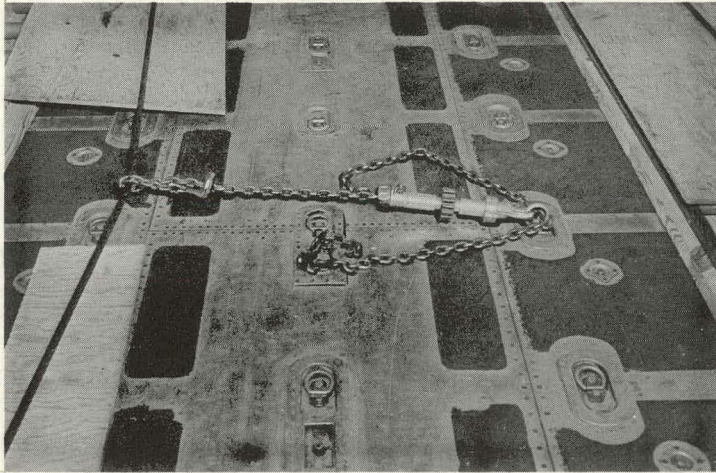


Figure B-17

D-1 tiedown fittings used to pull cable to starboard

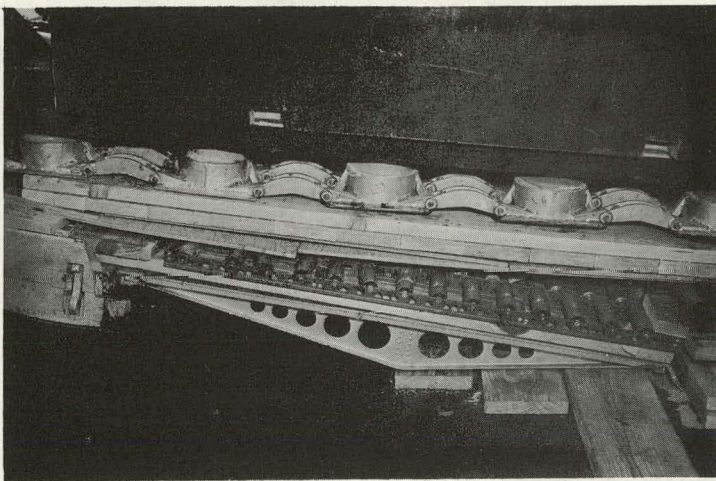


Figure B-18

Power conversion mockup on loading ramp extensions. Note broken roller conveyors, caused by heavy point loading

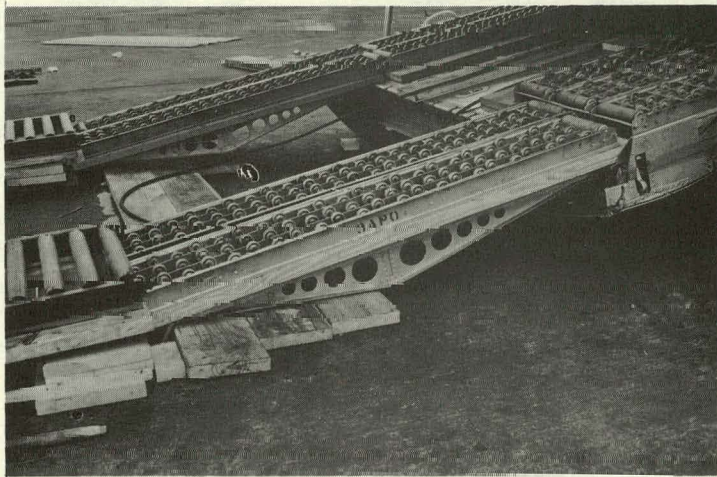


Figure B-19

Roller-skate-wheel type
conveyors

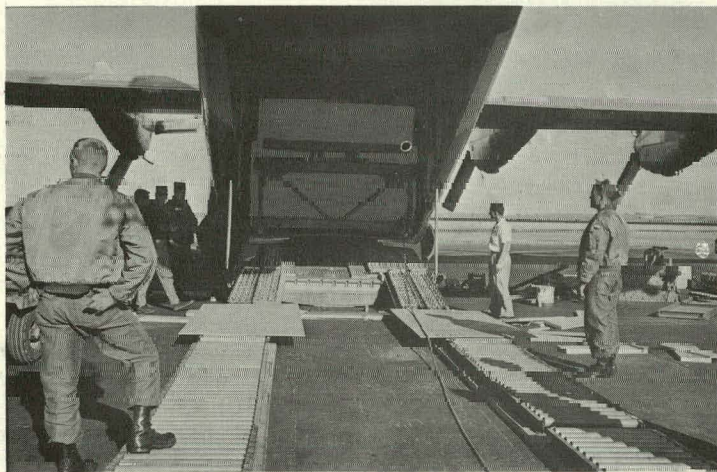


Figure B-20

Power conversion mockup
being loaded with roller-
skate-wheel type conveyor

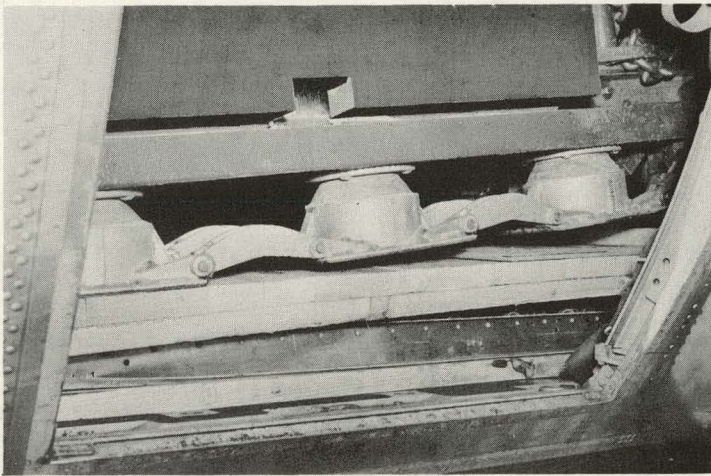


Figure B-21

View of mockup from starboard jump door, just before mockup tilted to level of aircraft floor

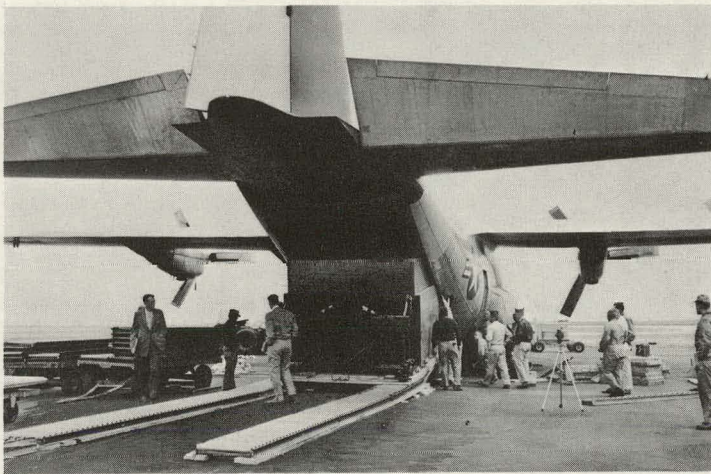


Figure B-22

Mockup on loading ramp incline

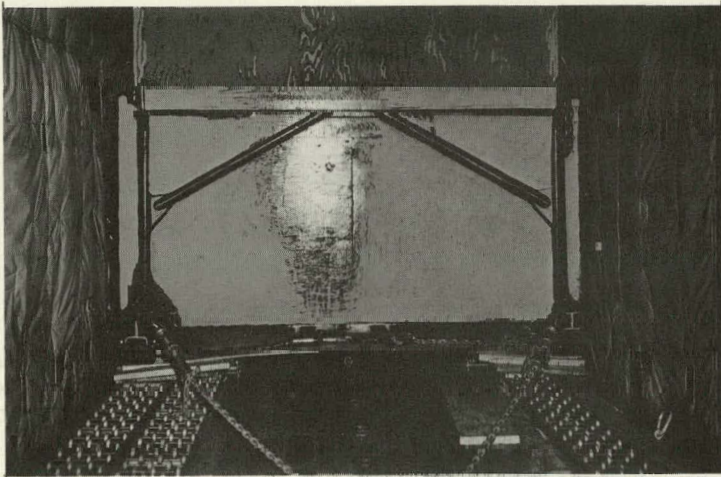


Figure B-23

Mockup slipping to starboard
on roller conveyors; inside
C-130 aircraft

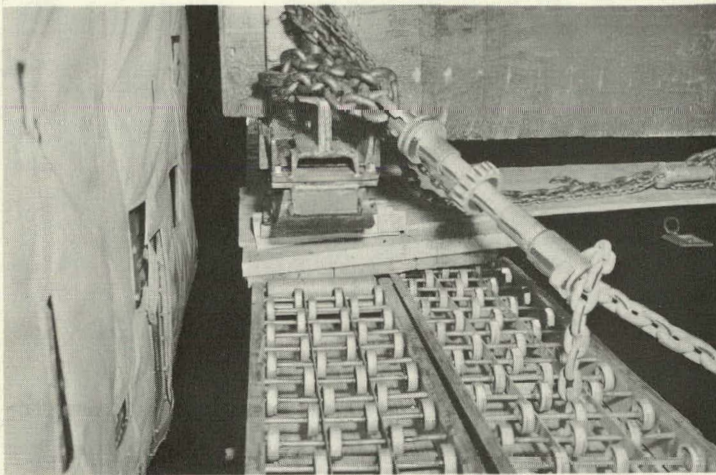
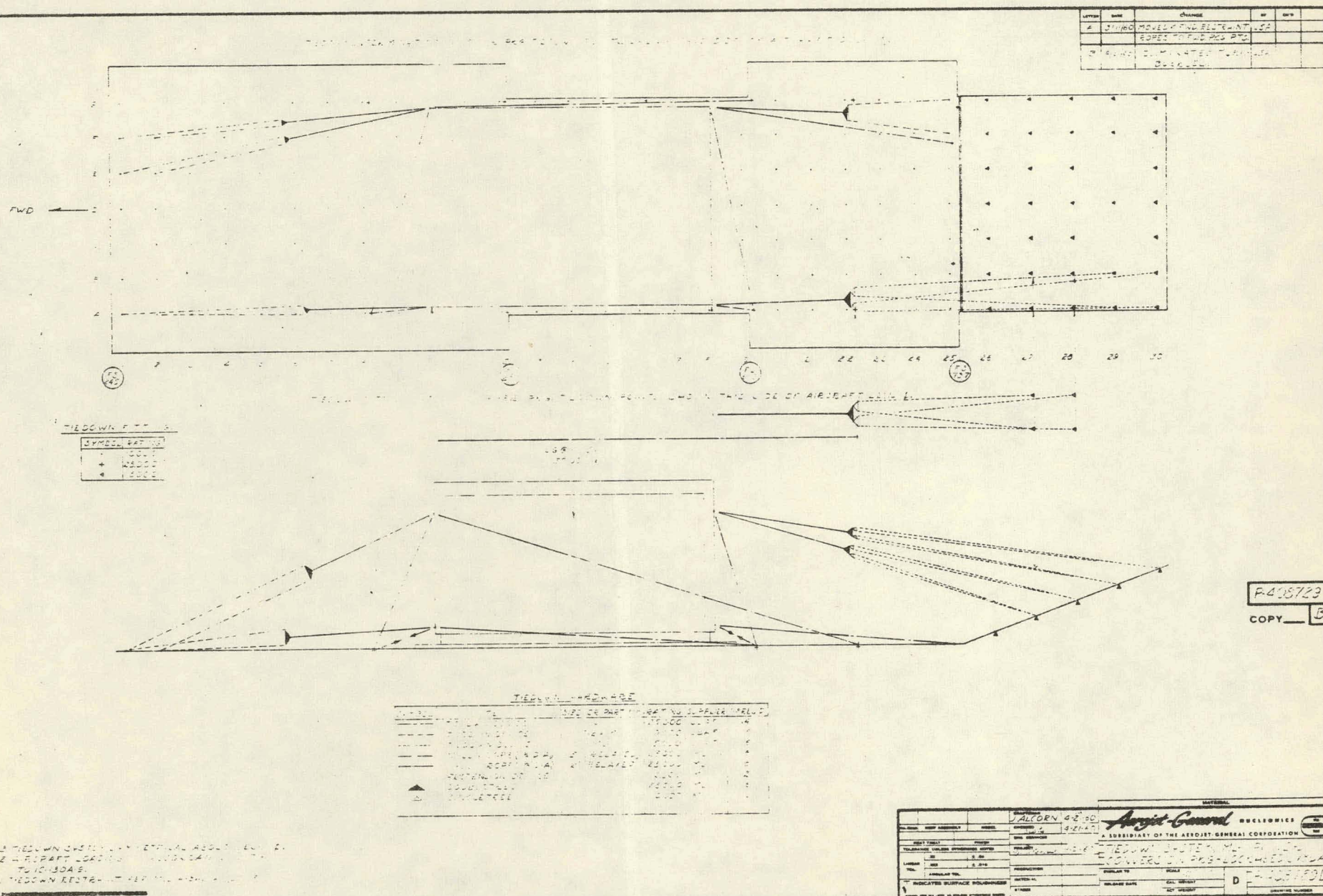


Figure B-24

Close-up of slippage on
starboard side



APPENDIX B
RECAPITULATION OF TIME STUDIES
ML-1 MOCKUP AIRCRAFT LOADING TESTS

at

Travis Air Force Base
Fairfield, California

September 1959

C R E W

Aerojet Representatives

Task Engineers	J. W. Blakley
Mechanical Engineers	L. G. Del Valle/A. K. Shaffer/J. S. Alcorn
Time Records	D. H. Moran
Mechanic	J. K. Mahanna
Carpenter	E. R. Finigan

Air Force Representatives

Aircraft Load Master Assigned
to Aircraft Used for Each Test

Army Representatives

Fort Bragg, N. C.	Lt. Col. R. G. Snodgrass
	1 NCO in charge
	2 enlisted men
Fort Baker, California	M/Sgt. R. King, NCOIC
	2 enlisted men (truck driver and helper)

C-130 AIRCRAFT

LOADING TESTS WITH REACTOR MOCKUP

TABULATION OF ELEMENTAL TIMESC-130 REACTOR PACKAGE MOCKUPLOADING OPERATIONS

SU				O				I				D				AD			
Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S
1		78		6		1	50	7			45	9		2	44				
2		14		8			22	11		1	2	12		1	27				
3		15		10			13	14			55	16		3	32				
4		15		13			3	18			37	20		1	53				
5		5		15			2	22			26	28		2	40				
52		10	30	17			16	24		3	12	41		6	20				
				19			5	26		1	20	55			39				
				21			14	27		2	40								
				23			13	32		2	58								
				25			10	34			47								
				29			10	36		1	53								
				30		3	55	39			45								
				31			5	43		1	22								
				33			7	45		1	50								
				35			5	47			41								
				37		3	29	49			1								
				38			16	51		1	34								
				40			15	54			52								
				42			40	57		1	34								
				44			12												
				46			12												
				48			55												
				50			17												
				53			13												
				56			12												
				58		1	12												
Total				2		17	30		8		43		26		13		19		15
Rounded																			
Off				2		18			9		26				19				

TIEDOWN OPERATIONS

	59		27	48			
	60		3				
	61		24				
	62		25	25			
	63		33	35			
Total				1	53	48	

OFF-LOADING OPERATIONS

	65		45				
Total					45		

C-130 AIRCRAFT
LOADING TESTS WITH REACTOR MOCKUP
ELEMENTAL DESCRIPTIONS & ELAPSED TIMES

September 17, 1959

The crew arrived at the airplane at 0845 hours.

Element 1 (SU)

The plane was relocated so that the front end was higher. This was done to avoid the lateral slipping experienced with the power conversion mockup. The M-172 trailer was backed up to the tail door; ramp toes were used between the rear loading ramp door and the M-172 trailer, as seen in Figure B-26 and B-27. In some of these pictures there are many Air Force personnel shown observing the operation. The Air Force used this operation as a training aid for their newly assigned load masters. The trailer was put into place and shoring was being laid inside the aircraft during this element. Refer to Figure B-28 for trailer support detail. Figure B-29 shows a side view of the trailer.

Elapsed Time: 78 min

Element 2 (SU)

Cable rigged for winching aboard -- shoring being nailed together in plane -- shoring being greased. Reference Figures B-31 and B-32.

Elapsed Time: 14 min

Element 3 (SU)

Two jeeps to restrain the rear end of the reactor package, one on either side; reference Figure B-16. The level of the airplane had been checked at this point and it was found to be off 1/4" in two feet, the low side being the port side of the plane.

Elapsed Time: 15 min

Element 4 (SU)

Pictures being taken -- continue to inspect level of aircraft. Carpenter is chipping corners of all shoring as can be noted by inspecting closely the end of the shoring in Figure B-27. These small bevels are extremely important in enabling the shock mounts to travel easily over discontinuities.

Elapsed Time: 15 min

Element 5 (SU)

Instructions given to the loading crew as follows: One man in each of the two jeeps on the rear end of the reactor package. A winch operator in the M-52 tractor stationed on the forward port side of the airplane. Figure B-34 shows the winch tractor. The sergeant in charge of the winch was the key man in the operation and took his instructions from the men observing clearance at the rear cargo loading doors on either side. Some of the preparations that have been made for this loading can be noted in Figure B-35, which indicates small aircraft snap-lock fittings that were used as restraint for two pieces of 2 x 4 nailed to the side of the shoring. This 2 x 4 was put there in an attempt to keep the shock mounts from riding off the shoring inside the aircraft. Precautions were taken to hold the needs of the shoring down inside the aircraft, as can be seen in Figures B-36 and B-37. Due to the form of motion of the package, the shoring has a tendency to slip forward and even though the shoring is greased, there is a relative motion between the flooring and the shoring, unless chain is applied as shown in these pictures. Figure B-38 shows the separators used in the center of the aircraft between the shoring in an attempt to keep the shoring in position during loadings. Figure B-31 shows the reactor package immediately before winching aboard.

Elapsed Time: 5 min

Element 6 (O)

Winch forward.

Elapsed Time: 1 min 50 sec

Element 7 (I)

Rear center shocks were not riding up on the shoring. This situation was inspected.

Elapsed Time: 45 sec

Element 8 (O)

Winch forward until front end swings to starboard.

Elapsed Time: 22 sec

Element 9 (D)

Straight load using Johnson bar. Johnson bar can be seen in Figures B-38 and B-39.

Elapsed Time:

2 min 44 sec

Element 10 (O)

Winch forward.

Elapsed Time: 13 sec

Element 11 (I)

Check clearance on top and sides.

Elapsed Time: 1 min 2 sec

Element 12 (D)

Slack off tension on cable. Put 15,000 lb snatch block on one side to restrain that side in an effort to keep load moving straight. This snatch block can be seen in Figure B-40.

Elapsed Time: 1 min 27 sec

Element 13 (O)

Winch forward.

Elapsed Time: 3 sec

Element 14 (I)

Inspect load.

Elapsed Time: 55 sec

Element 15 (O)

Winch forward.

Elapsed Time: 2 sec

Element 16 (D)

Adjust shoring at ramp toes. This adjustment was made at the point shown in Picture N5-323. It was made in order to enable the shock mounts to rise smoothly over the end of the ramp toes and on the shoring on the ramp surface.

Elapsed Time: 3 min 32 sec

Element 17 (O)

Winch forward.

Elapsed Time: 16 sec

Element 18 (I)

Check clearance.

Elapsed Time: 37 sec

Element 19 (O)

Winch forward.

Elapsed Time: 5 sec

Element 20 (D)

Adjust D-1 fitting at reactor. As can be seen in Figure B-30, two D-1 aircraft fittings have been attached to the snatch block which is at the reactor. When the load shifts either to port or starboard, the D-1 fittings on the side of the direction of the shift is shortened so that the next time tension is applied the load will straighten out.

Elapsed Time: 1 min 53 sec

Element 21 (O)

Winch forward.

Elapsed Time: 14 sec

Element 22 (I)

Check alignment and clearance.

Elapsed Time: 26 sec

Element 23 (O)

Winch forward.

Elapsed Time: 13 sec

Element 24 (I)

Check alignment, use two Johnson bars in an effort to guide shock mounts up on shoring.

Elapsed Time: 3 min 12 sec

Element 25 (O)

Winch forward.

Elapsed Time: 10 sec

Element 26 (I)

Check alignment.

Elapsed Time: 1 min 20 sec

Element 27 (I)

Slack off, check transverse level, using carpenter's level. The level was about 1/2 a degree off. This is considered to be very good.

Elapsed Time: 2 min 40 sec

Element 28 (D)

At this point the airplane noticeably creaked, probably due to the hydraulic strut attached to the rear cargo door, or due to a shift in the wheel struts. Neither the pilot or the load master could tell what had actually shifted. The level of the airplane was measured and estimated to be the same as before, slightly off by 1/2 a degree. However, the starboard jeep was repositioned to a point closer to the airplane with the chain taut between the reactor and the jeep.

Elapsed Time: 2 min 40 sec

Element 29 (O)

Winch forward with starboard jeep as a deadman.

Elapsed Time: 10 sec

Element 30 (O)

Jeep pulling at right angles to centerline of plane to straighten load.

Elapsed Time: 3 min 55 sec

Element 31 (O)

Winch forward.

Elapsed Time: 5 sec

Element 32 (I)

Check alignment, put in additional shoring. The position of the reactor at this point is such that the rear end of the package is 40 inches from the end of the ramp. (See Figure B-41).

Elapsed Time: 2 min 58 sec

Element 33 (O)

Winch forward.

Elapsed Time: 7 sec

Element 34 (I)

Check alignment.

Elapsed Time: 47 sec

Element 35 (O)

Winch forward.

Elapsed Time: 5 sec

Element 36 (I)

Instruct crew and discuss alignment.

Elapsed Time: 1 min 53 sec

Element 37 (O)

Winch forward.

Elapsed Time: 3 min 29 sec

Element 38 (O)

Winch forward.

Elapsed Time: 16 sec

Element 39 (I)

Check alignment.

Elapsed Time: 45 sec

Element 40 (O)

Winch forward.

Elapsed Time: 15 sec

Element 41 (D)

Chop off top of the port side 2 x 4 rail at the rear jump door which was interfering with the support channel of the reactor package. That is, the height of this rail had to be cut down. This rail can be seen in Figure B-35.

Elapsed Time: 6 min 20 sec

Element 42 (O)

Winch forward.

Elapsed Time: 40 sec

Element 43 (I)

Check alignment.

Elapsed Time: 1 min 22 sec

Element 44 (O)

Winch forward.

Elapsed Time: 12 sec

Element 45 (I)

Check alignment.

Elapsed Time: 1 min 50 sec

Element 46 (O)

Winch forward.

Elapsed Time: 12 sec

Element 47 (I)

Check alignment.

Elapsed Time: 41 sec

Element 48 (O)

Winch forward.

Elapsed Time: 55 sec

Element 49 (I)

Check alignment.

Elapsed Time: 1 min

Element 50 (O)

Winch forward.

Elapsed Time: 17 sec

Element 51 (I)

Check alignment.

Elapsed Time: 1 min 34 sec

At 1145 hours the crew knocked off for lunch and returned at 1305 hours.

Element 52 (SU)

Cut necessary additional shoring to carry the package so that the center of gravity of the package would reach station 510. Grease the shoring and chain down as shown in Figure B-40.

Elapsed Time: 10 min 30 sec

Element 53 (O)

Winch forward.

Elapsed Time: 13 sec

Element 54 (I)

Check alignment.

Elapsed Time: 52 sec

Element 55 (D)

Adjust the D-1 fitting on port side at the snatch block connected to the reactor package.

Elapsed Time: 39 sec

Element 56 (O)

Winch forward.

Elapsed Time: 12 sec

Element 57 (I)

Inspect and adjust cable and snatch block.

Elapsed Time: 1 min 34 sec

Element 58 (O)

Winch forward to point where center of gravity of reactor package is at station 510 as prescribed in the loading procedures. At this point the reactor package was considered to have been winched aboard and preparations for tie down were begun.

Elapsed Time: 1 min 12 sec

Element 59 (O) -- Tie Down Operations

Began tie down of forward end of reactor package; two men detailed to this job. Remove shoring and expose tie down fittings.

Elapsed Time: 27 min 48 sec

Element 60 (O)

Start two men and a crew on the aft end of the reactor package. Two additional men passed the nylon tie down rope through the aft jump door.*

Elapsed Time: 3 min

Element 61 (O)

Start putting the D-rings in the aft end of the aircraft. The crew at the forward end start putting in on the cross-ties. Note Figure B-42

at the point where the screwdriver is located. The procedure for putting the D-ring is as follows: The cover screws must be removed by the screwdriver and then the D-ring studs have to be screwed into the hole.**

Elapsed Time: 24 min

* Figure B-43 shows the two men working on the tiedown at the forward end of the reactor package. Figure B-44 shows two men working on the tie downs at the aft end of the package.

**The crew at the forward end began putting on cross ties during this element.

Element 62 (0)

Anchor shackles were placed on the forward end of the reactor package and the aft end of the reactor package, two crews working simultaneously. See Figure B-45.

Elapsed Time: 25 min 25 sec

Element 63 (0)

The aft end tie downs were completed during this element and the cross ties were being put on. The cross ties on the aft end can be seen in Figure B-46. Cross ties on the forward end can be seen in Figure B-47.

Elapsed Time: 33 min 35 sec

The tie down operation was completed at 1539 hours. Figure B-48 shows the aft and tie down system. Figure B-49 shows the forward and tie down system. Figure B-50 shows the nylon rope, (rated at 15,000 lbs working tension). Picture N5-343 shows the whiffle trees used to distribute the load, the D-1 and C-1 aircraft fittings connected to the chains which, in turn, were connected to the floor tie down points.

Element 64 (SU)

Remove tie down fittings and clear from aircraft.

Elapsed Time: 36 min

Element 65 (0) -- Off Loading Operation

Off loading was accomplished in exactly 45 minutes, went very smoothly, and the operation was completed at 1700 hours. Figure B-51 shows the off loading.

Elapsed Time: 45 min

This is the end of operations performed on C-130 aircraft.

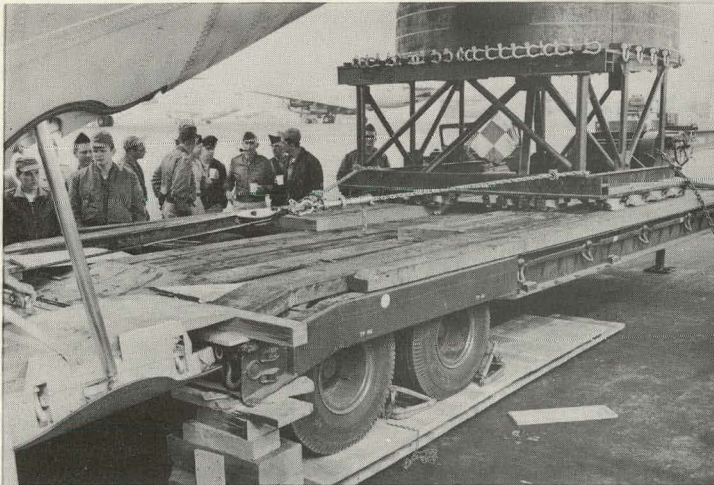


Figure B-26

M-172 trailer backed up to
C-130 rear loading door, prior
to loading reactor mockup

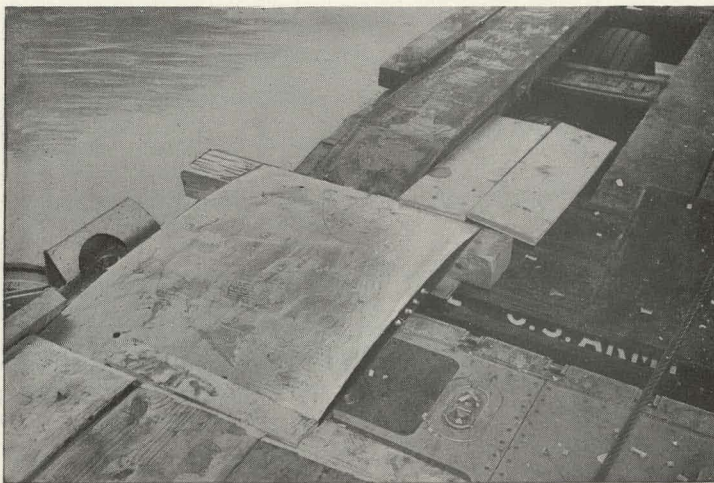


Figure B-27

Ramp toe extensions bridging
gap between aircraft and
trailer

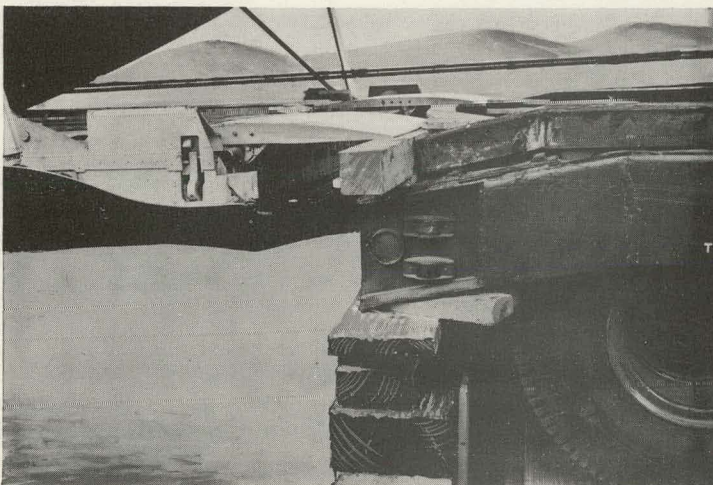


Figure B-28

Wood shoring supporting end
of trailer

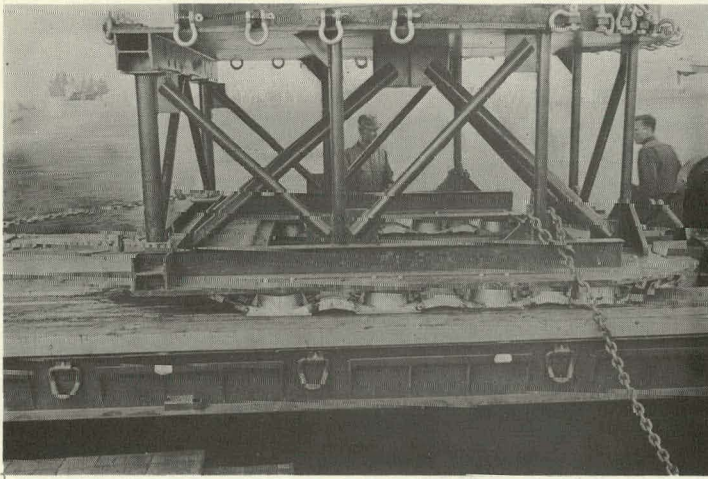


Figure B-29

Chain connections to reactor mockup prior to loading; chain at right for lateral thrust is attached to a jeep

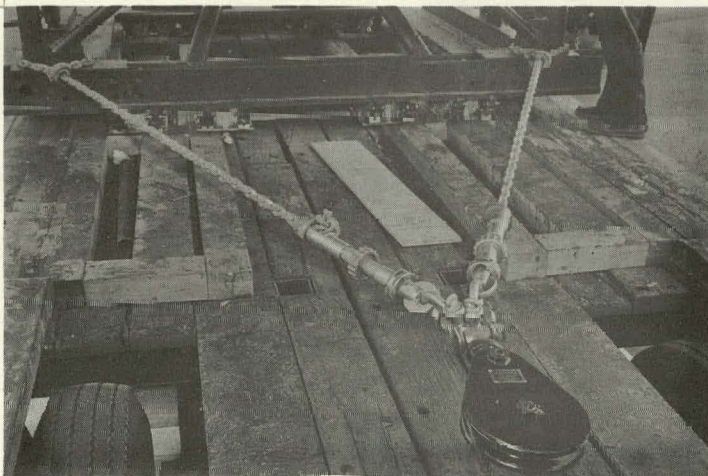


Figure B-30

D-1 aircraft tiedown fittings used to adjust side motion; attached to central 15,000-lb pulley



Figure B-31

View from inside C-130, showing shoring, cables, and positions for trailer and mockup

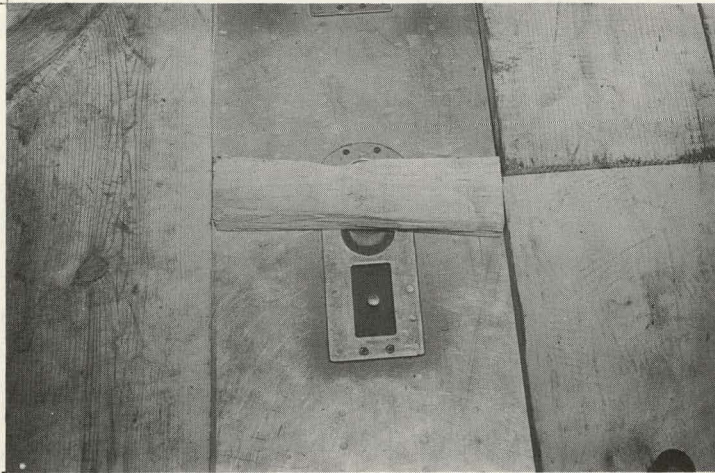


Figure B-32

Wood separators used between shoring to keep it in place



Figure B-33

Prior to loading reactor mockup. Jeep is attached to apply side thrust during loading



Figure B-34

Winch in place on port side of aircraft, showing cable through snatch block and forward cargo door

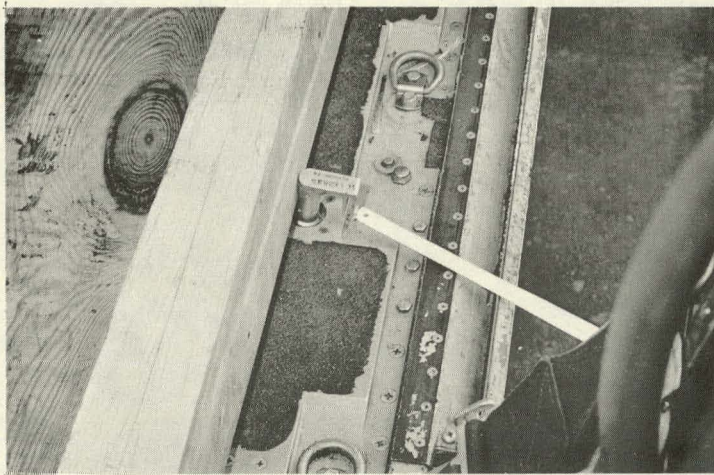


Figure B-35

Tape points to aircraft snatch block fitting, used to hold shoring in place

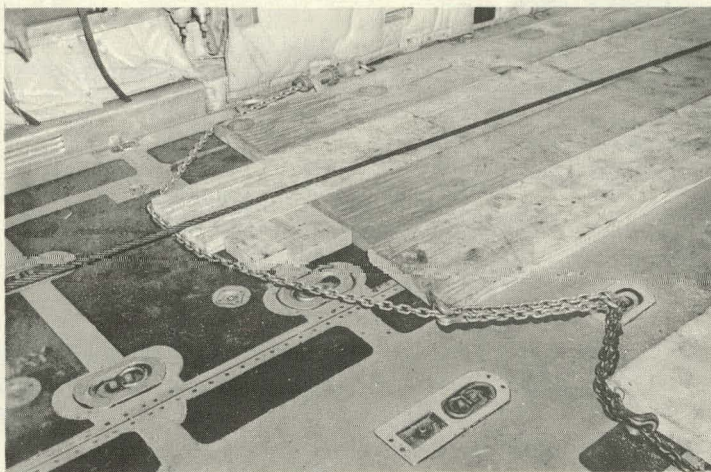


Figure B-36

Shoring used during reactor mockup loading; chain keeps shoring from slipping forward

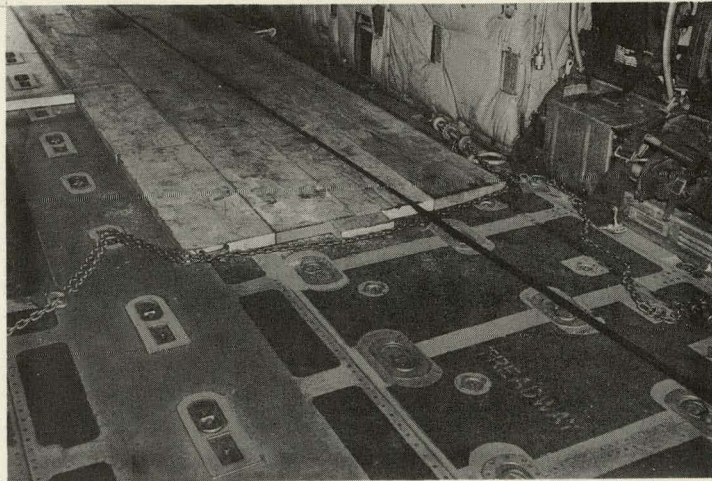


Figure B-37

Another view of shoring and chains used to hold it in place

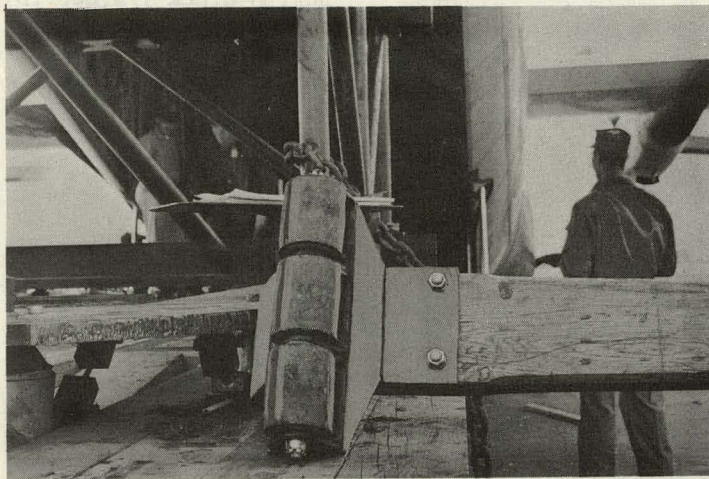


Figure B-38

Johnson Bar used to straighten load

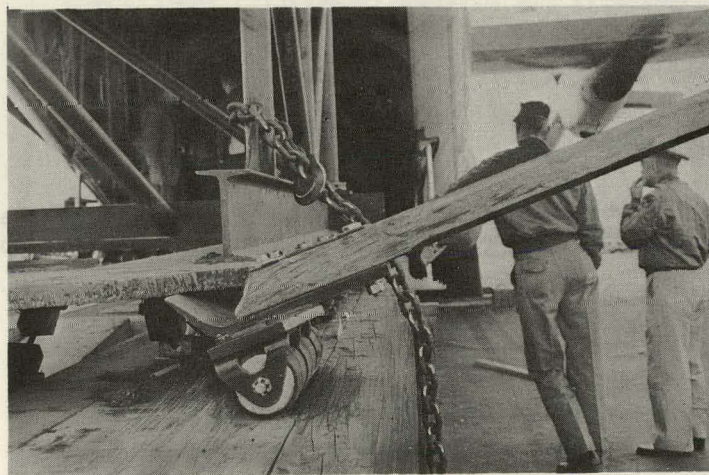


Figure B-39

Johnson Bar applied at rear of reactor mockup

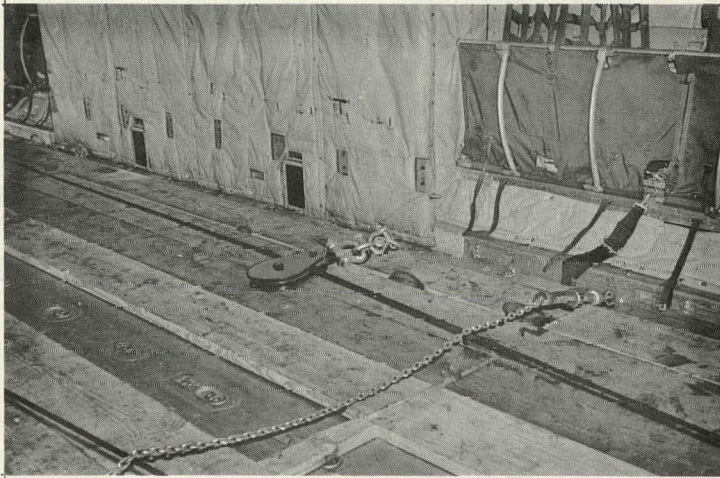


Figure B-40

Snatch block (15,000 lb) in place for side restraint. Chain is safety precaution in case cable should break

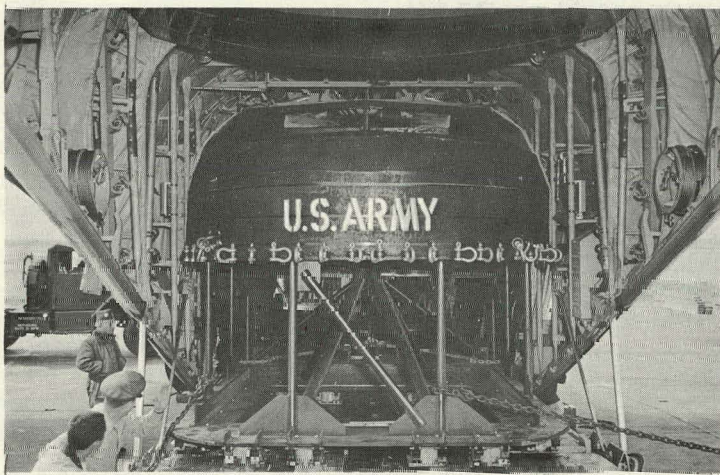


Figure D-41

Reactor mockup, 40 inches from end of loading ramp

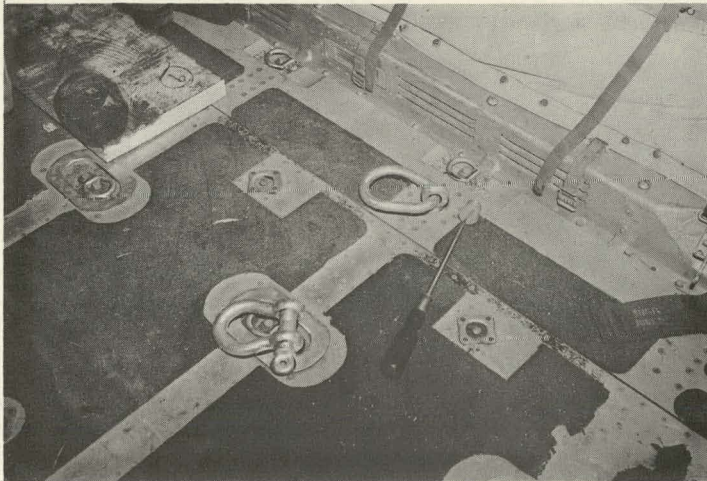


Figure B-42

Screwdriver points to one of the cover screws which had to be removed to fit in D-ring studs prior to tiedown



Figure B-43

Tiedown operations, reactor mockup in C-130



Figure B-44

Reactor mockup tiedown, aft end of C-130



Figure B-45

Tiedown operations; drive
pin used to remove bolt
in clevice

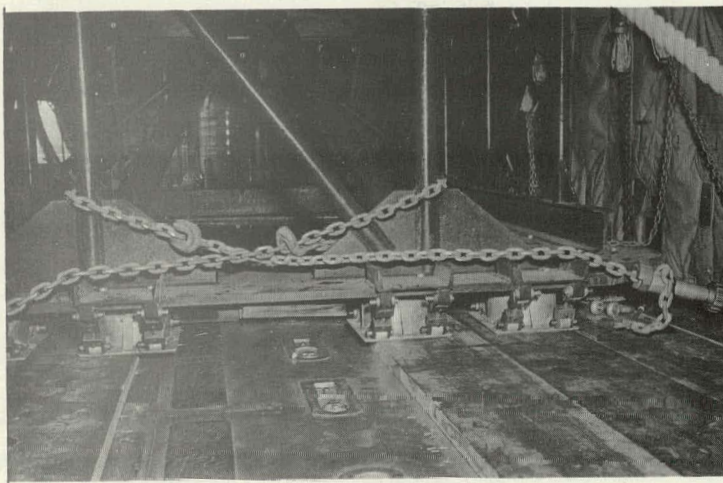


Figure B-46

Reactor mockup chained down
inside C-130

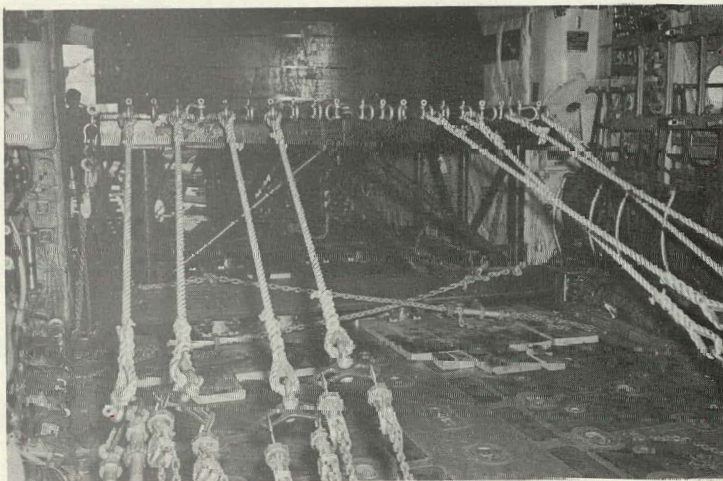


Figure B-47

Tiedown arrangement, forward
end of C-130

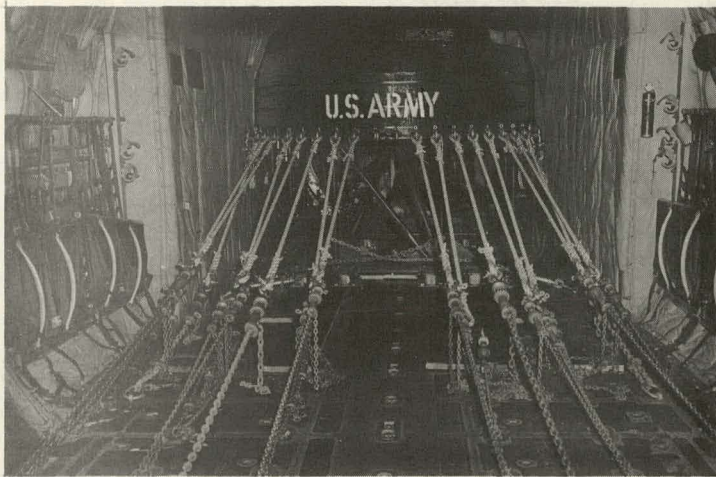


Figure B-48

Tiedown arrangement, aft end
of C-130



Figure B-49

Nylon rope cleavices on
reactor mockup

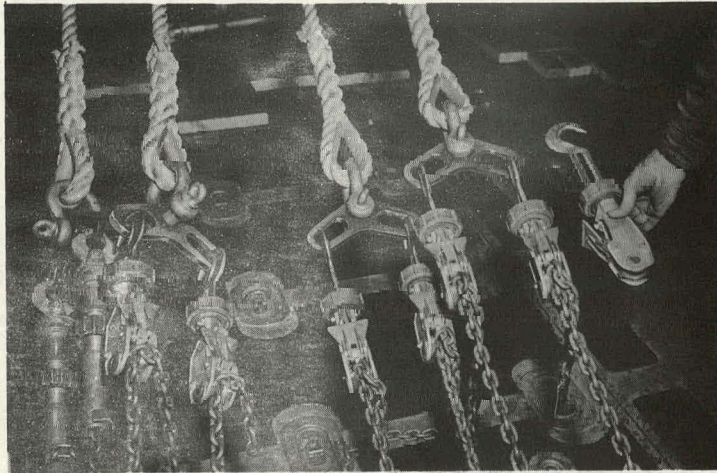


Figure B-50

Reactor mockup tiedown system,
showing swiffle trees and
C-1 aircraft fittings (open
and closed)

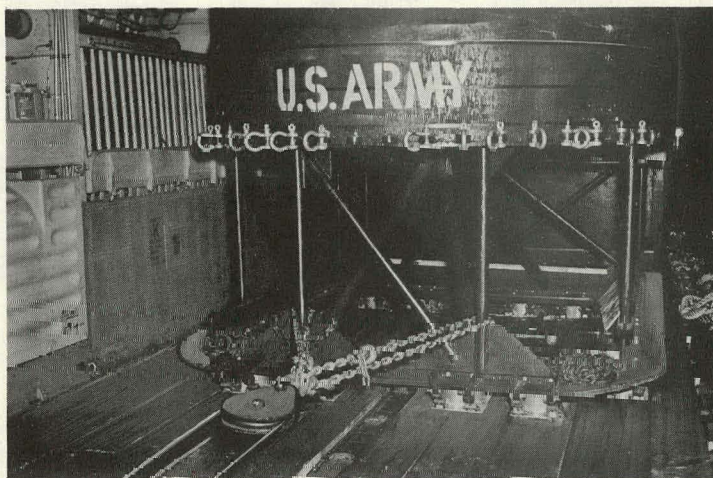
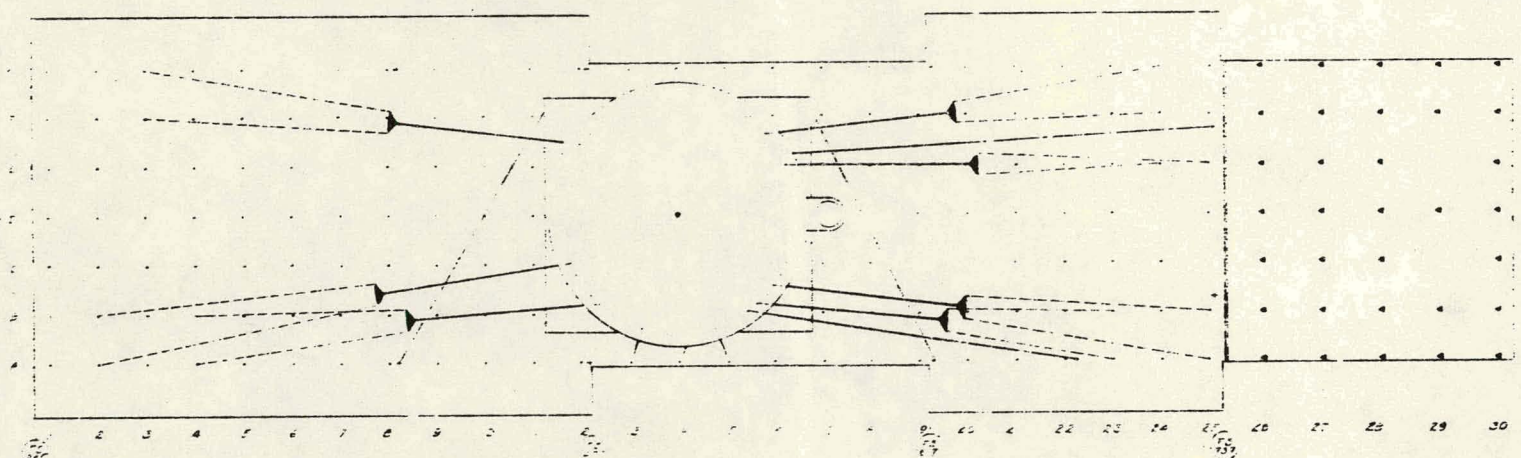


Figure B-51

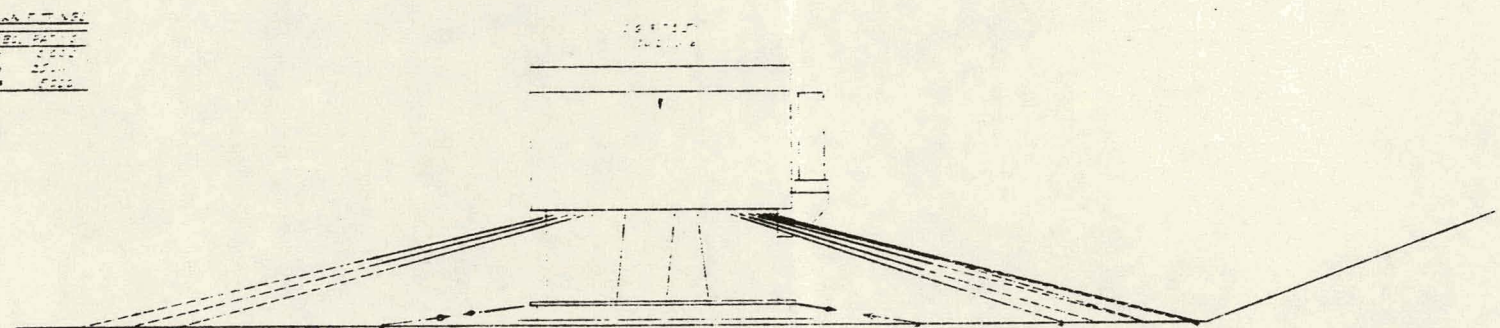
Cable hookup and ramp shoring,
prior to off-loading

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APP'D	DATE	CHANGE	BY	NO.
A	12/15/64	REVISED	USA	



TENSION TABLE	
WIRE SIZE	TENSION
1/16"	1000
1/8"	2000
3/16"	3000



TENSION TABLE			
WIRE	SIZE	TENSION	REMARKS
---	1/16"	1000	WIRE
---	1/8"	2000	WIRE
---	3/16"	3000	WIRE
---	1/2"	4000	WIRE
---	3/4"	5000	WIRE
---	1"	6000	WIRE
---	1 1/4"	7000	WIRE
---	1 1/2"	8000	WIRE
---	1 3/4"	9000	WIRE
---	2"	10000	WIRE

2408749A
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Figure B-52

1. TENSION SYSTEM COMPONENTS MUST BE OF THE
2. TENSION SYSTEM COMPONENTS MUST BE OF THE
3. TENSION SYSTEM COMPONENTS MUST BE OF THE
4. TENSION SYSTEM COMPONENTS MUST BE OF THE

Argus General A SUBSIDIARY OF THE ARGUS GENERAL CORPORATION		LOCKHEED C130A TENSION SYSTEM, M1 REACTOR
PROJECT NO. 2408749A	DRAWING NO. 2408749A	DATE 12/15/64
DESIGNED BY USA	CHECKED BY USA	APPROVED BY USA

C-133 AIRCRAFT

LOADING TESTS WITH BOTH THE REACTOR AND POWER CONVERSION MOCKUPS

TABULATION OF ELEMENTAL TIMESC-133 REACTOR AND POWER CONVERSION PACKAGE MOCKUPSLOADING OPERATIONS -- POWER CONVERSION PACKAGE MOCKUP

SU				O				I				D				AD			
Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S
1	27	45	10			5	9		50		11		10		60		37		
2	51		16		1	15	17		10		12		7	10	67		13		
3	4	25	18			40	19		2	20	13		7	10					
4	43	50	20			20	23		8		14		20	10					
5	24		22			32	25		2		15		2	40					
6	23	45	24			15	29		1	7	21			50					
7	4	35	26			8	31		5	37	27		10	27					
8	1	45	28			8	33		45		53		3	3					
43	9	16	30			6	35		48		57		8						
45	5	1	32		1	10	37		3	18	75		9	45					
49	6	30	34			7	39		3	57	76			55					
55	8	17	36			17	41		1	20	78			54					
59	15		38		1	13	47		1	17	80		3	3					
61	5	10	40			5	51		1	6	83		9	10					
62	11	50	42		2	30	66		8	10	85			59					
63	10	25	44			34	70		30		88		2	25					
64	29	45	46		2		82		3	20	90			30					
65	14	40	48			27					92			24					
71	5	15	50			15					94			5					
73	3	20	52			5					96		10	35					
98	1	10	54			31													
100	11	43	56			13													
102	8	23	58			15													
104	17	10	68			45													
			69			48													
			72			42													
			74			18													
			77		2	21													
			79			2													
			81			30													
			84			34													
			86		1	27													
			87			15													
			89			42													
			91			2													
			93			2													
			95			55													
			97		1	5													
			99		3	17													
			101			35													
			103			22													
			105			20													
Total					5	44		28	16		34	45	1	48	15		50		
Rounded																			
Off					5			28			35		1	48			50		

C-133 REACTOR AND POWER CONVERSION PACKAGE MOCKUPSTIEDOWN OPERATIONS

<u>SU</u>				<u>O</u>				<u>I</u>				<u>D</u>				<u>AD</u>			
Operation				Op.				Op.				Op.				Op.			
Number	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S	No.	H	M	S
106		1	40																
107		4	45																
TOTAL					6	25													

OFF-LOAD OPERATIONS

111	12	20	108	5	30	109	2	30	113	4	20
119		5	110		30	132	2	10	115	8	40
122	1	10	112		20	136		15	117	1	55
124	1	35	114			138		45	130	2	45
126	14	55	116		15				131		5
128	6	23	118		15				134	5	5
140	1	27	120	2	10						
			121		25						
			123		30						
			125	1	35						
			127	3	50						
			129		47						
			133		35						
			135		10						
			137		10						
			139		43						
			141		35						
Total	37	55		18	20		5	40		22	50
RoundedOff	38			18			6			23	

ELEMENTAL DESCRIPTION AND ELAPSED TIME
FOR OPERATIONS ON C-133 AIRPLANE

September 21, 1959 -- Loading of the Power Conversion Package

The crew is the same as for the C-130 aircraft. The equipment is the same, except where noted. The C-133 airplane can be seen in Figure B-53.

At 9045 the shoring, the power conversion package, the crew and the equipment were all standing by as shown in Figure B-54. Shoring was laid in the plane from the loading ramp to station 399 inside the plane, as can be seen from Figure B-55.

Element 1 (SU)

Lay in cross pieces of 2 x 12 to keep shoring in place. Use shingles to wedge in place. These separators can be seen in Figure B-56 and B-57. Snap on fittings were used to hold the shoring in place laterally, as pointed out in Figures B-56 and B-58.

Elapsed Time: 27 min 45 sec

Element 2 (SU)

Raise the rear loading ramp door, back trailer in position for placing shoring to bridge the gap between the trailer and the plane. (Took three passes to position the trailer.)

Elapsed Time: 51 min

Element 3 (SU)

Take another pass at positioning the trailer making a total of 4 passes.

Elapsed Time: 4 min 25 sec

Element 4 (SU)

Place wooden blocks under the loading ramp for support of the package as it leaves the trailer as seen in Figure B-59. The bridge of the shoring between the trailer and airplane can be seen in Figure B-60. The carpenter had to chip bevels on the end of the shoring using a hatchet. The bevels can be seen by looking closely in Figure B-60. Next, the method of rigging was determined and at 1140 hours the crew knocked off for lunch, returning at 1310 hours.

Elapsed Time: 43 min 50 sec

Element 5 (SU)

Rig chain and D-1 devices on power conversion skid with 15 ton snatch block,

as seen in Figures B-60 and B-61. Position the M-52 tractor aft of the plane on the port side. Run cable through the shieve on the port side at station 580 as shown in Figure B-62, then back through the snatch block at the load as shown in Figure B-60, and up to the deadman on the starboard side located at station 778, as shown in Figure B-63. The end of the cable connected to the winch on the M-52 tractor is hooked into a 25,000# tie down fitting.

Elapsed Time: 24 min

Element 6 (SU)

Grease shoring as shown in Figure B-58. Take pictures of the entire setup, re-rig the port snatch block at station 58, which was for some reason improperly fastened.

Elapsed Time: 23 min 45 sec

Element 7 (SU)

Rig a cable dynamometer at the deadman station 778, as shown in Figure B-64. Take a picture of the setup. The ends of the shoring at the forward end of the airplane were held in place by nylon straps, as shown in Figure B-65.

Elapsed Time: 4 min 35 sec

Element 8 (SU)

Take up tension on the cable.

Elapsed Time: 1 min 45 sec

Element 9 (I)

Check all cables.

Elapsed Time: 50 sec

Element 10 (O)

Winch forward. Plane had shifted so that the rear loading ramp door engaged the trailer.

Elapsed Time: 5 sec

Element 11 (D)

Inspection disclosed that the chocks under the airplane had not been properly seated, and the plane had moved into the trailer. This was confirmed by the aircraft loadmaster. The chocks had been placed under the wheels the night before and had not been resealed for the morning loading operations. The tires had lost pressure due to change in temperature.

Elapsed Time: 10 min

Element 12 (D)

Uncouple the cable, reel it back on the M-52 winch, move the M-52 back and hitch it up to the M-172 trailer.

Elapsed Time: 7 min 10 sec

Element 13 (D)

Reposition the trailer and put blocking under the trailer as shown in Figure B-66.

Elapsed Time: 7 min 10 sec

Element 14 (D)

Uncouple the tractor and trailer. Reposition for winching as shown in Figure B-67. Reattach cable for pulling aboard. Make sure the plane and trailer are chocked properly. Cable is reeved through the different snatch blocks up to the deadman at station 778, as shown in the pictures listed above.

Elapsed Time: 20 min 10 sec

Element 15 (D)

Take up slack on cable.

Elapsed Time: 2 min 40 sec

Element 16 (O)

Winch forward. The plane moved about 1" before the power conversion package started to move. A rough gage had been set up between the trailer and the rear loading ramp load to see just exactly what the shift was.

Elapsed Time: 1 min 15 sec

Element 17 (I)

Check the alignment of the load with respect to the airplane clearances.

Elapsed Time: 10 sec

Element 18 (O)

Winch forward.

Elapsed Time: 40 sec

Element 19 (I)

Check alignment. The reading on the dynamometer was as follows:

Static Reading: 4600 lbs

Kinetic Reading: 2700 lbs

Elapsed Time: 2 min 20 sec

Element 20 (O)

Winch forward.

Elapsed Time: 20 sec

Element 21 (D)

Move snatch block which was hitting shoring at the location indicated. The snatch block was hitting the cross piece shown on the right hand side of Figure B-56.

Elapsed Time: 50 sec

Element 22 (O)

Winch forward.

Elapsed Time: 32 sec

Element 23 (I)

Check alignment.

Elapsed Time: 8 sec

Element 24 (O)

Winch forward.

Elapsed Time: 15 sec

Element 25 (I)

Check alignment.

Elapsed Time: 2 sec

Element 26 (O)

Winch forward.

Elapsed Time: 8 sec

Element 27 (D)

The rear of the power conversion skid is at this point approximately 5' from the end of the trailer ramps as shown in Figure B-55. The rear end of the load has moved to the port side. Adjust the shoring on the port side at the end of the trailer.

Elapsed Time: 10 min 27 sec

Element 28 (O)

Winch forward.

Elapsed Time: 8 sec

Element 29 (I)

Check alignment.

Elapsed Time: 1 min 7 sec

Element 30 (O)

Winch forward.

Elapsed Time: 6 sec

Element 31 (I)

Check alignment.

Elapsed Time: 5 min 37 sec

Element 32 (O)

Winch forward.

Elapsed Time: 1 min 10 sec

Element 33 (I)

Check alignment.

Elapsed Time: 45 sec

Element 34 (O)

Winch forward.

Elapsed Time: 7 sec

Element 35 (I)

Check alignment.

Elapsed Time: 48 sec

Element 36 (O)

Winch forward.

Elapsed Time: 17 sec

Element 37 (I)

Check alignment.

Elapsed Time: 3 min 18 sec

Element 38 (O)

Winch forward. At this point the load pivoted, the rear to the port side.

Elapsed Time: 1 min 13 sec

Element 39 (I)

Check alignment. Readjust the pulleys to pull the load to the starboard. This meant that the D-1 fitting on the starboard side was tightened in order to exert more pull on that side and shift the load. The D-1 fitting can be seen in Figure B-60.

Elapsed Time: 3 min 57 sec

Element 40 (O)

Pull load to straighten.

Elapsed Time: 5 sec

Element 41 (I)

Check alignment.

Elapsed Time: 1 min 20 sec

Element 42 (O)

Winch forward. At this moment the cable dynamometer read 2300 lbs for the static pull and 1950 lbs for kinetic.

Elapsed Time: 2 min 30 sec

Element 43 (SU)

Re-rig the snatch block and the deadman to station 372. Note: The static dynamometer pull varied between 4300 lbs and 4500 lbs on the level floor of the airplane.

Elapsed Time: 9 min 16 sec

Element 44 (O)

Winch forward.

Elapsed Time: 34 sec

Element 45 (SU)

Re-seat pin in the snatch block on the port side.

Elapsed Time: 5 min 1 sec

Element 46 (O)

Winch forward. Cable dynamometer readings: 3,000 static; 2200 to 2500 lbs kinetic.

Elapsed Time: 2 min

Element 47 (I)

Check alignment. At this point it was noted that 2 x 4 siderails should have been put on the sides of the shoring as were used in the C-130 airplane loading of the reactor package. Reference back to this loading recap -- Figure B-35 indicates the location of these 2 x 4 siderails by the rear jump door of the C-130 airplane.

Elapsed Time: 1 min 17 sec

Element 48 (O)

Winch forward. Cable dynamometer reading 3,000#, maximum on a static pull.

Elapsed Time: 27 sec

Element 49 (SU)

Adjust cable and chain to straighten load.

Elapsed Time: 6 min 30 sec

Element 50 (O)

Winch ahead to straighten load.

Elapsed Time: 15 sec

Element 51 (I)

Check alignment.

Elapsed Time: 1 min 6 sec

Element 52 (O)

Winch forward.

Elapsed Time: 5 sec

Element 53 (D)

Readjust cables and chain for straight pull. This adjustment was performed by placing a snatch block about midway between the deadman and the load. It was engaged with the cable, fastened by a D-1 chain and fitting to the floor, so that it would exert a transverse pull on the cable, thus moving the package more to one side than the other.

Elapsed Time: 3 min 3 sec

Element 54 (O)

Winch forward.

Elapsed Time: 31 sec

Element 55 (SU)

Check alignment, put snatch block back to station 301.

Elapsed Time: 8 min 17 sec

Element 56 (O)

Winch forward, front end of head twisted to starboard.

Elapsed Time: 13 sec

Element 57 (D)

Slack off, attach chain to straighten out. Pull forward, straighten out load.

Elapsed Time: 8 min

Element 58 (O)

Winch forward to point where center of gravity of the power conversion is located exactly opposite station 680. This is the point predetermined to be the final location of the power conversion package in the C-133 airplane.

Elapsed Time: 15 sec

Element 59 (SU)

Tied down 4 corners with chain for the night as shown in Figure B-68. This tiedown was performed simply in case the aircraft had to be moved from that location during the night.

Elapsed Time: 15 minutes

Note: With the center of gravity of the package located at station 680, the rear end of the power conversion package is located approximately at station 605 as can be seen in Figure B-69.

September 22, 1959 -- Loading of the Reactor Package

The power conversion package and the shoring were left in the plane overnight. The same crew and equipment were used as on 9/21/59, except as noted below. Operations began at 0833 hours.

Element 60 (AD)

Wait for tools to be delivered. Wait to find out if airplane has to be moved to another position on the base. Tools arrived. Notification that aircraft did not have to be moved was received.

Elapsed Time: 37 min

Element 61 (SU)

Put blocks under ramp door of plane as shown in Figure B-70. Back 172 trailer up to the rear loading ramp, place blocks under the rear of the trailer for support when load is moved over the end, as shown in Figure B-66. Lower 5th wheel on the trailer.

Elapsed Time: 15 min 10 sec

Element 62 (SU)

Lay shoring inside plane for support of the inboard shock mounts on the reactor package. The amount of shoring involved can be seen in Figure B-71. Shoring can also be seen in Figure B-72. Note that the tape is pointing to safety strap to protect personnel in case of cable break. It has been recommended for the final reactor package that these inboard shock mounts be removed, since they interfered constantly with the shoring during loading and unloading operations.

Elapsed Time: 11 min 50 sec

Element 63 (SU)

Rig snatch block, place pieces of wood to separate the shoring in the plane. The snatch block can be seen in Figures B-72 and B-73. The deadman can be seen located in the right hand side of Figure B-72. and

is also shown in Figure B-74. The ends of the shoring near the power conversion package were blocked and held in by snap-locks as can be seen in Figure B-75. This again was to prevent the shoring from sliding to the forward end of the aircraft as the reactor package moved on the shoring.

Elapsed Time: 10 min 25 sec

Element 64 (SU)

Continued to put the separators between the shoring. Threaded the cable through the pulleys up to the deadman. The method of purchase on the reactor package consisted of two snatch blocks, one in each corner of the front end, as indicated in Figure B-76. A close-up of one of the snatch blocks is shown in Figure B-77. The setup at the rear of the aircraft prior to relocating the M52 tractor for winching operations can be seen in Figure B-78.

Elapsed Time: 29 min 45 sec

Element 65 (SU)

Grease shoring. Take pictures, complete putting separators between the shoring.

Elapsed Time: 14 min 40 sec

Element 66 (I)

Check wheel chocks, shoring and the support struts. A support strut and a 10,000 lb tie down fitting are shown in Figure B-79.

Elapsed Time: 8 min 10 sec

Element 67 (AD)

Coffee break for the crew.

Elapsed Time: 13 min

Element 68 (O)

Winch forward, front end of the reactor package pulled to the starboard.

Elapsed Time: 45 sec

Element 69 (O)

Winch forward, aft end pulled to the port.

Elapsed Time: 48 sec

Element 70 (I)

Inspect the load.

Elapsed Time: 30 sec

Element 71 (SU)

Slack off, put the deadman on a 25,000 lb tie down fitting at station 778. The picture taken at this point is Figure B-80.

Elapsed Time: 5 min 15 sec

Element 72 (O)

Winch forward.

Elapsed Time: 42 sec

Element 73 (SU)

Slack off, move truck to new location; moving picture taken of new location. The crane was set up as a deadman for the trailer and the M-52 tractor was re-located to get a different angle on the pull in an effort to straighten the load. This was a simple repositioning from the general setup.

Elapsed Time: 3 min 20 sec

Element 74 (O)

Winch forward. Rear inboard shock was caught on shoring which should have been beveled. Ref: Figure B-81 which pictures this situation but does not show it as clearly as the motion pictures of the setup do.

Elapsed Time: 18 sec

Element 75 (D)

Carpenter beveled shoring with a hatchet. Note: The chain holding the snatch blocks on each side of the package must be the same length for straight pull. When the unit fishtails to one side or the other, the chain must be shortened on the side to which the unit moved.

Elapsed Time: 9 min 45 sec

Element 76 (D)

Crew resumed operating positions. Note: The operating positions were as follows: Two observers inside plane, one near deadman, one near snatch block. These observers signaled the sergeant in charge of the winch stationed at the rear of the trailer who in turn signaled the winch operator in the truck.

Elapsed Time: 55 sec

Element 77 (O)

Winch forward.

Elapsed Time: 2 min 21 sec

Element 78

Adjust shoring.

Elapsed Time: 54 sec

Element 79

Winch forward. Shoring at the top of the ramp moved. It should be fastened down if possible.

Elapsed Time: 2 sec

Element 80 (D)

Slack off, recheck shoring.

Elapsed Time: 3 min 3 sec

Element 81 (O)

Winch forward. Load at this point only about 5° off straight with respect to the center line of the airplane.

Elapsed Time: 30 sec

Element 82 (I)

Inspect shoring and discuss the problem of keeping shoring from binding on the inboard shocks.

Elapsed Time: 3 min 20 sec

Element 83 (D)

Slack off on the cable. Change the deadman to a Y tie down as shown in Figure B-82. Lay additional shoring in the airplane for the inboard shocks to ride on. Grease the newly laid shoring (carpenter sawed one additional piece of shoring).

Elapsed Time: 9 min 10 sec

Element 84 (O)

Winch forward.

Elapsed Time: 34 sec

Element 85 (D)

End of shoring at the top of the ramp is lifting, this must be pushed down.

Elapsed Time: 59 sec

Element 86 (O)

Winch forward. Shoring for inboard shocks is not beveled at each succeeding board and should have been.

Elapsed Time: 1 min 27 sec

Element 87 (O)

Winch forward.

Elapsed Time: 15 sec

Element 88 (D)

Added wedges for inboard shocks.

Elapsed Time: 2 min 45 sec

Element 89 (O)

Winch forward.

Elapsed Time: 42 sec

Element 90 (D)

Adjust shoring under package.

Elapsed Time: 30 sec

Element 91 (O)

Winch forward.

Elapsed Time: 2 sec

Element 92 (D)

Adjust shoring.

Elapsed Time: 24 sec

Element 93 (O)

Winch forward.

Elapsed Time: 2 sec

Element 94 (D)

Adjust shoring.

Elapsed Time: 5 sec

Element 95 (O)

Winch forward.

Elapsed Time: 55 sec

Element 96 (D)

Slack off, bevel shoring for aft inboard shock. Carpenter at this point had to work inside the reactor package as is indicated by the soldier shown on the inside of the package in Figure B-81. This will not be possible with the final package, since this void will be filled up on the final design. The deadman at the end of the winch cable was changed from the Y configuration to an in-line configuration, as shown in Figure B-80.

Elapsed Time: 10 min 35 sec

Element 97 (O)

Winch forward, aft end moved to port.

Elapsed Time: 1 min 5 sec

Element 98 (SU)

Remove safety strap over cable, slack off, change deadman to a Y. (See Figure B-83).

Elapsed Time: 1 min 10 sec

Element 99 (O)

Winch forward.

Elapsed Time: 3 min 17 sec

Element 100 (SU)

Rerig for pulling the reactor package to within 28 inches of the power conversion skid. This meant rerigging the snatch blocks as close to the power conversion skid as possible, shown in Figure B-73.

Elapsed Time: 11 min 43 sec

Element 101 (O)

Winch forward.

Elapsed Time: 35 sec

Element 102 (SU)

Slack off, reset sheave and deadman. Reset snatch blocks and deadman.

Elapsed Time: 8 min 23 sec

Element 103 (O)

Winch forward.

Elapsed Time: 22 sec

Element 104 (SU)

Reset deadman forward of power conversion package.

Elapsed Time: 17 min 10 sec

Element 105 (O)

Winch forward to final position within 28 inches of the power conversion skid.

Elapsed Time: 20 sec

Element 106 (O) -- Tiedown Operations

Begin performing tiedown of the load for air flight. The crew size during this operation varied from 2 to 6 men.

Elapsed Time: 1 hr 40 min

Element 107 (O)

Complete tie down of both packages for air flight. This operation ended at 1700 hours.

Elapsed Time: 4 hrs 45 min

The following pictures indicate the results of the tiedown operation. The port, starboard, front and rear are with respect to the airplane itself. Beginning with the front end or forward end of the airplane, the power conversion package tiedown system is shown in Figures B-84 and B-85. The starboard side rear end of the reactor package with the power conversion package seen beyond in the picture is shown in Figure B-86. A detail of the front end of the starboard side of the power conversion package is

shown in Figure B-87. The rear end, port side of the reactor package tie down system is shown in Figure B-88 and the rear tiedown for the reactor are shown in Figure B-89. These tiedowns are hooked into tie down fittings right at the hinge of the rear loading ramp door.

Element 108 (O) -- Reactor Package Off-Loading Operations

Off load, straight through pull. Note: Preparations for off-loading were made while the front were being put in place.

Elapsed Time: 5 min 30 sec

Element 109 (I)

One shock is digging in, (an inboard shock).

Elapsed Time: 2 min 30 sec

Element 110 (O)

Off load.

Elapsed Time: 30 sec

Element 111 (SU)

Remove chain which was holding shoring from sliding out of airplane. This chain was located on the aft end of the shoring in a manner similar to the strap shown in Figure B-65, and was used for the same purpose.

Elapsed Time: 12 min 20 sec

Element 112 (O)

Off load.

Elapsed Time: 20 sec

Element 113 (D)

Adjust shoring. One shock was digging into the shoring.

Elapsed Time: 4 min 20 sec

Element 114 (O)

Off load.

Elapsed Time: 20 sec

Element 115 (D)

Put D-1 fitting and chain on each front corner. Note here the moving pictures will have to be referred to in order to see the exact method of purchase on the reactor package during off loading.

Elapsed Time: 8 min 40 sec

Element 116 (O)

Off-Load.

Elapsed Time: 15 sec

Element 117 (D)

Put longer chains on the D-1's attached aft. Pound shoring down in front so that the front shocks will not dig into the shoring. A sledge hammer was used at this point to pound the shoring down.

Elapsed Time: 1 min 55 sec

Element 118 (O)

Off-load.

Elapsed Time: 15 sec

Element 119 (SU)

Remove chain holding down shoring.

Elapsed Time: 5 sec

Element 120 (O)

Off-load.

Elapsed Time: 2 min 10 sec

Element 121 (O)

Off-load.

Elapsed Time: 25 sec

Element 122 (SU)

Slack off. Remove chain from starboard side, attach sheave to straighten. The sheave was attached on the cable between the reactor package and the M-52 winch drum in an effort to straighten the load.

Elapsed Time: 1 min 10 sec

Element 123 (O)

Off load. The load is now straight.

Elapsed Time: 30 sec

Element 124 (SU)

Reattach chain to starboard side for straight pull.

Elapsed Time: 1 min 35 sec

Element 125 (O)

Off load. Remove cable from reactor package.

Elapsed Time: 1 min 35 sec

Note: The M-52 tractor was hooked up to the trailer and the load taken to the staging area off the air strip. The reactor package was off loaded by the crane and then the crane and the M-52 and M-172 returned to the airplane at 1925 hours, at which time preparations were made for off loading the power conversion package.

Element 126 (SU) -- Power Conversion Package Off Loading Operations

Set up for off loading, position the truck and the winch, etc.

Elapsed Time: 14 min 55 sec

Element 127 (O)

Off load the power conversion package, one continuous straight pull. Things went rather well during this element.

Elapsed Time: 3 min 50 sec

Element 128 (SU)

Position snatch block on M-172 for port pull to the center of the power conversion skid.

Elapsed Time: 6 min 23 sec

Element 129 (O)

Off load. At the end of this element the center of load was at the top of the ramp. The rear of the power conversion package had fishtailed to the port side.

Elapsed Time: 47 sec

Element 130 (D)

Straighten load, put on a chain at the rear of the power conversion package in an effort to straighten.

Elapsed Time: 2 min 45 sec

Element 131 (D)

Apply tension to straighten load.

Elapsed Time: 5 sec

Element 132 (I)

Inspect alignment.

Elapsed Time: 2 min 10 sec

Element 133 (O)

Off load.

Elapsed Time: 35 sec

Element 134 (D)

Remove broken shoring at the point where the shoring meets the channel covering M-172 wheel wells. Put a snatch block on the trailer.

Elapsed Time: 5 min 5 sec

Element 135 (O)

Off load.

Elapsed Time: 10 sec

Element 136 (I)

Check alignment.

Elapsed Time: 15 sec

Element 137 (O)

Off load.

Elapsed Time: 10 sec

Element 138 (I)

Inspect load, inspect alignment, remove snatch block which was attached to the trailer.

Elapsed Time: 45 sec

Element 139 (O)

Off load.

Elapsed Time: 43 sec

Element 140 (SU)

Rerig the winch cable since the chain at the end of the cable had been reached.

Elapsed Time: 1 min 27 sec

Element 141 (O)

Off load to point where the power conversion package is positioned properly on the trailer.

Elapsed Time: 35 sec

At this time the airplane was completely swept and cleaned with solvent. The area was cleaned and the equipment was removed to the staging area off the air strip.

The crew worked straight through, not knocking off for dinner until the power conversion package was completely off loaded and the plane was completely cleaned out and swabbed down.

The job was completed at 2030 hours.

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Figure B-53
C-133 aircraft



Figure B-54
C-133, M-172 trailer with
power conversion mockup



Figure B-55
Separators used between
shoring; power conversion
mockup ready for loading

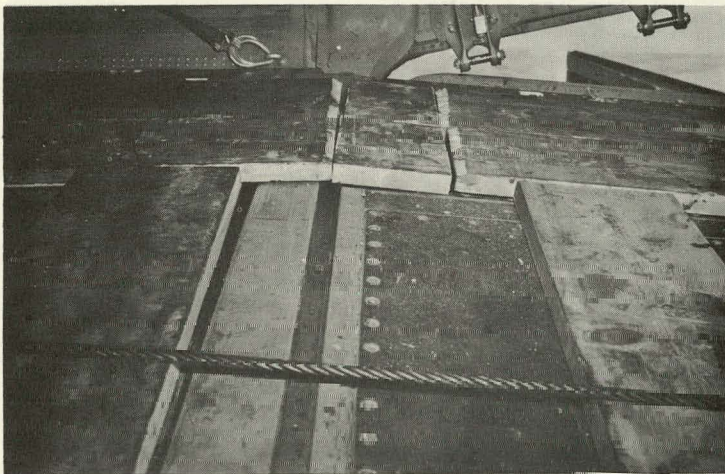


Figure B-56

Close-up of separators between shoring

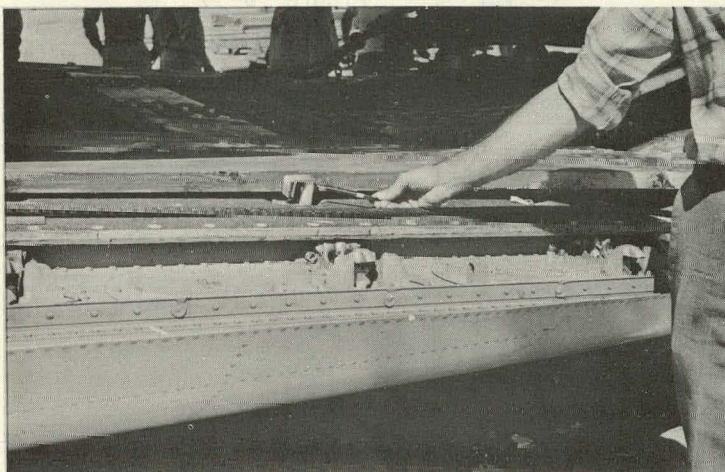


Figure B-57

Snap-on fitting used to hold shoring in place



Figure B-58

Applying grease to shoring;
tape points to snap-lock
fitting holding shoring in
place

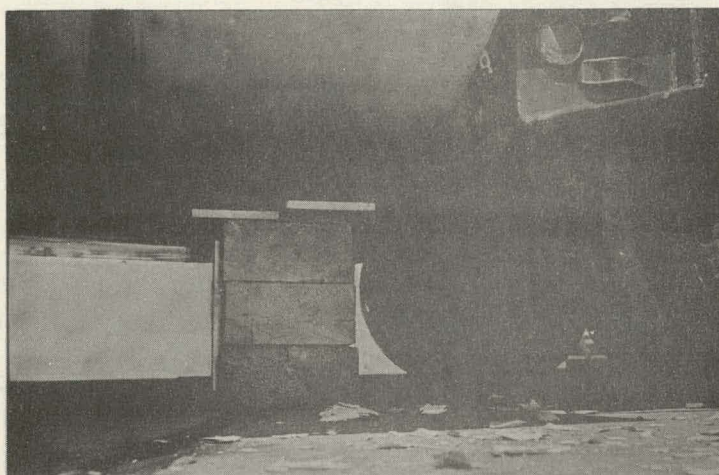


Figure B-59

Wood blocks supporting rear
door loading ramps, C-133



Figure B-60

Chains and D-1 tiedown devices
attached to power conversion
mockup

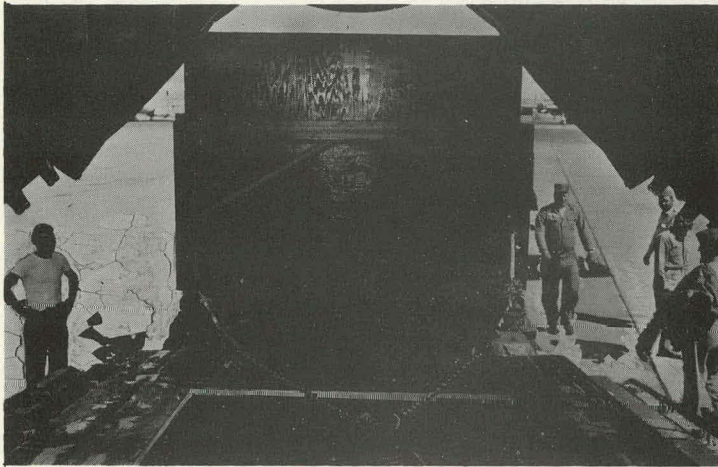


Figure B-61

Chain, D-1 devices, and 15-ton snatch block on power conversion mockup

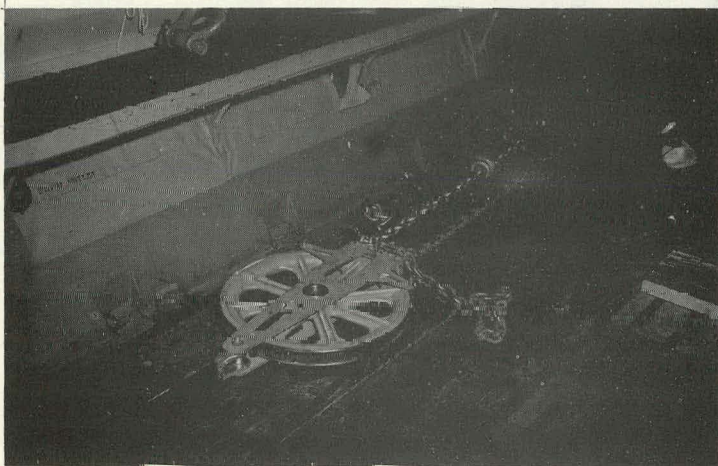


Figure B-62

Inside C-133 aircraft

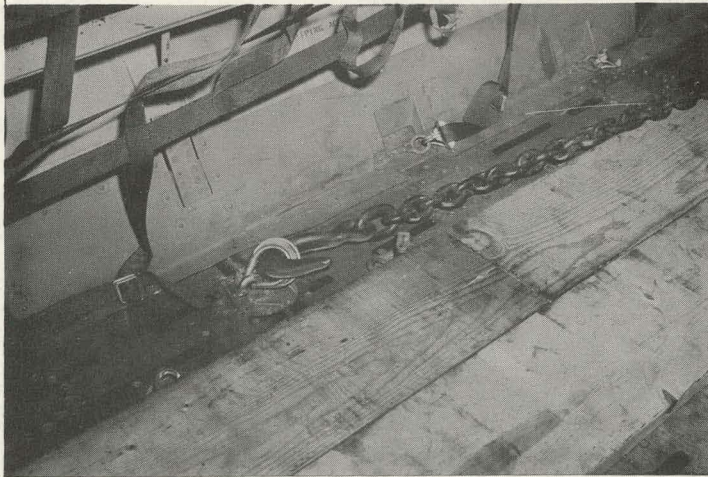


Figure B-63

Deadman end of cable attached
to 25-lb tiedown fitting in
C-133

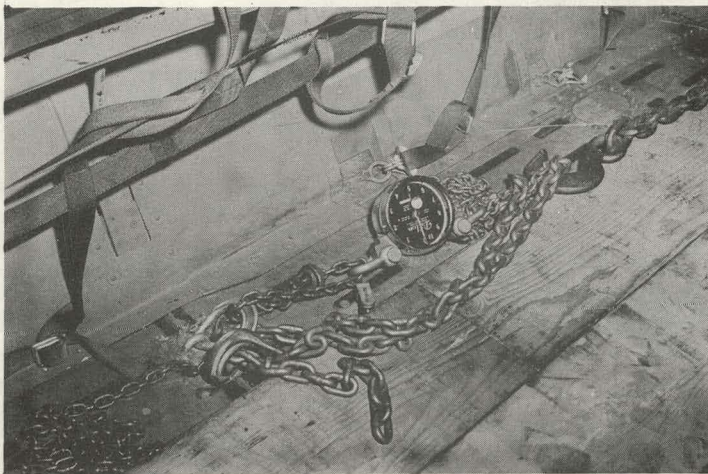


Figure B-64

Dynamometer on deadman end
of cable

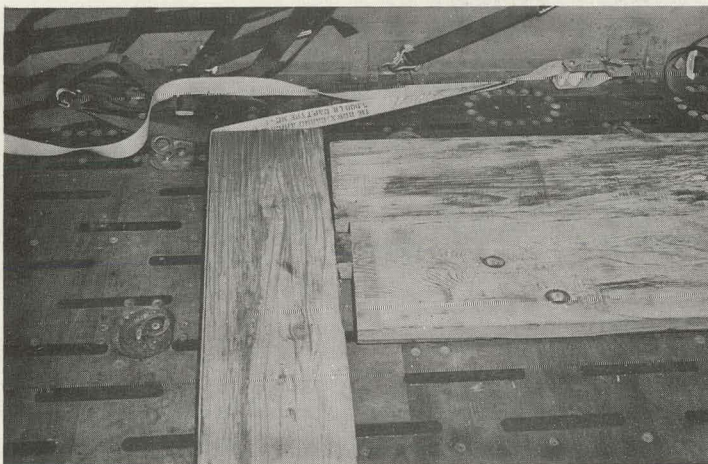


Figure B-65

Nylon safety strap used to
prevent shoring longitudinal
motion

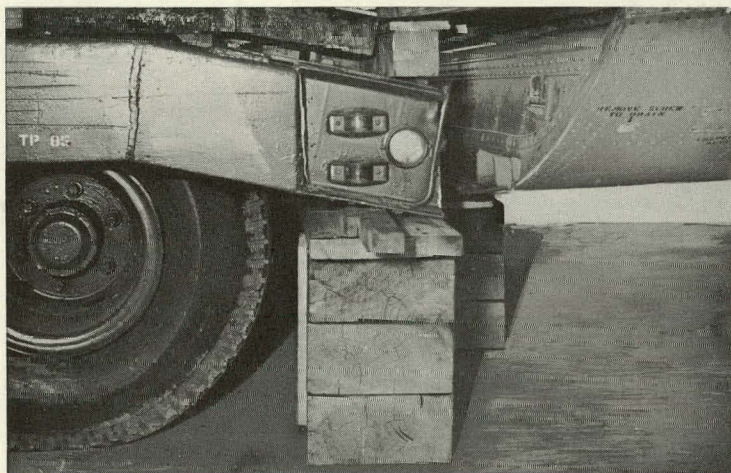


Figure B-66

Blocking under trailer

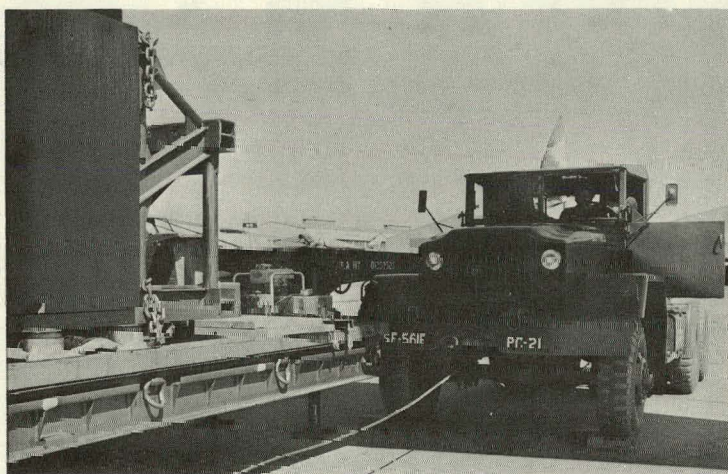


Figure B-67

Tractor re-positioned to resume winching operation after interruption to move trailer

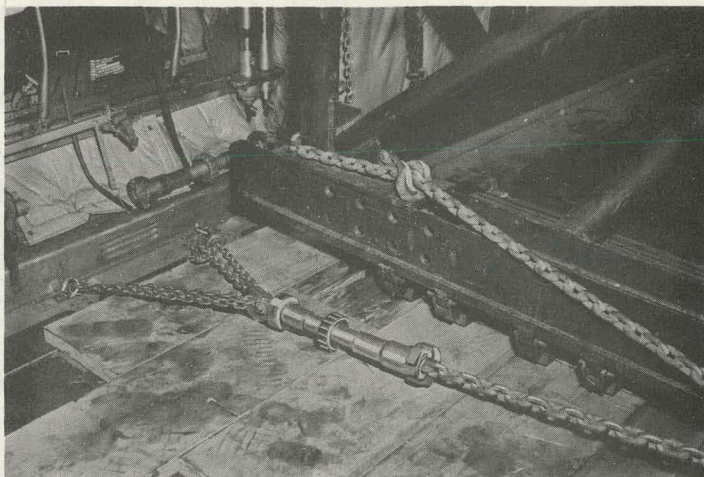


Figure B-68

Power conversion mockup tied down in C-133 for safety, overnight, prior to loading reactor mockup

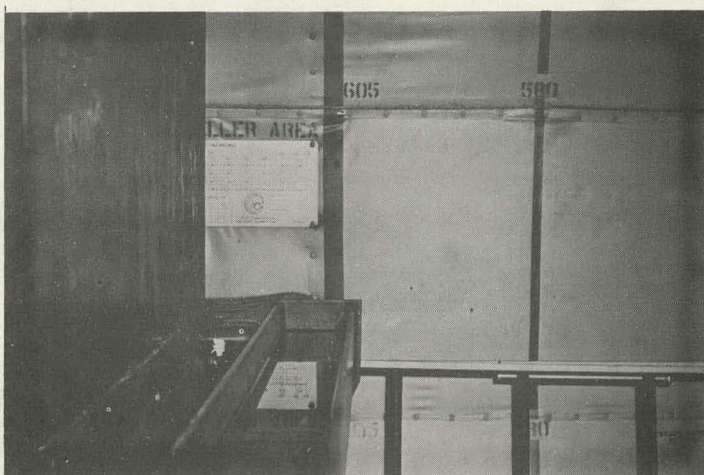


Figure B-69

Aft end of power conversion mockup inside C-133

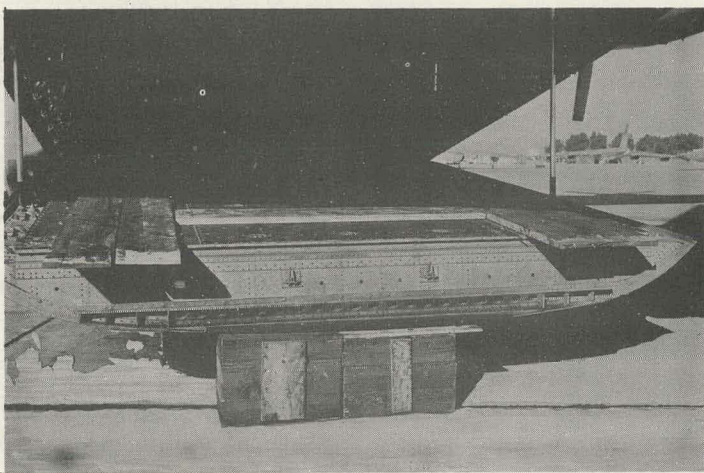


Figure B-70

Supporting blocks under rear loading ramp of C-133



Figure B-71

Shoring laid to support
inboard shock mounts on
reactor mockup

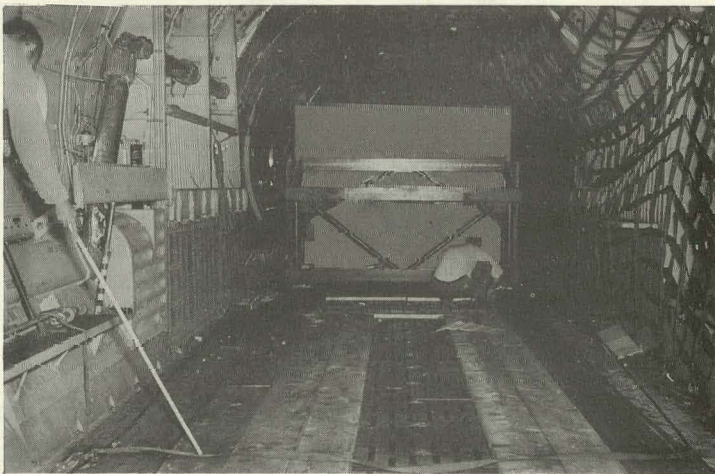


Figure B-72

Tape points to safety strap
for personnel protection if
cable should break

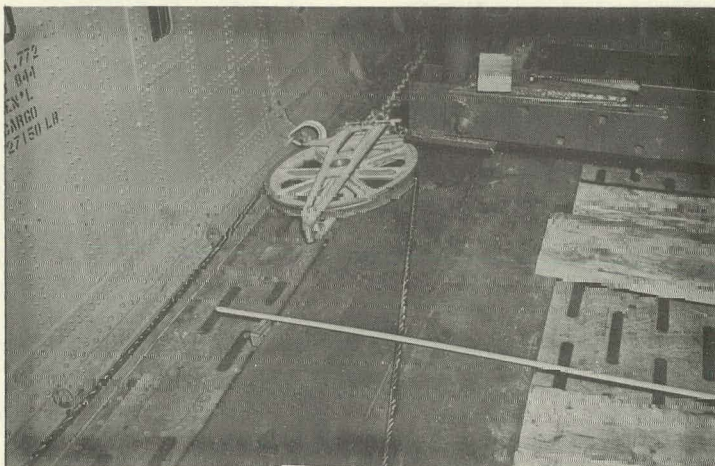


Figure B-73

Snatch block used during
loading operations; tape points
to fitting which prevented
lateral motion of shoring



Figure B-74

Tape indicates dead end of winching cable, hooked into tiedown fitting



Figure B-75

Tape points to snap lock fitting that holds shoring in place

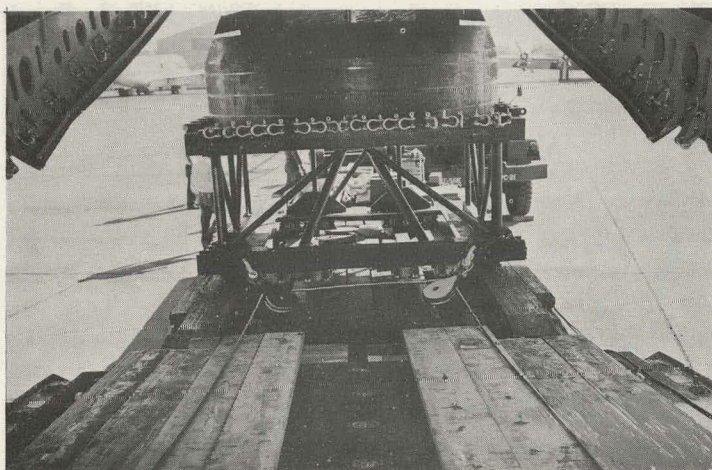


Figure B-76

Reactor mockup, prior to loading into C-133

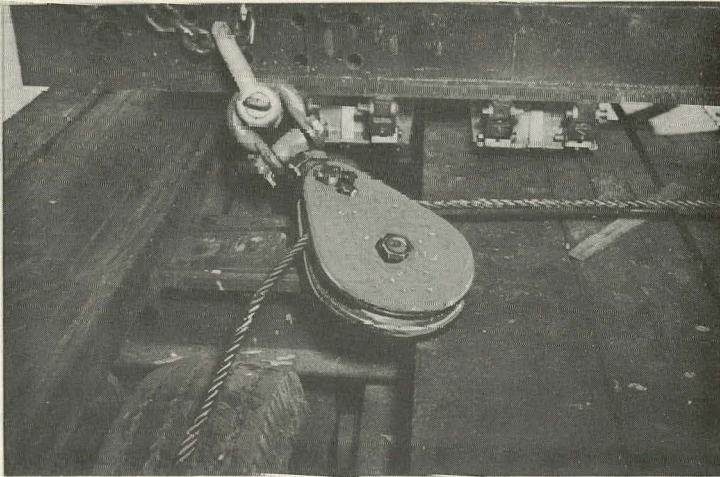


Figure B-77

Snatch block connected to reactor mockup prior to loading onto C-133



Figure B-78

Setup at rear of C-133 prior to re-loading M-52 tractor for winching operation

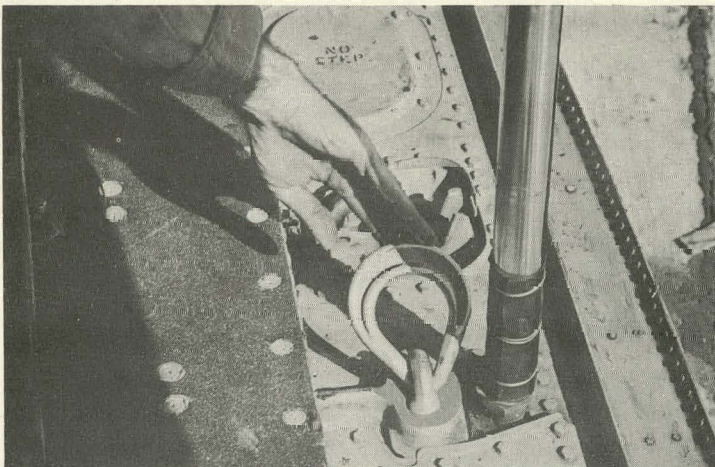


Figure B-79

Close-up of 10,000-lb tiedown fitting on C-133

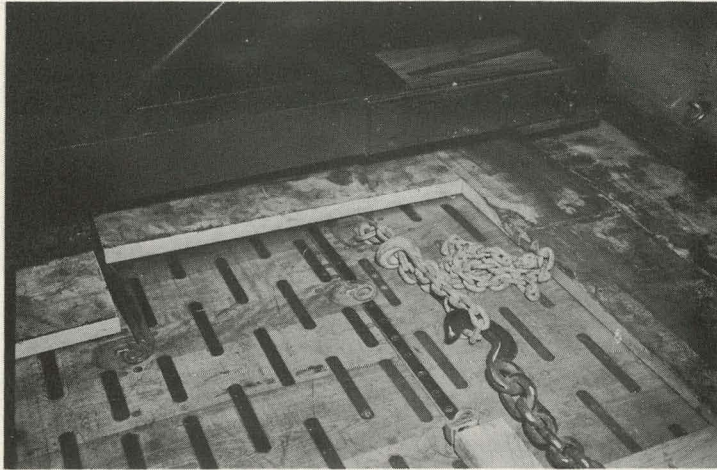


Figure B-80

Deadman relocated near center of aircraft



Figure B-81

Inboard shock mounts on reactor mockup binding on shoring during loading

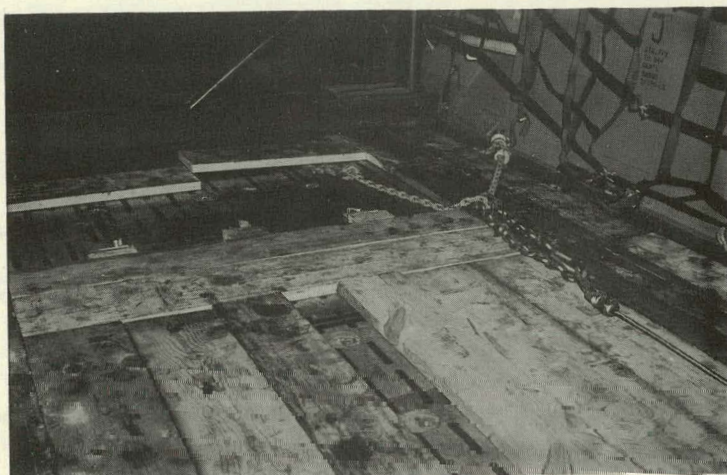


Figure B-82

Deadman attached to two tie-down fittings

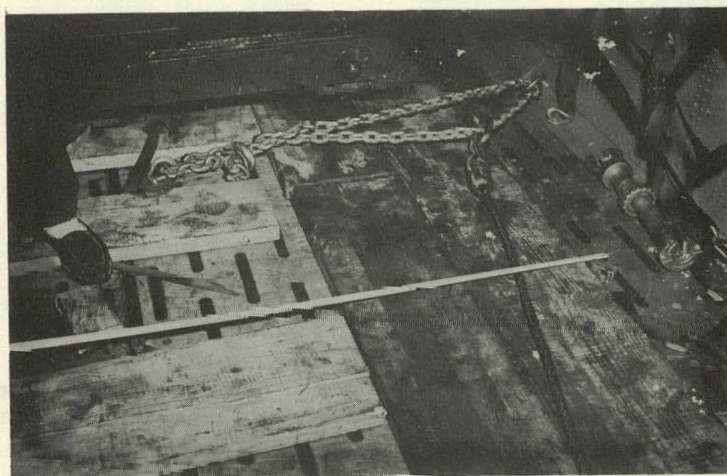


Figure B-83

Deadman re-positioned; tape indicates snap lock fitting

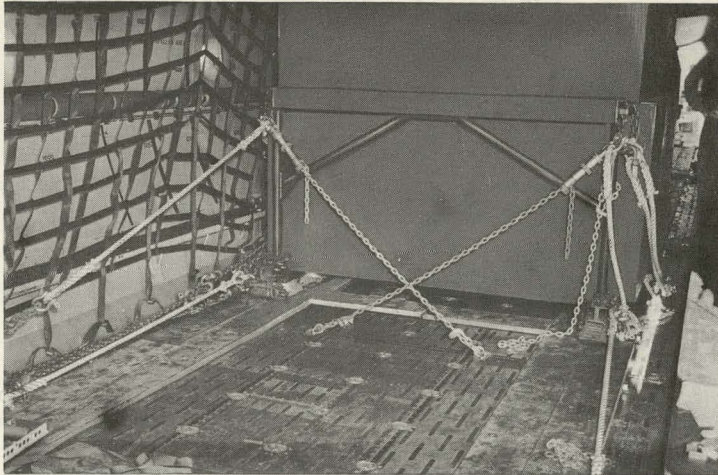


Figure B-84

Tiedown arrangement at forward end of power conversion mockup, C-133



Figure B-85

Tiedowns at port, forward end of power conversion mockup



Figure B-86

Tiedowns at starboard, aft end of reactor mockup

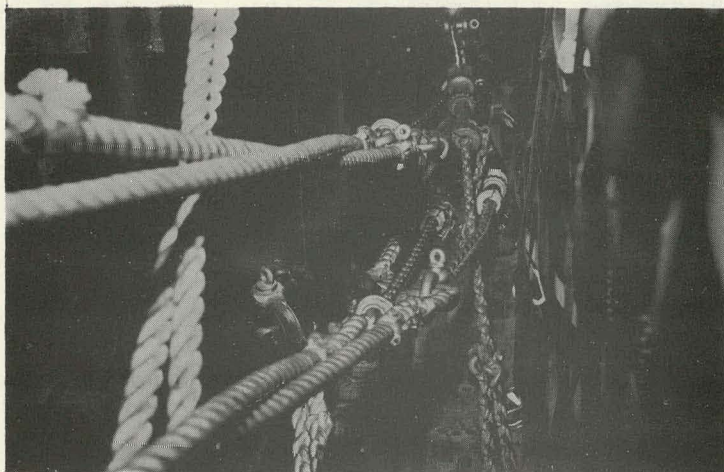


Figure B-87

Tiedown at forward, starboard side of power conversion mock-up, in C-133

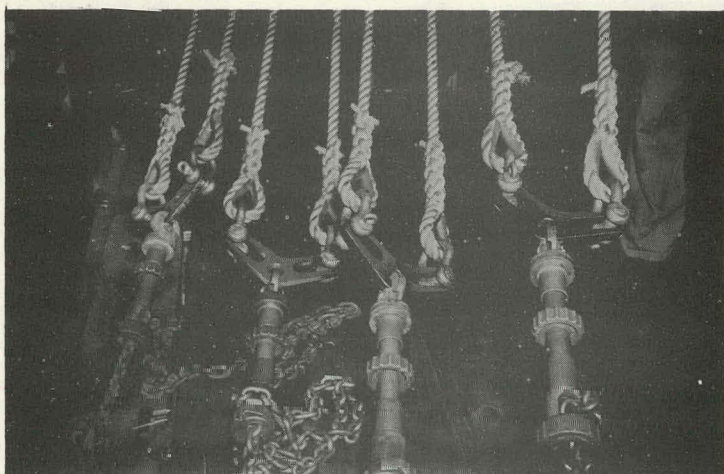


Figure B-88

Tiedown system - aft end, port side of reactor mockup

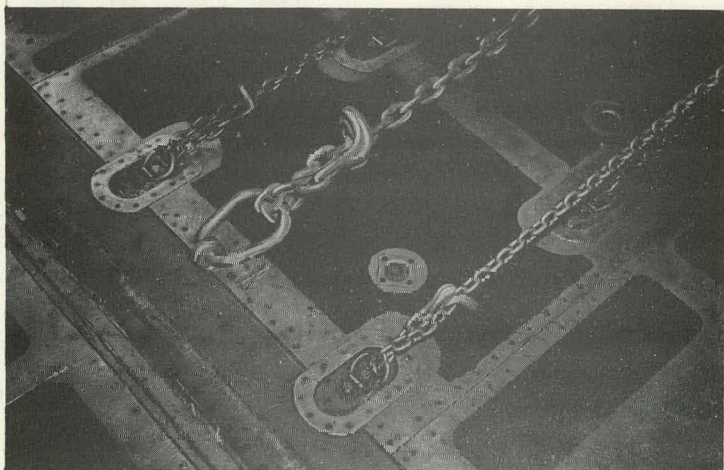
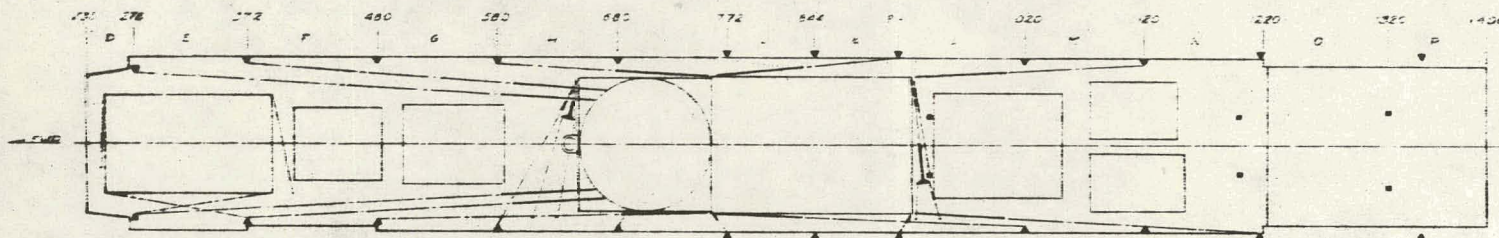


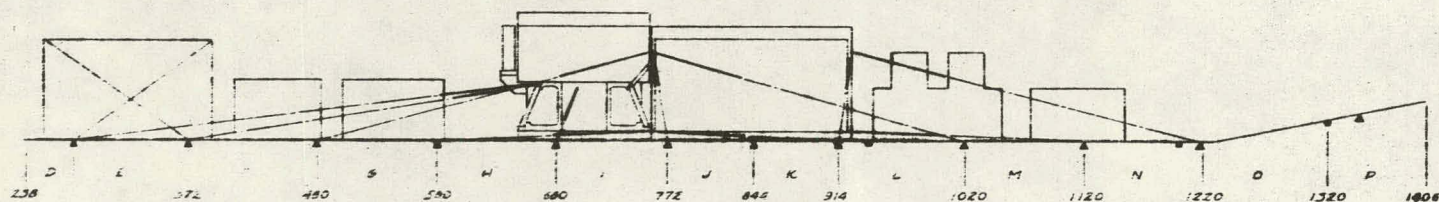
Figure B-89

Tiedown system - also at aft end, port side of reactor mockup

ITEM	QTY	DESCRIPTION	UNIT	WEIGHT	REMARKS
A	43590	REACTOR: P/K PEG-133A			
		COUPLED-TIEDOWN			
		RESTRAINT PER			
		TC-10-33A-9.			



CONTROL CAB 5000 FS 307
 REACTOR STORAGE 3000 FS 445
 GAS STORAGE 1700 FS 540
 REACTOR 30000 FS 702
 POWER CONVERSION PL. 30000 FS 542
 GAS REEL 8000 FS 1000
 GAS/WATER MAKEUP 3000 FS 1115
 MEL CREW 2800 FS 1300
 PACKAGE WEIGHT C.G.



TIEDOWN FITTINGS

SYMBOL	RATING
▲	25000
■	10000
●	10000

TIEDOWN HARDWARE

SYMBOL	ITEM	SIZE OR PART NUMBER	RATING	SUPPLIER	NOTES
—	TIEDOWN DEVICE	D-1	25000	USAF	
—	TIEDOWN DEVICE	C-2 & ME-1	10000	USAF	
—	TIEDOWN DEVICE	MC-1	5000	USAF	
—	NYLON ROPE	1/2" DIA. 5' LG.	25000	ML-1	
—	NYLON ROPE	1/2" DIA. 5' LG.	25000	ML-1	
—	DOUBLE TREE		25000	ML-1	
—	RESTENSION DEVICE		2500	ML-1	

1. REACTOR: P/K PEG-133A COUPLED FOLLOWING DIRECT LOADING FROM MEL CREW TAILER.
2. P/K PEG-133A COUPLED CONTROL CAB TIEDOWNS TERMINATING IN LOWER PER TIEDOWN POINTS SHOWN ABOVE DECK 1.
3. TIEDOWNS TERMINATING IN UPPER PER TIEDOWN PTS. SHOWN BELOW DECK 1.
4. ENTIRE TIEDOWN SYSTEM SYMMETRICAL ABOUT AIRCRAFT DECK 1.
5. AIRCRAFT LOADING IN ACCORDANCE WITH TC-10-33A-9.
6. TIEDOWN RESTRAINT PER TC-10-33A-9.

NOTES: 1. SHOW ALL DIMS AND GRADE DIMS.

P408745A

COPY

Aircraft General A SUBSIDIARY OF THE ARMOY-GENERAL CORPORATION		ML-1 TIEDOWN SYSTEM - COUPLED REACTOR: P/K PEG-DOUGLAS C-133
PROJECT NO. 101 DRAWING NO. 101 REVISION NO. 101	DATE 10/1/54 BY 101 CHECKED 101	P408745A

Military Characteristics (Cont'd)

- 7 -

- E. Radioactive waste from the plant will be kept to a minimum. Disposal of radioactive waste will be in accordance with field procedures approved by the Chief Chemical Officer. (NOTE: Disposal will be subject to AEC approved procedures at NRTS).
- F. The plant will be completely self-sufficient to permit steady state operation without the need for auxiliary equipment. For startup and shutdown operations, the plant should require no more than a 45 KW diesel generator and necessary construction equipment for erection of the supplemental expedient shield. Equipment for expedient shield construction shall not be part of overall plant equipment.
- G. The power plant shall be equipped with all special purpose tools required for normal maintenance and startup, but not for refueling. Special equipment and procedures required for field refueling shall be specified. The plant shall be equipped with complete operating manuals (AR 310-3) defining detailed operating, maintenance, installation, and relocation procedures.

C-124 AIRCRAFT

LOADING TESTS WITH THE POWER CONVERSION MOCKUP

TABULATION OF ELEMENTAL TIMES
C-124 LOADING OPERATIONS
POWER CONVERSION PACKAGE

SU				O				I				D				AD			
Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S	Op. No.	H	M	S
1	1	37						7			55	9		10	45				
2		6	50	6		1	20					11		2	50				
3		11	10	8			30					13			25				
4		3	30	10		1	10					15		7	10				
5		50	40																
26		2		12			55					16		6	40				
				14			25					18		17	6				
				17			59					19		18	30				
				21		1	2					20		14	15				
				23			20					22		5	18				
				24		6	5												
				25		3	20												
Total				2	51	10			16	6		35	1	12	59				
Round-																			
so Off.				31			16						1	13					

TIEDOWN OPERATIONS

				27	1	7										29		25	
				28	1	10													
Total					2	17												25	

OFF-LOADING OPERATIONS

30	10		35	1	17	43	1	45	38	20	53	33	3	55					
31	20		37		2				40	2	40								
32	11		39		5				41	4	25								
34	1		42	1	20				45	2									
36	20	8	44	4	30				48	1	30								
			46	1	5														
			47		55														
			49		10														
Total				1	2	8	9	24	1	45	31	28	3	55					
Round.																			
Off				31	2		9	24	2		31	28		4					

ELEMENTAL DESCRIPTION AND ELAPSED TIME
FOR ML-1 MOCK-UP LOADING TEST
ON C-124 AIRPLANE

September 23, 1959 -- Power Conversion Package Mockup

The crew was the same as for the two previous aircraft. The tool list was the same except as follows:

Due to its availability on airfields, a Euclid tow tractor was used to pull the power conversion into the C-124. This tractor has a 27,000 lb drawbar pull capacity.

At 0953 hours the shoring arrived via tractor and trailer.

Element 1 (SU)

The C-124 Globemaster has a forward cargo loading door of the clam shell type. The airplane can be seen in Figure B-91. The cargo door and loading ramp can be seen in Figure B-92. This element consisted of preparation of the airplane for loading the power conversion package. 2 x 12 shoring was cut and placed 3 pieces wide on the ramp as shown in Figure B-93. The 15,000 lb tie down rings were placed in their threaded holes inside the airplane before shoring was laid. The shoring in the plane can be seen in Figures B-94 and B-95. Approximately 40 feet of shoring was laid out from the end of the ramp on the runway as seen in Figure B-96.

Elapsed Time: 1 hr 37 min

Element 2 (SU)

Position M-172 trailer straddling the shoring on the ground, as shown in Figure B-97. The 20 ton crane was placed at right angles to the C-124 loading ramp on the port side. Slings from the crane were attached to the package. This setup can be seen in Figures B-98 and B-99. The pictures show the setup after the crane has removed the power conversion package from the M-172 trailer.

Elapsed Time: 6 min 50 sec

Element 3 (SU)

Hoist power conversion package from trailer. Pull trailer out from under load to position seen in Figure B-99.

Elapsed Time: 11 min 10 sec

Element 4 (SU)

Unshackle the crane slings. Back the crane to position shown in Figures:

B-100 and B-111. At this point the crew took time off for lunch. The time was 1145 hours.

Elapsed Time: 3 min 30 sec

The crew returned from lunch at 1300 hours. The general setup can be seen in Figures B-102 and B-103. The Euclid tow tractor is shown in position in these pictures. It will also be noted that the crane as seen in Figure B-103 is in position to exert a port restraining force and the M-52 tractor winch is in position on the opposite side. The M-52 can barely be seen in the left hand side of the Figure B-102. The M-52 was in position to exert a restraining force on the starboard side of the power conversion package. Note: Port and starboard are taken with respect to the airplane only.

Element 5 (SU)

Grease the shoring, thread the cable for winching aboard the aircraft and position the equipment. The cable was attached to the front end of the power conversion skid using D-1 fittings and a chain at the corners. These chains ran to a central purchase point along the centerline of the power conversion skid. However, no snatch block was used at this central pull point. The cable was run back through the aircraft and through two snatch blocks at the rear end of the aircraft as shown in Figure B-104. It was run back out through the aircraft and hooked on to the Euclid tow tractor.

Elapsed Time: 50 min 40 sec

Element 6 (O)

Winch forward.

Elapsed Time: 1 min 20 sec

Element 7 (I)

Inspect alignment.

Elapsed Time: 35 sec

Element 8 (O)

Winch forward.

Elapsed Time: 30 sec

Element 9 (D)

Tighten safety lines and shoring which had slipped. An explanation of the safety lines is as follows. At the top of this very steep loading ramp

as can be seen in Figure B-94, D-1 fittings and chains were run around the ends of the shoring in an effort to restrain the thrust, in the direction indicated, as the power conversion package was dragged up the ramp. Another safety precaution is shown in Figure B-93, where nylon straps were used at the ends of the shoring. This, incidentally, shows the setup during off loading. This was simply to keep the shoring from buckling up as the friction forced the shoring together. After this loading test it was decided that the very longest length of shoring possible should be used, and that because an attempt was made to fill in every little void rather than simply over-lapping long pieces of shoring, much time was lost. Every time the shoring moved (one piece relative to another), and bound up, the only way to smooth it out was either to saw it off or chip it off with a hammer and chisel or hatchet. It was a very time consuming process.

Elapsed Time: 10 min 45 sec

Element 10 (O)

Winch forward.

Elapsed Time: 1 min 10 sec

Element 11 (D)

Tighten safety chain, reference Figure B-94, remove web straps holding down shoring, reference Figure B-103.

Elapsed Time: 2 min 50 sec

Element 12 (O)

Winch forward.

Elapsed Time: 55 sec

Element 13 (D)

Shoring buckled at interface between two lengths of shoring. This had to be pushed down flat.

Elapsed Time: 25 sec

Element 14 (O)

Winch forward. At this point the rear of the power conversion package is half way up the ramp. Reference Figure B-105 and B-106 for side clearance.

Elapsed Time: 25 sec

Element 15 (D)

Rig snatch block inside plane on starboard side. This was done in an effort

to straighten out the load and force the cable to pull toward the starboard side.

Elapsed Time: 7 min 10 sec

Element 16 (D)

Release chains holding the end of the shoring at the top of the ramp. The front end of the power conversion package is now at that point. Put safety chains across cable and grease shoring. A man is stationed at the tail stand in case the center of gravity of the airplane shifts and the tail drops down. This tail stand can be seen immediately under the tail of the airplane in Figure B-102. It is very important that a man be stationed at this point on the C-124; otherwise the plane may drop down on its tail and be damaged.

Elapsed Time: 6 min 40 sec

Element 17 (O)

Winch forward.

Elapsed Time: 59 sec

Element 18 (D)

Push shoring back into place.

Elapsed Time: 17 min 6 sec

Element 19 (D)

Fix shoring.

Elapsed Time: 18 min 30 sec

Element 20 (D)

Fix shoring and fasten down.

Elapsed Time: 14 min 15 sec

Element 21 (O)

Pull load forward to straighten.

Elapsed Time: 1 min 2 sec

Element 22 (D)

Remove snatch block inside on starboard.

Elapsed Time: 5 min 18 sec

Element 23 (O)

Winch forward.

Elapsed Time: 20 sec

Element 24 (O)

Adjust shoring.

Elapsed Time: 6 min 5 sec

Element 25 (O)

Winch forward to final position in plane, as shown in Figure B-107.

Elapsed Time: 3 min 20 sec

Element 26 (SU)

Unhitch cables and reel cable back on the drums.

Elapsed Time: 2 min 0 sec

Element 27 (O)

Proceed with the tiedown of the power conversion package.

Elapsed Time: 1 hr 7 min

At 1645 hours the crew knocked off for the day and started again at 9010 hours on 9/24/59.

The tiedown was performed using the diagram in the C-124 aircraft loading test manual as a guide.

Element 28 (O)

The tiedown operation was finished at 1040 hours. This included 20 minutes for a coffee break.

Elapsed Time: 1 hr 10 min

Element 29 (AD)

Take picture of the setup.

Elapsed Time: 25 min

Note: For purposes of explanation the orientation is port and starboard with respect to the aircraft. Reference Figure B-108 shows the forward end of the power conversion package tied down for longitudinal, lateral and vertical restraint. Proceeding along the starboard side of the power conversion package, Figures B-109 and B-110 show the starboard front end. Proceeding around to the rear of the power conversion package, Figure B-111 shows the rear starboard top side tie down connections to the power conversion package. Proceeding around to the rear of the power conversion

package, Figure B-112 shows some of the tiedowns connected to the floor and shows the whiffle trees and D-1 devices in fair detail.

The port rear side detail of the tiedowns are shown in Figure B-13 and B-114.

Figure B-15 shows the port rear tiedowns. Figure B-116 shows the port front end tied down. These same chains can be seen also in the right hand side of Figure B-108. The reader has now completed circuit of the power conversion package tiedown system.

Element 30 (SU)

Remove the tiedown fittings and store the chains, D-1 and C-1 devices in the receptacles at the rear of the airplane.

Elapsed Time: 10 min

Element 31 (SU)

Replace shoring in the airplane -- rig the cable -- position the M-52 for off loading.

Elapsed Time: 20 min

Note: The crew took off for lunch at 1135 hours. Crew returned from lunch at 1315 hours.

Element 32 (SU)

Element consisted of completing shoring and rigging for off loading.

Elapsed Time: 11 min

Element 33 (AD)

Take picture.

Elapsed Time: 3 min 55 sec

Element 34 (SU)

Get signals straight with the crew and post the guides at the following positions. Two men were posted inside the airplane at the rear of the power conversion package; one man was posted on the starboard wing of the airplane giving signals to another man on the ground at the foot of the ramp and to a man out by the M-52 tractor who gave further instructions to the winch operator.

Elapsed Time: 1 min

Element 35 (O)

Off-load.

Elapsed Time: 1 min 17 sec

Element 36 (SU)

Tie down shoring for longitudinal and side movement inside of airplane as can be seen in Figure B-117 with the power conversion package at the brink of the ramp during off loading operations. It can also be seen that for off loading, a snatch block was used.

Elapsed Time: 20 min 8 sec

Element 37 (O)

Off load. Two outboard pieces of shoring on each side moved sideways at the top of the ramp.

Elapsed Time: 2 sec

Element 38 (D)

Re-position shoring.

Elapsed Time: 20 min 53 sec

Element 39 (O)

Off load.

Elapsed Time: 5 sec

Element 40 (D)

Rig plane winch at the back of the power conversion package. It was found at this point that the rear end of the power conversion package had to be hoisted up in order to reduce the frictional thrust on the shoring so that the off loading could be performed much more smoothly up to the point where the power conversion package tipped to a position parallel with the incline of the ramp.

Elapsed Time: 2 min 40 sec

Element 41 (D)

Adjust shoring with plane winch.

Elapsed Time: 4 min 25 sec

Element 42 (O)

Off-load.

Elapsed Time: 1 min 20 sec

Element 43 (I)

Inspect alignment.

Elapsed Time: 1 min 45 sec

Element 44 (O)

Off-load.

Elapsed Time: 4 min 30 sec

Element 45 (D)

Adjust shoring on ramp, lap shoring.

Elapsed Time: 2 min

Element 46 (O)

Off-load. Re-checked ground.

Elapsed Time: 1 min 5 sec

Element 47 (O)

Off-load.

Elapsed Time: 0 min 55 sec

Element 48 (D)

Adjust shoring.

Elapsed Time: 1 min 30 sec

Element 49 (O)

Complete off loading.

Elapsed Time: 0 min 10 sec

1500 hours: Job completed -- commence cleanup.



Figure B-91
C-124 aircraft



Figure B-92
C-124 loading ramp (note clam-shell doors) during preparations for loading power conversion mockup



Figure B-93
Nylon safety straps used to prevent slippage of the shoring while loading mockup

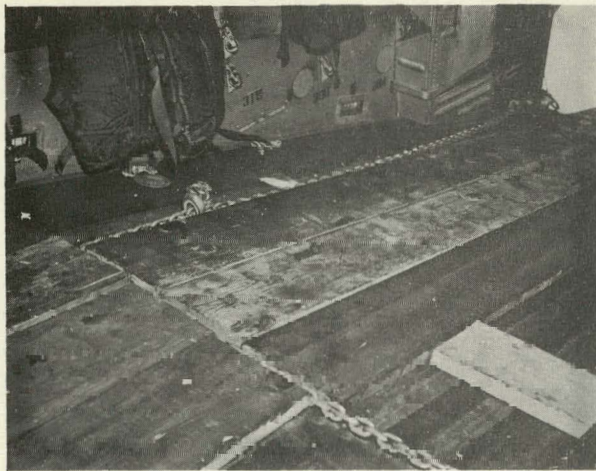


Figure B-94

Shoring in place on ramp

Figure B-96

View from top of loading ramp

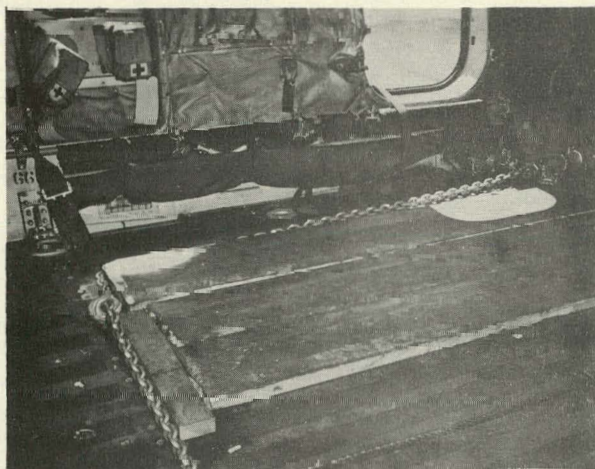


Figure B-95

Shoring held in place against
longitudinal movement

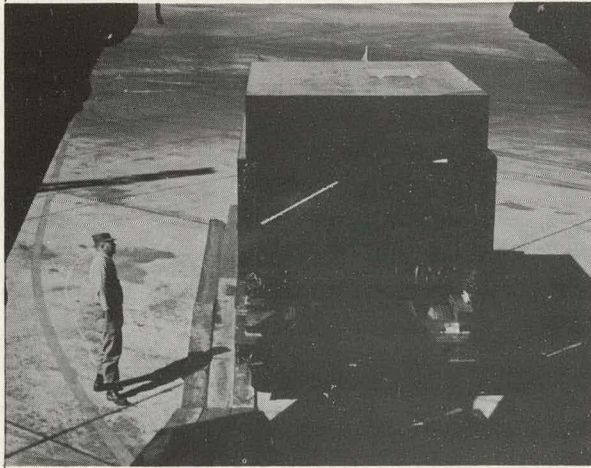


Figure B-97

Power conversion mockup on
M-172 trailer, prior to be-
ing hoisted by crane

Figure B-98

General arrangement of equip-
ment during loading

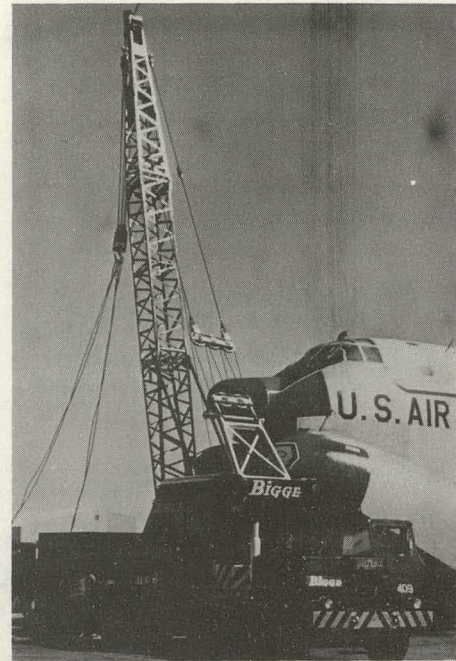


Figure B-99

Another view of equipment
during power conversion
mockup loading operations

Figure B-100

Equipment readied for loading
power conversion mockup

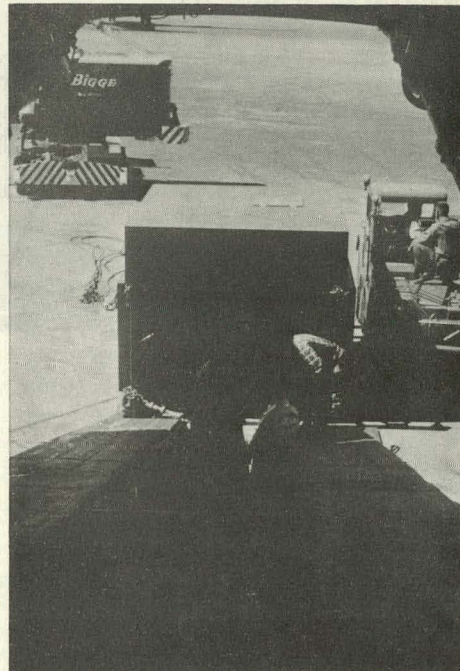


Figure B-101

Mockup at end of loading ramp,
ready for winching



Figure B-102

View of preparations for loading power conversion mockup

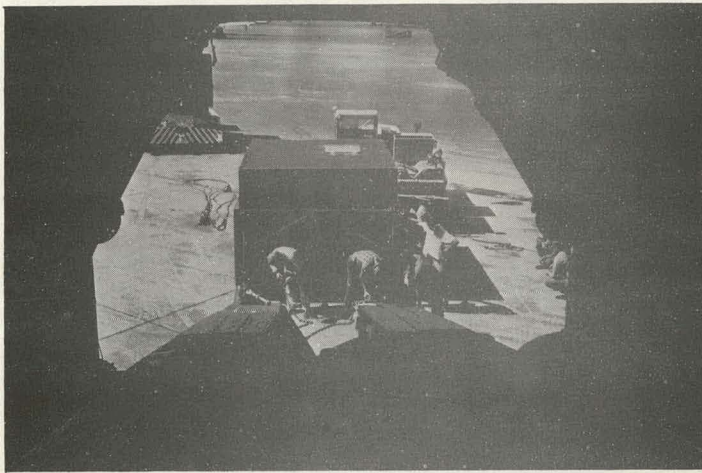


Figure B-103

View from top of loading ramp. Note 20-ton crane (upper left) for applying rear restraint

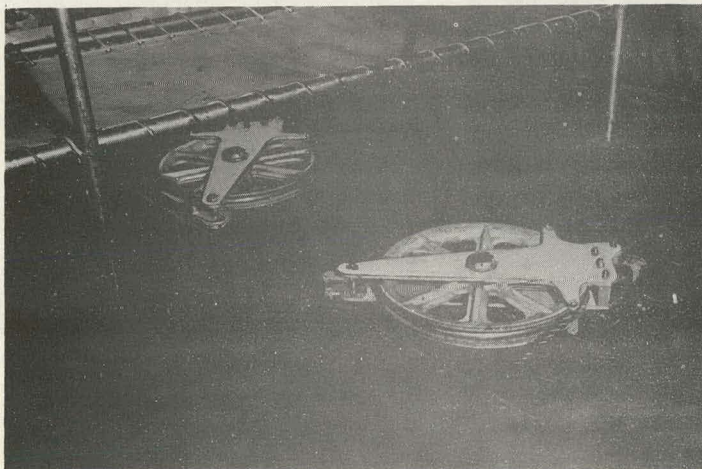


Figure B-104

Snatch blocks used at aft end of aircraft for reversing cable direction

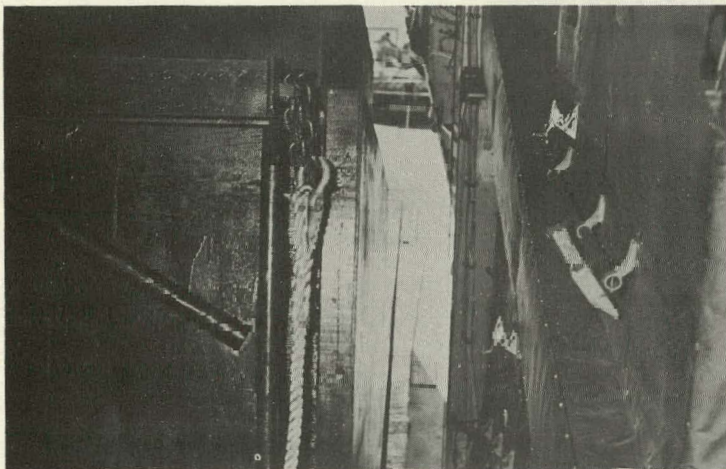


Figure B-105

Clearance between power
conversion mockup and air-
craft, starboard side,
halfway up loading ramp

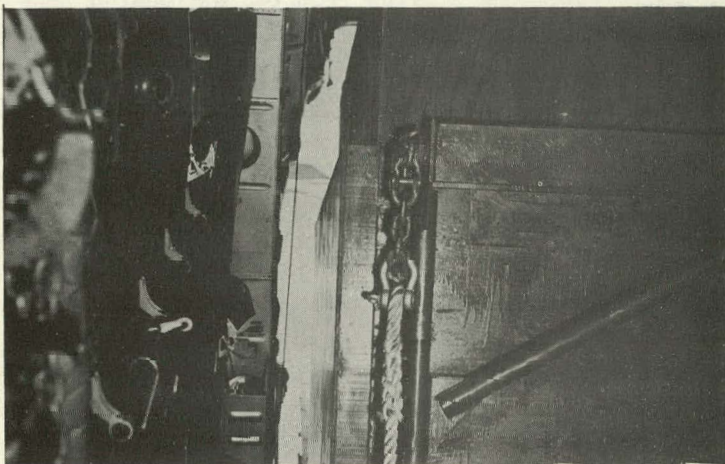


Figure B-106

Clearance on port side, also
halfway up loading ramp

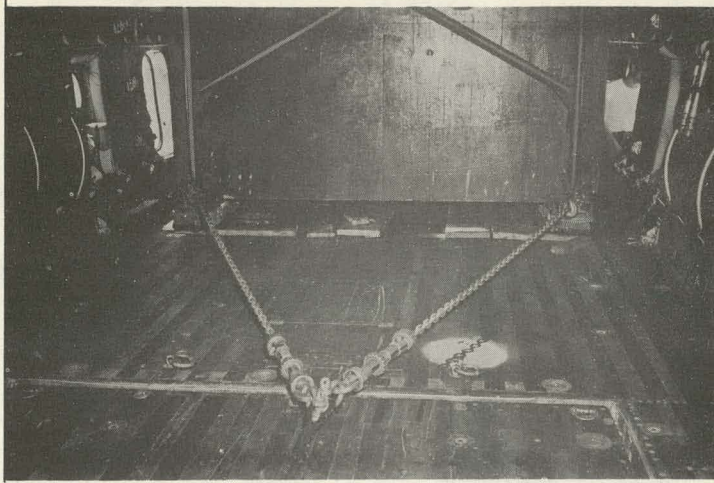


Figure B-107

Mockup in final position
inside C-124



Figure B-108

Tiedown arrangement, forward
end of aircraft

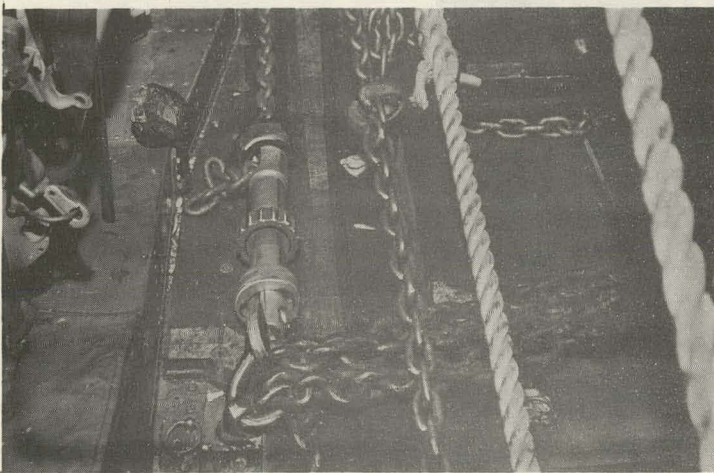


Figure B-109

Tiedowns at forward end of
aircraft, starboard side

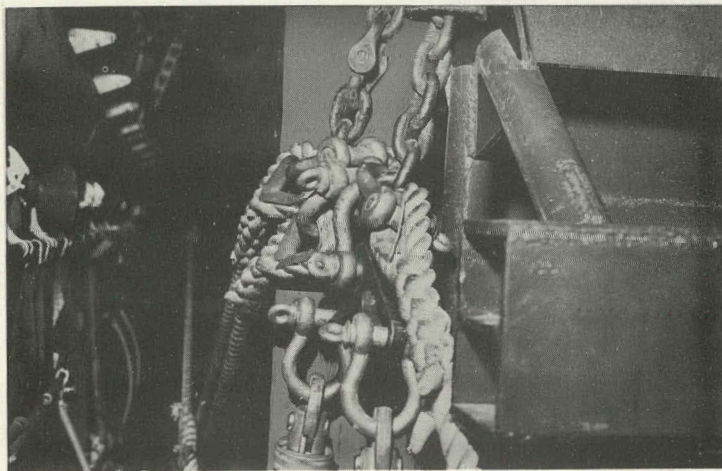


Figure B-110

Tiedowns, starboard, forward
end of mockup



Figure B-111

Tiedowns, starboard, aft end

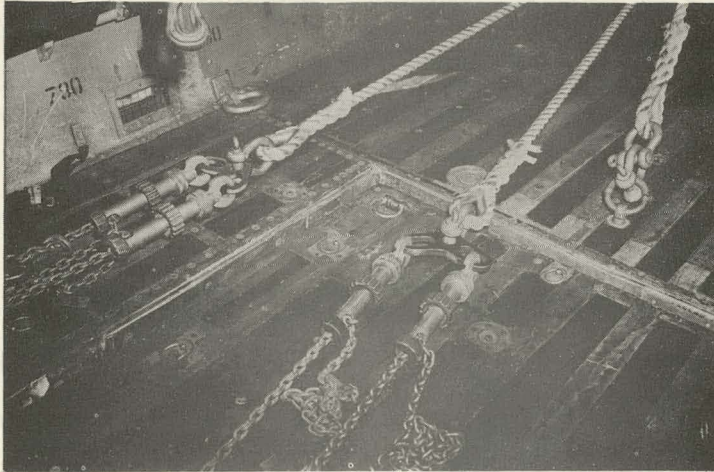


Figure B-112

Tiedown connections to floor
of aircraft, aft , port side

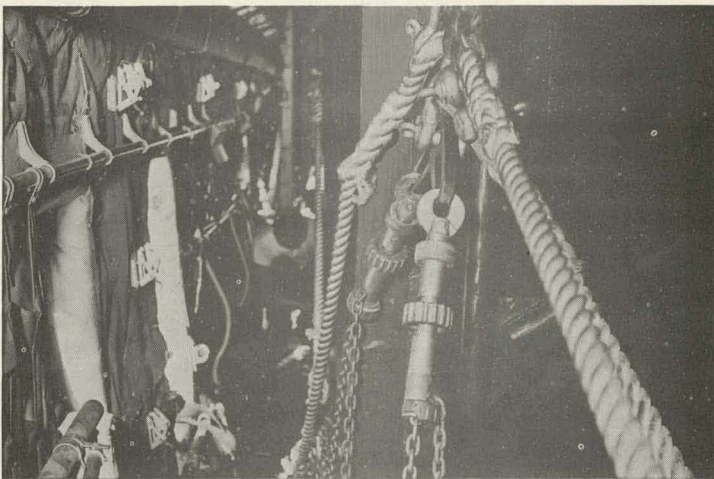


Figure B-113

Tiedown connections, aft, port
side

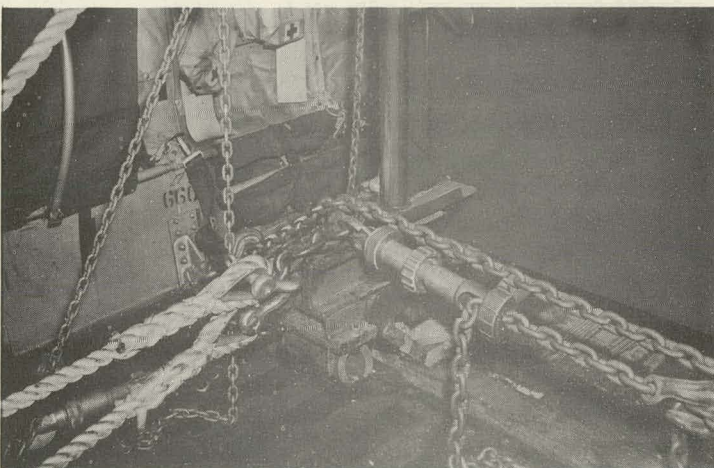


Figure B-114

Tiedown connections, aft,
port side

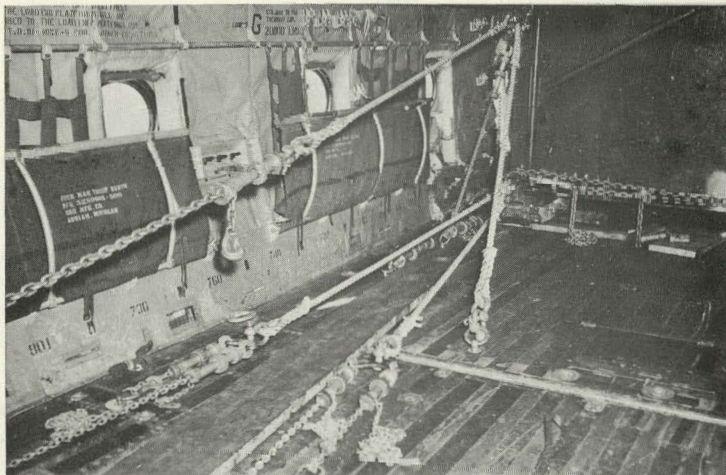


Figure B-115

Tiedown connections to
floor, aft, port side

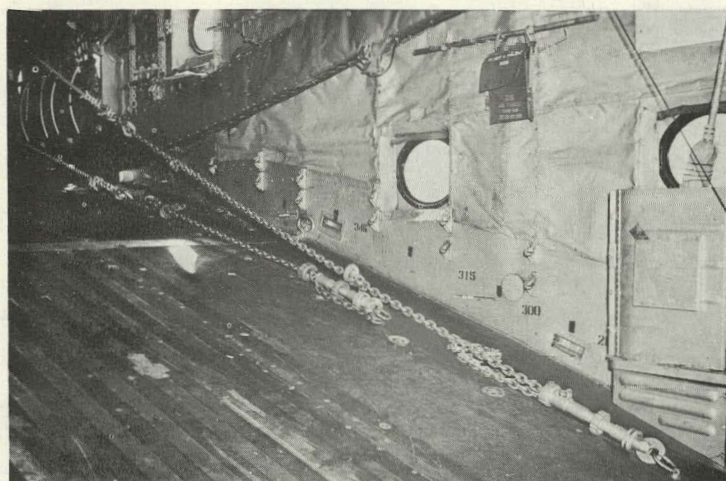


Figure B-116

Tiedown connections to
floor, forward, port

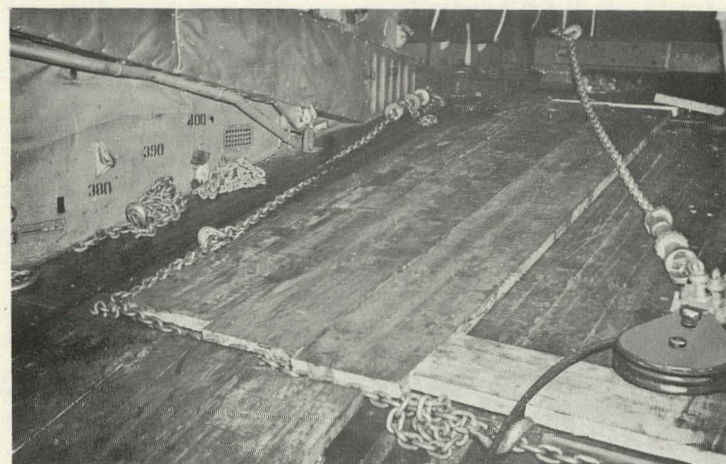
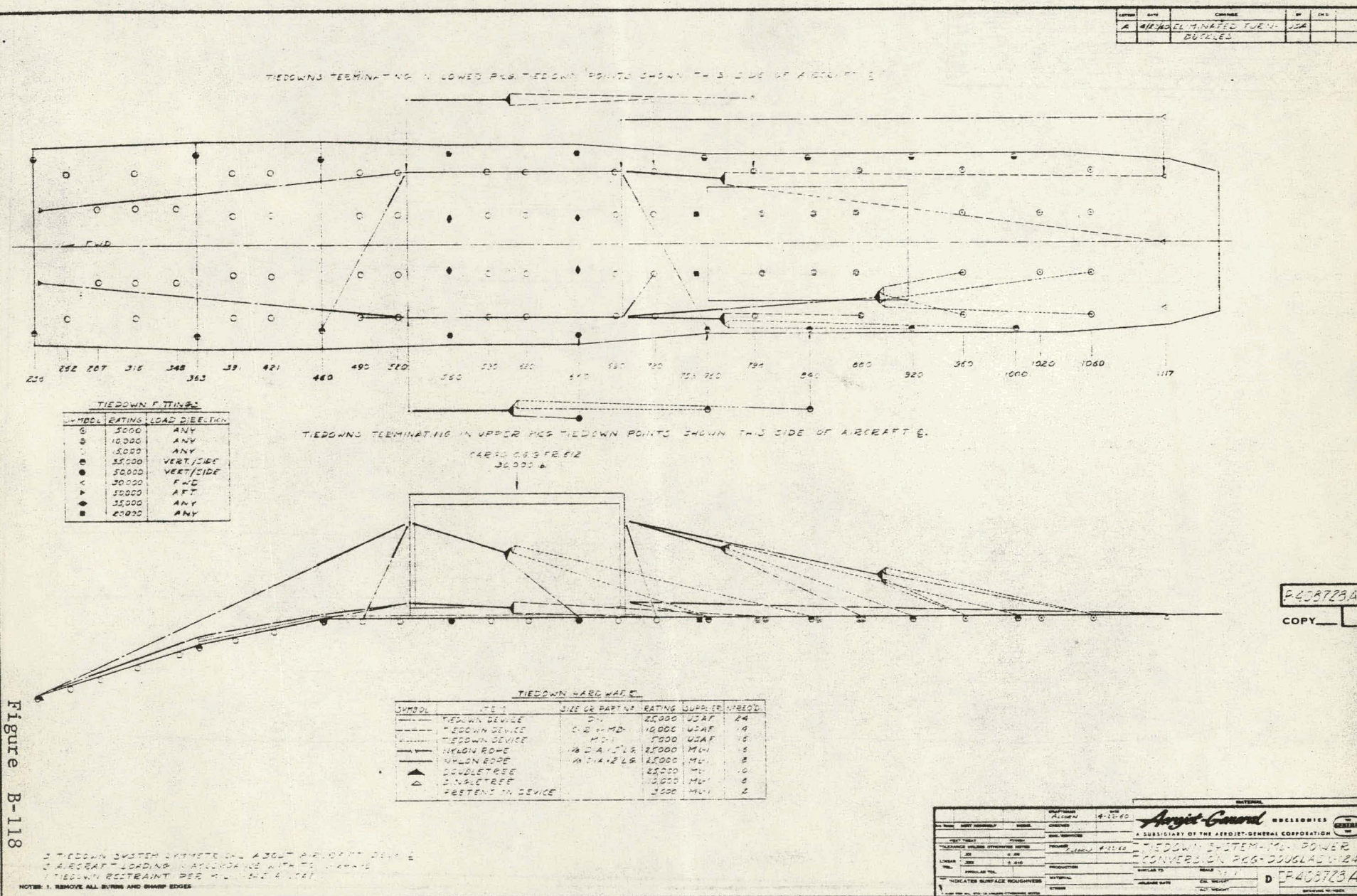


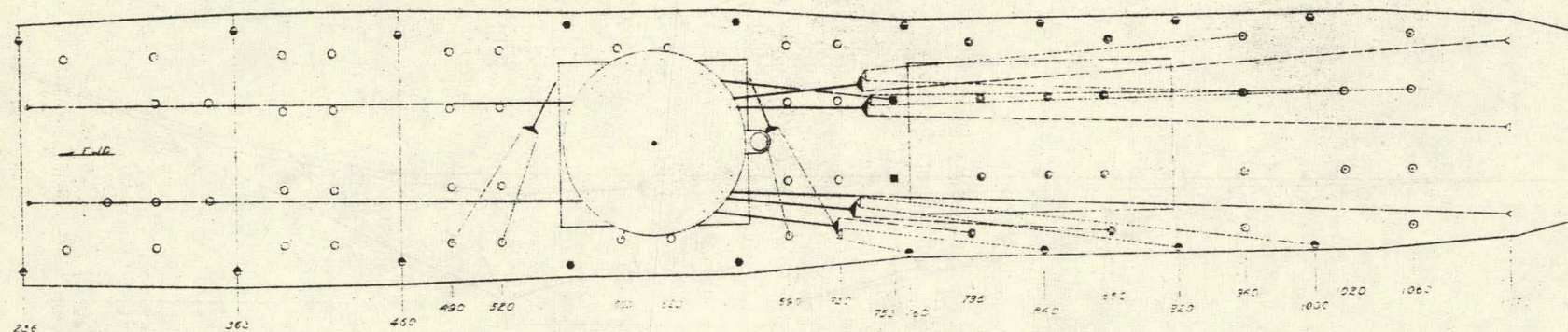
Figure B-117

Cable rigged for off-loading
power conversion mockup.
Note chain for restraining
shoring from longitudinal
movement.

B-113



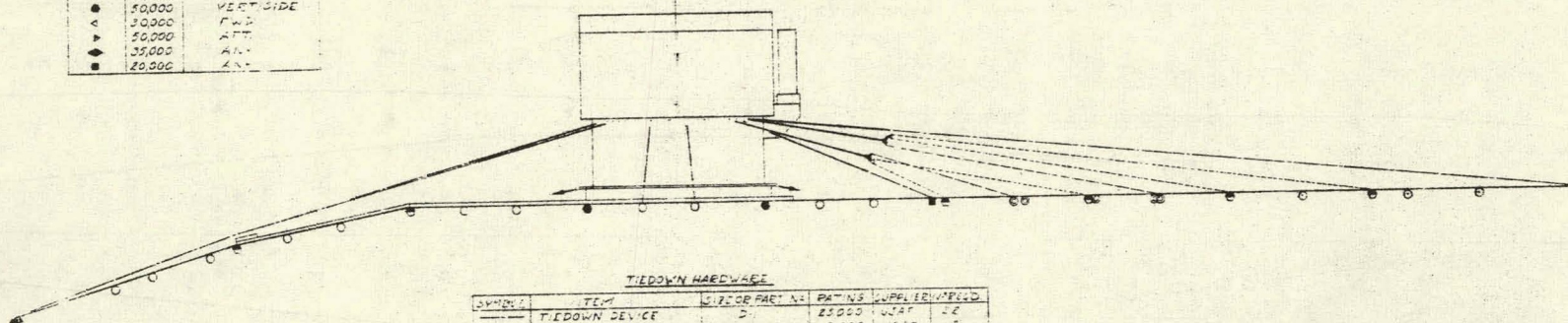
LETTER	DATE	CHANGE	BY	CHK
A	5-10-64	REVISED REACTOR CONFIGURATION	SA	
2) ELIMINATED TURNBUCKLES.				



TIEDOWN FITTINGS

SYMBOL	RATING	LOAD DIRECTION
○	5000	ANY
●	10,000	ANY
○	15,000	ANY
○	25,000	VERT. SIDE
○	50,000	VERT. SIDE
△	30,000	FWD
△	50,000	ATT
△	35,000	ATT
■	20,000	ANY

CARGO CARRIER
30,000 L



TIEDOWN HARDWARE

SYMBOL	ITEM	QUANTITY	PART NO.	RATING	SUPPLIER/STOCK
—	TIEDOWN DEVICE	2	25000	USAF	12
—	TIEDOWN DEVICE	2	0000	USAF	2
—	TIEDOWN DEVICE	1	5000	USAF	10
—	NYLON ROPE (1/2 DIA)	1	25000	ML-1	10
—	NYLON ROPE (1/2 DIA)	2	25000	ML-1	10
—	DOUBLETREE		25000	ML-1	12
—	SINGLE TREE		10000	ML-1	5
—	PRETENSION, ASK		3000	ML-1	2

44087274

COPY

Figure B-119

4. TWO FWD TIEDOWN NOT SHOWN ON ELEVATION FOR CLARITY.
5. TIEDOWN SYSTEM IS METRICALLY ABOUT 10% BULKY.
6. AIRCRAFT LOADING IN ACCORDANCE WITH TIE-DOWN MANUAL.
7. TIEDOWN RESTRAINT FOR MIL-STD-883C (HUNG).

NOTES: 1. REMOVE ALL BURRS AND SHARP EDGES.

JALLEN 3-11-64		Aircraft General		AERONAUTICS	
DESIGNED		A SUBSIDIARY OF THE AERONAUTICAL CORPORATION		GENERAL	
CHECKED		TIEDOWN SYSTEM, ML REACTOR		DOUGLAS C-124	
DRAWN		44087274		D 44087274	
MATERIAL		RELEASE 6-12		DATE 12-1-64	
INDICATES SURFACE TREATMENT		MATERIAL		FINISH	
SPECIFIC SURFACE TREATMENT		SPECIFIC SURFACE TREATMENT		SPECIFIC SURFACE TREATMENT	

APPENDIX C

RAILROAD SHOCK TESTS

I. DISCUSSION OF THE MASTER DATA SHEET

The Master Data Sheet at the end of this appendix summarizes data obtained in the railroad switching and humping tests and in the tests simulating an aircraft emergency landing. The table is largely self-explanatory, but some clarification may be needed.

Column 1 is a pictorial description of the test conditions. All cars not specifically labeled are refrigerator cars having an average weight of 60,000 lb. Columns 2 and 3 give the run number and date on which the tests were performed. Note that some tests were not run consecutively in the first series; for instance, Run 28 took place earlier than Run 10.

Column 4 lists the velocity of the impacting car; in the case where the package was moving, the velocity of the test car. Columns 5 and 6 list the weight and number of the impacting cars. Column 7 gives the condition of the shoring. Note that Runs 28, 29 and 30 preceded Run 10, so that the greased shoring used for this latter run could be used for subsequent runs. Column 8 gives the condition of the brakes on the test car. In the case where the moving car struck the four stationary refrigerator cars, the brakes on all four cars were fully set. Column 9 lists tension of a typical nylon tiedown at the beginning of the run (upper figure) and at the end of the run (lower figure). All are direct readings obtained from a dynamometer placed in series with one of the ropes.

Column 10 gives two values for the maximum rope tension reached during a run. The upper value was obtained from the final position of the maximum indicator hand. (Film records from the high-speed camera showed that the maximum-indicating hand of the dynamometer was thrown past the point of maximum tension during most runs having impact velocities greater than 8 mph.) The lower value (shown in brackets) is either the value read from the film, or an estimate of the maximum tension made

from Figure C-1. The values based on Figure C-1 were marked with an asterisk. The estimated values are more accurate than the upper values, but not as accurate as the bracketed numbers.

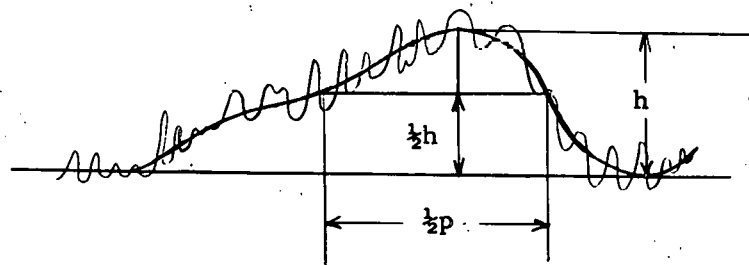
Column 11 gives the scratch gauge readings for horizontal displacement. Scratch gauges were not added until Run 10. Positive numbers represent the maximum distance the package moved from its rest position toward the "power conversion package" end of the car; negative numbers indicate the distance the package moved toward the "reactor" end of the car. Column 12 lists the displacement readings from Visicorder charts. These readings are probably less accurate than the scratch gauge readings. (See discussion of errors, Part III of this appendix). The first reading is the maximum package displacement in the direction opposite that of impact. The second reading lists the maximum package displacement in the other direction.

Column 13 gives the delay, in milliseconds, from the moment of impact to the point where the package begins to move. Column 14 lists the time interval between impact and the point of maximum package displacement. Column 15 gives scratch gauge readings for the vertical displacements. The positive value is an upward displacement; the negative value, downward displacement. Two vertical scratch gauges were used. Column 16 gives the frequency, in cycles per second, of the vertical motion. Column 17 gives scratch gauge readings from the power conversion end of the combined packages. Columns 18 and 19 give transverse displacements recorded by scratch gauges on both ends of the combined mockups. The maximum displacement was recorded in every case.

Data for the horizontal acceleration of the test car are listed in Columns 20 through 24.

The pulse duration of the horizontal acceleration (Column 20) was derived as follows:

A smooth, averaged curve was drawn through the actual recorded trace (see diagram below). The time duration was measured at a point one-half the amplitude of the average curve. The magnitude of this time duration is one-half of the pulse duration.



The delay to the peak is defined as the time interval from the initial impact to the maximum of the averaged curve (Column 21). Column 22 gives the maximum peak of the curve as it was recorded on the Visicorder chart. Column 23 gives the maximum value of the average curve (i.e. the height h in the diagram above). Column 24 gives the frequency of the acceleration pulse in cycles per second.

Columns 25 through 28 give the vertical acceleration of the test car. Three entries (marked with a "T") are data for transverse accelerations on the runs where they were measured. Column 25 lists shock duration, i.e. the time from the initial impact until the time the vibrations died out. Note that this is not the same as the pulse duration recorded in the preceding columns. The peak vertical acceleration (Column 26) and the average acceleration (Column 27) are defined in the same manner, using the average curve. Column 28 gives the frequency of the vertical shock impulses, in cycles per second.

Columns 29 through 32 list data for the horizontal acceleration of the package. Column 29 gives the delay from the moment of impact until the package experienced an acceleration. The duration of the pulse (Column 30) is defined as the time interval from the moment of impact until the horizontal acceleration of the package returns to zero. Column 31 gives the time interval from the moment of impact until the attainment of the maximum horizontal acceleration on the package. The amplitude of the largest horizontal acceleration is given in Column 32. Column 33 gives the velocity of the package relative to the test car. This is obtained by dividing the value in Column 11 by the time interval shown in Column 14.

Columns 34 through 37 give the vertical acceleration of the package. (Entries marked "T" are transverse, not vertical accelerations.) Column 34 lists the time interval from the moment of impact until the package experienced a vertical acceleration. Column 35 gives the duration of the vertical shock on the package, i.e. the time from the initial impact until the vertical acceleration returned to zero. The maximum vertical package acceleration is given in Column 36. The frequency of the vertical package vibration is given in Column 37.

Column 38 lists the number of tiedowns used in each run.

The columns in Table C-2, (the portion of the Master Data Sheet covering the simulated emergency landing tests) are the same as those for Table C-1 with two exceptions: In Columns 11 and 12, two scratch gage readings are recorded. Column 24 gives an "equivalent period" for the horizontal aircraft acceleration. The equivalent period is defined as the period of a versine pulse having the same amplitude as the average curve drawn through a recorded trace, and with the same area under it as the area under the recorded trace.

II. DATA ANALYSES

Typical Visicorder charts from the test runs have been selected for reproduction as Figures C-1 thru C-9. Each vertical division represents 0.5 g for all acceleration traces. The longitudinal

displacement, not linear, is obtained by the use of the correction factor noted on each chart and from the calibration graph. (See Figure C-10.) Vertical displacements were not read from the oscillograph charts; scratch gauge data were used instead. Sharp peaks on some of the longitudinal displacement curves, such as those in Run 18D, resulted from the erratic action of the contacting arm in the potentiometer used in recording this measurement. After a period of 50 to 60 microseconds, the contacting arm remained in steady contact, and the measurements were in no way affected by its action. None of the other measurements given on the Master Data Sheet was affected by this instrument behavior.

Approximate impact velocities were recorded by an "impact meter" supplied by the Southern Pacific Company. Figure C-11 shows the values obtained from this meter in comparison to the velocity obtained from the Visicorder charts. Apparently, the "impact meter" underestimated the velocity of impact in nearly every case. This is especially true when the test car was impacted by a relatively small mass, such as an empty refrigerator car. Only when the loaded sand car was used did the values from the railroad "impact meter" roughly correspond to the Visicorder values.

Figure C-12 shows nylon rope tension plotted against the impact velocity. Because the dynamometer maximum recording hand was thrown well beyond the true maximum position, it is to be expected that many points will lie above the lines as drawn. These lines agree quite well with dynamometer readings obtained from the films, and with the unperturbed readings from the instrument itself. Note that the initial tension in the rope was 750 to 1500 lb and that the lines do not pass through the origin. Since the initial tension in the nylon ropes is at least 750 lb, the chart indicates that the impacting velocity must be greater than 2.4 mph to move the package when the shoring is greased, and greater than 3.6 mph when the shoring is ungreased.

Figure C-13 shows the displacement of the package on the test car plotted against the impact velocity. Although there is no reason to expect that this is a linear relationship, the points seem to fit three straight lines better than they fit any other curve. This figure indicates that when a full tiedown system is used, no package displacement will occur if the velocity of the impacting car is less than 4.7 mph with ungreased shoring, or less than 3.3 mph with greased shoring. When half the tiedowns were used and the package was on greased shoring, the package began to move at impacting velocities of 3.7 mph.

The threshold velocities for the package motion given above do not agree. There are two reasons for this: 1) If the tension in the nylon ropes is increased above 1000 lb (but to less than 1500 lb) the impact velocities will be in close agreement with those for the displacement curves; and 2) there is no reason to expect that either of these relationships is entirely linear, and the nonlinearity is probably most evident through the horizontal axis.

Figure C-14 shows the acceleration of the test car as a function of the velocity of the impacting car. The data fit fairly well on two

exponential curves. One curve represents data taken from runs in which the sand-filled car was used for impacting and the test car moved. The other curve shows the results of runs in which a single refrigerator car was used for impacting. The variation between the two curves is explained by noting the difference in impacting masses. The mass of the sand car was $84\frac{1}{2}$ tons; that of the refrigerator car, about 30 tons.

The acceleration of the ML-1 package and the acceleration of the test car are compared in Figure C-15. In both cases the curves have been plotted against the velocity of the impacting car. The curve for the ML-1 is drawn above the experimental points; hence, shock reductions calculated from this chart are conservative.

Figure C-16 gives the vertical acceleration on the flatcar and on the package as a function of the velocity of the impacting car. The data are more scattered and do not fall into a pattern as well as the horizontal acceleration data. These curves indicate that at higher impacting velocities (10 mph and over) the vertical shock reduction has about the same magnitude as the horizontal shock reduction (i.e., about 10 to 1). These reductions are displayed graphically in Figure C-17. The data for this figure were taken from the curve for the impacting sand car from Figure 16.

Figure C-18 shows data from simulated aircraft emergency landing tests. The maximum acceleration of the package is plotted against the acceleration of the test car, as shown in an "averaged curve." This averaged curve is a smooth curve drawn through the Visicorder trace (see Figure C-4). Since many uncontrollable factors affected these relationships, (e.g. different action by draft gears on different cars, and the way in which the wooden blocks shattered which affected the magnitude and direction of impact) it is not feasible to represent the relationship by a single curve. It is only possible to state that for certain accelerations of the test car, the package acceleration will lie between the limits defined by dotted lines on Figure C-18.

Although the high-speed camera was used for recording dynamometer readings and for checking shock mount motions, it was possible in one run (Run 31B) to obtain shape of the displacement curve from the film. The data from this run as well as data obtained from the Visicorder charts of the same run are shown in Figure C-19. Since the camera swung around to follow the motion of the car (about 0.3 sec after the impact) the camera data cannot be correlated with the Visicorder data after this time. The coincidence of the two curves up to this point indicates the accuracy of the shape of the Visicorder curves for horizontal displacement.

Figure C-20 shows package displacement, as a function of time, relative to the test car. The upper curve is typical for greased shoring; the lower curve, for ungreased shoring. The upper curve is typical of runs made with the full complement of tiedown ropes. The lower curve shows that with half the tiedowns the amplitude of the pulse was greater, but the shape remained about the same.

III. DISCUSSION OF ERRORS

A. VELOCITY MEASUREMENTS

Any error made in measuring the velocity of impacting car just before the moment of impact was small. The greater part of this error was caused by mistakes in measuring elapsed time. The total error from all sources is less than 2%. Thus, errors in even the fastest runs do not exceed 0.4 mph.

B. DYNAMOMETER READINGS

The dynamometer readings for the initial tension on the nylon ropes may be in error approximately 100 lb. About the same magnitude of error was possible in reading the high-speed film. However, the maximum-recording hand reading is not dependable to within ± 3000 lb. The film shows that this hand can be thrown beyond the true value by as much as 2200 lb during runs made at impacting velocities over 8 mph. Estimates were made for all those runs not covered by film records. These values are lower than those recorded by the maximum recording hand.

C. PACKAGE DISPLACEMENTS

The scratch gauges used to measure both horizontal and vertical package displacement consisted of ballpoint-pen-type cores held rigidly in position in contact with strips of recording paper. The paper was securely fastened to the shoring on the flatcar. The error in package displacement is not over $1/4$ in., since this is the maximum distance that the ballpoint pen could have been deflected. The package displacement traced on the Visicorder chart, on the other hand, was subject to a number of errors and is not as accurate. Apparently, the wire used to transmit the displacement information slipped on the potentiometer pulley, because in a number of cases the trace on the chart did not return to its original position. The scratch gauge shows clearly that it should have returned to within one inch.

D. RAILROAD CAR ACCELERATIONS

The instruments used for recording horizontal, vertical, and transverse accelerations are accurate to within $\pm 5\%$. Errors in reading the data should not add more than 2 or 3% to this figure. Thus, the maximum error is about 8%.

IV. INSTRUMENTATION

The instrumentation system designed for the railroad tests was interconnected as shown in Figure C-21. The system consisted of the following equipment:

1. 1- Oscillograph, Heiland Visicorder Model 906B1
2. 1- Pulse generator, Berkeley Model 4904
3. 4- Accelerometers, Statham Model A501.TCa-25-350

4. 3- Potentiometers, Helipot Model A
5. 4- Microswitches
6. 1- Bridge balance unit, Baldwin-Lima-Hamilton
7. 8- Strain gauge, Baldwin-Lima-Hamilton Model SR4-A7
8. 1- Load dynamometer, Dillon
9. 1- Oscilloscope, Tektronix Model 531
10. 1- Power generator, Zeus Model GBl25
11. 1- Stabilizing transformer, Sola Model 20-13-210
12. 1- Control unit, AGN 0-408285
13. 2- Impact meters, Southern Pacific Company

Since this system had to operate under field conditions, simplicity, reliability and the power requirements of individual components and associated circuitry were the criteria used for component selection.

System error due to shock loading of the galvanometers was considered, since the instrumentation system was to be transported in a station wagon during part of the tests. A dummy galvanometer circuit was inserted to read spurious responses received by the instrument under those conditions.

A fourteen-channel, miniature galvanometer, optical-type oscillograph was selected to record all dynamic data. The oscillograph was a convenient size and less susceptible to shock loading than pen-type systems.

To achieve simplicity and to eliminate driver amplifiers, galvanometers having the best compromise between sensitivity, frequency response and balance were used.

A pulse generator with a triangular peak output waveform was selected for the time calibration to allow the detection of non-uniformity in the chart drive speed. A time calibration base of 10 milliseconds was selected to give a pulse peak spacing of .50 in. at the fastest chart speed (50 in./sec) and 10 in. pulse spacing at 10 in./sec.

Time calibration was checked periodically on an oscilloscope by comparing the pulse repetition rate against the power line frequency. Strain-gauge type accelerometers were arranged in a four-active-leg balanced bridge. The type selected had a satisfactory output level and a frequency at least twice as great as the maximum vibrational frequencies expected. The gauges allowed simple calibration by a resistive unbalance of the bridge. The accelerometers were arranged in two clusters of two each and were mounted in a sturdy bracket to eliminate localized vibrations in the mountings. The brackets were rigidly bolted on the mockups and on the railroad flatcar in a direction such that the sensitive axis of the accelerometers coincided with the components of acceleration. The mounting locations are shown in Figure C-22.

Ten-turn potentiometers were used to detect relative dynamic displacements. One was used to detect motion in the fore and aft direction and one at each end of the system detected vertical motion.

The rotary-type potentiometer used had the disadvantage that the linear motion of the mass under test had to be converted to rotary motion

at the potentiometer. This conversion was accomplished by a wire and pulley system. Some error was introduced by slippage between the wire and the pulley. However, direct, linear-motion potentiometers would have been damaged by the high shock loads produced in these tests. The potentiometers were incorporated into one leg of a bridge whose output was inherently non-linear (the output was corrected by a curve in Figure C-10.)

Impact velocity was measured by mounting a series of spring-arm-actuated microswitches alongside the railroad track. These switches were connected so that an arm mounted on the undercarriage of the leading impact car operated the switches sequentially, thereby turning off a bias current in one galvanometer. The spacing of the switches was accurately measured and the impact point was adjusted for every test run so that impact would occur immediately after the last switch had been tripped. A toggle switch was included so that a different switch spacing could be used whenever a slower chart speed was needed to record a run.

A strain gauge switching and balancing unit was used to control eight strain gauges. The switching allowed a selection of different strain gauge locations for each test run. In general, the strain gauges were used to determine stresses in the vicinity of the tiedown locations.

A load dynamometer was placed in series with a typical tiedown rope and was read under dynamic conditions with a high-speed camera. This method was used so that strain data could be correlated with cable tension and acceleration records.

The entire instrumentation system was powered by a gasoline-engine-driven generator. This generator incorporated a voltage stabilizing transformer.

A control unit was designed to accept the output signal of all transducers and present the signal to the oscillograph galvanometers at the proper level and impedance. This unit allowed full control and calibration of the system. Static calibration and the zero-reference position of each channel were recorded on the oscillograph before and after each run.

V. TIEDOWN DIAGRAMS

Figures C-23 through 27 show the mockups tied down on a standard railroad flatcar. Figures C-26 and C-27 are diagrams of the tiedown arrangement used in the simulated aircraft emergency landing tests.

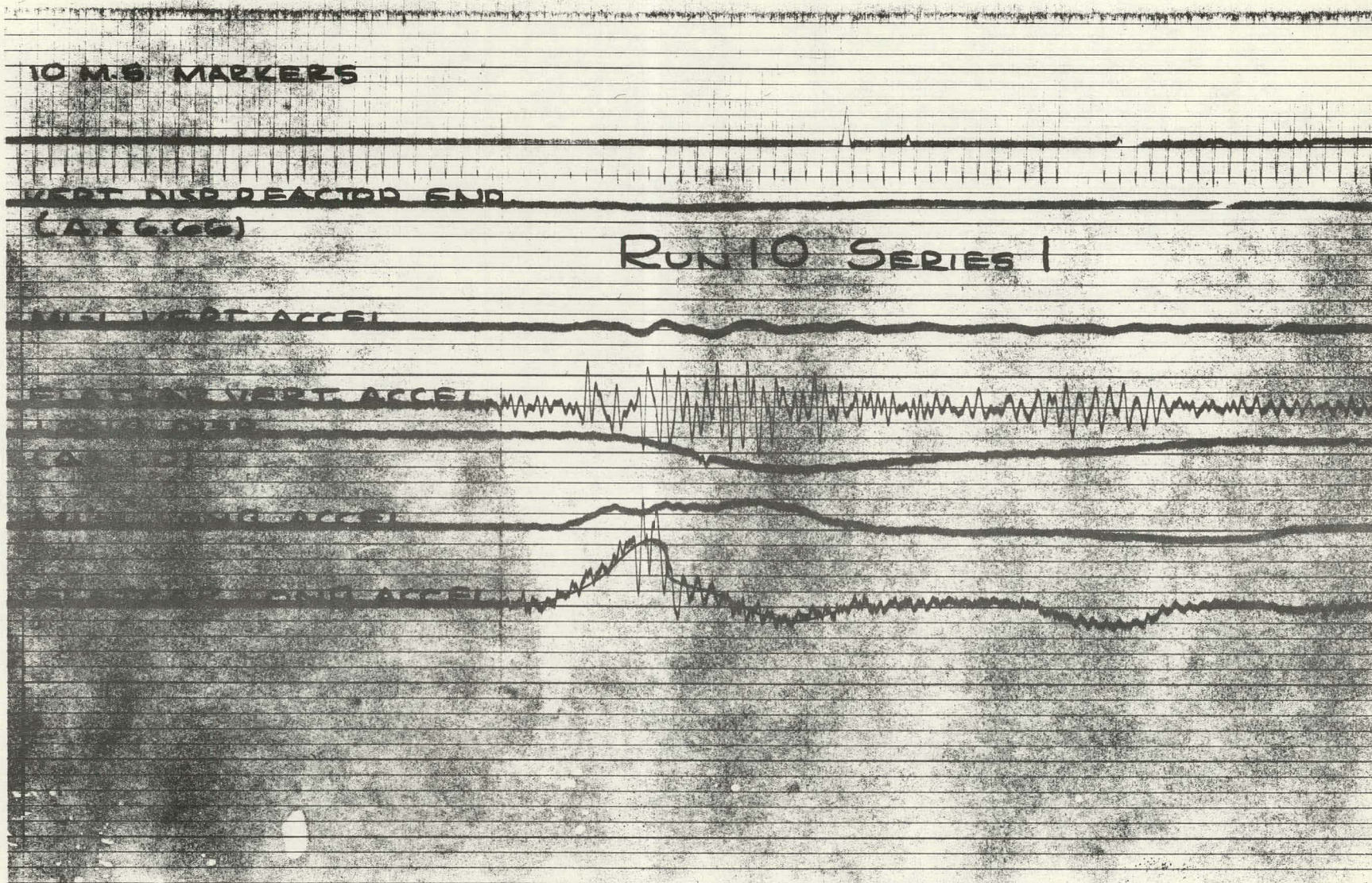


Figure C-1

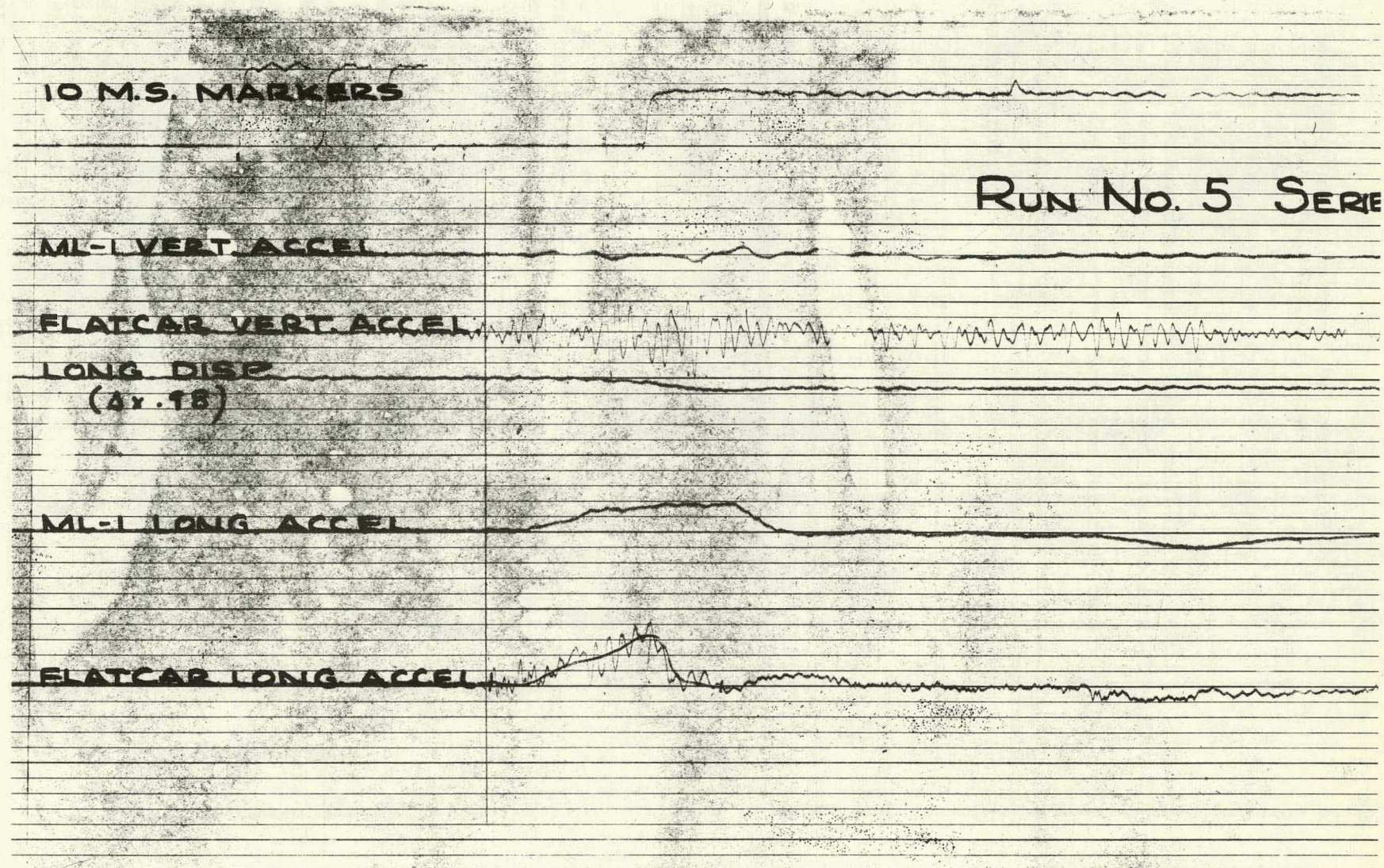


Figure C-2

10 M.S. MARKERS

VERT DISP REACTOR END
($\Delta \times 6.40$)

RUN NO

MI-1 VERT ACCEL

FLATCAR VERT ACCEL

LONG DISP
($\Delta \times 1.03$)

MI-1 LONG. ACCEL

FLATCAR LONG ACCEL

STRAIN

C-11

Figure C-3

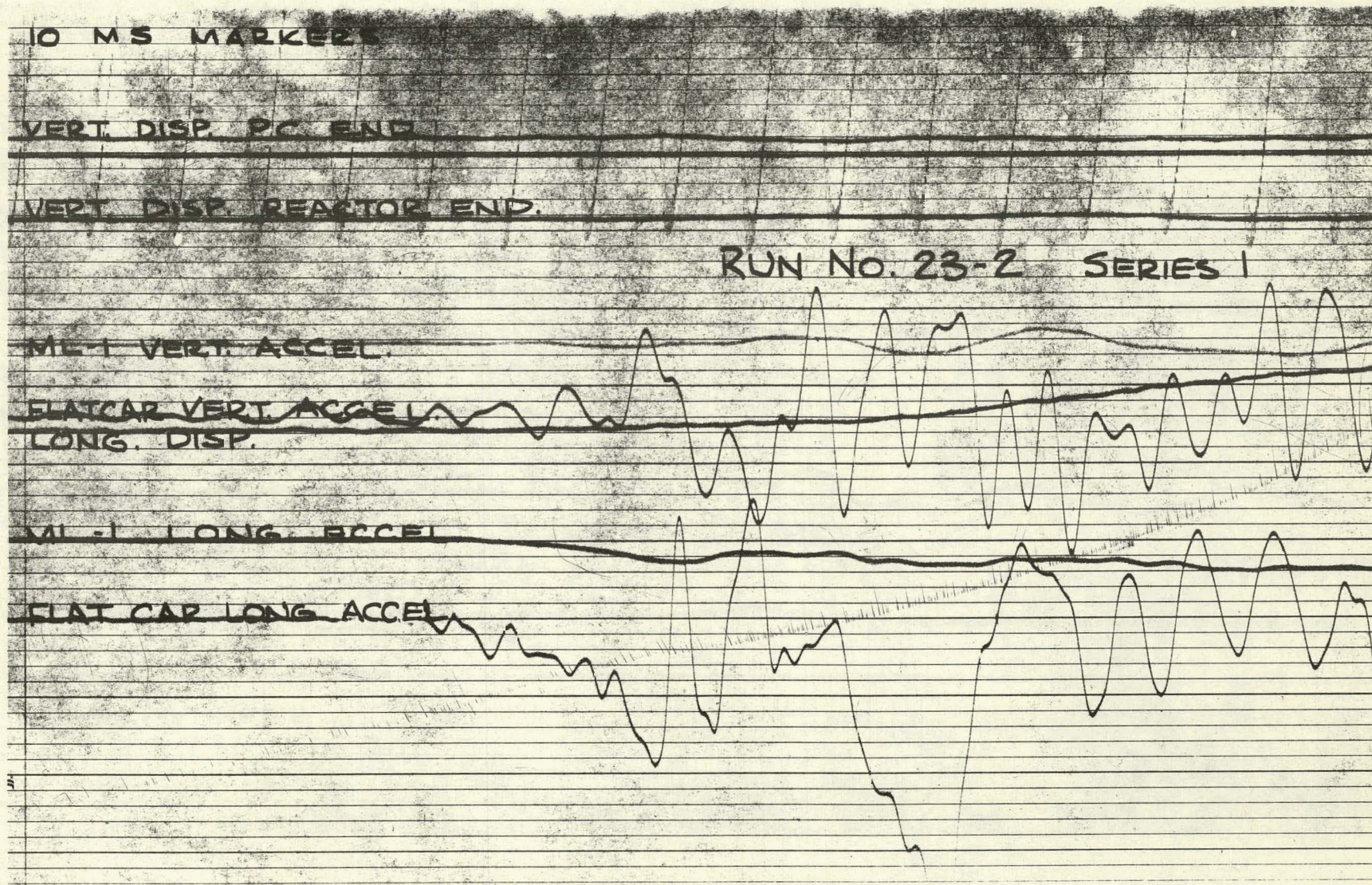


Figure C-4

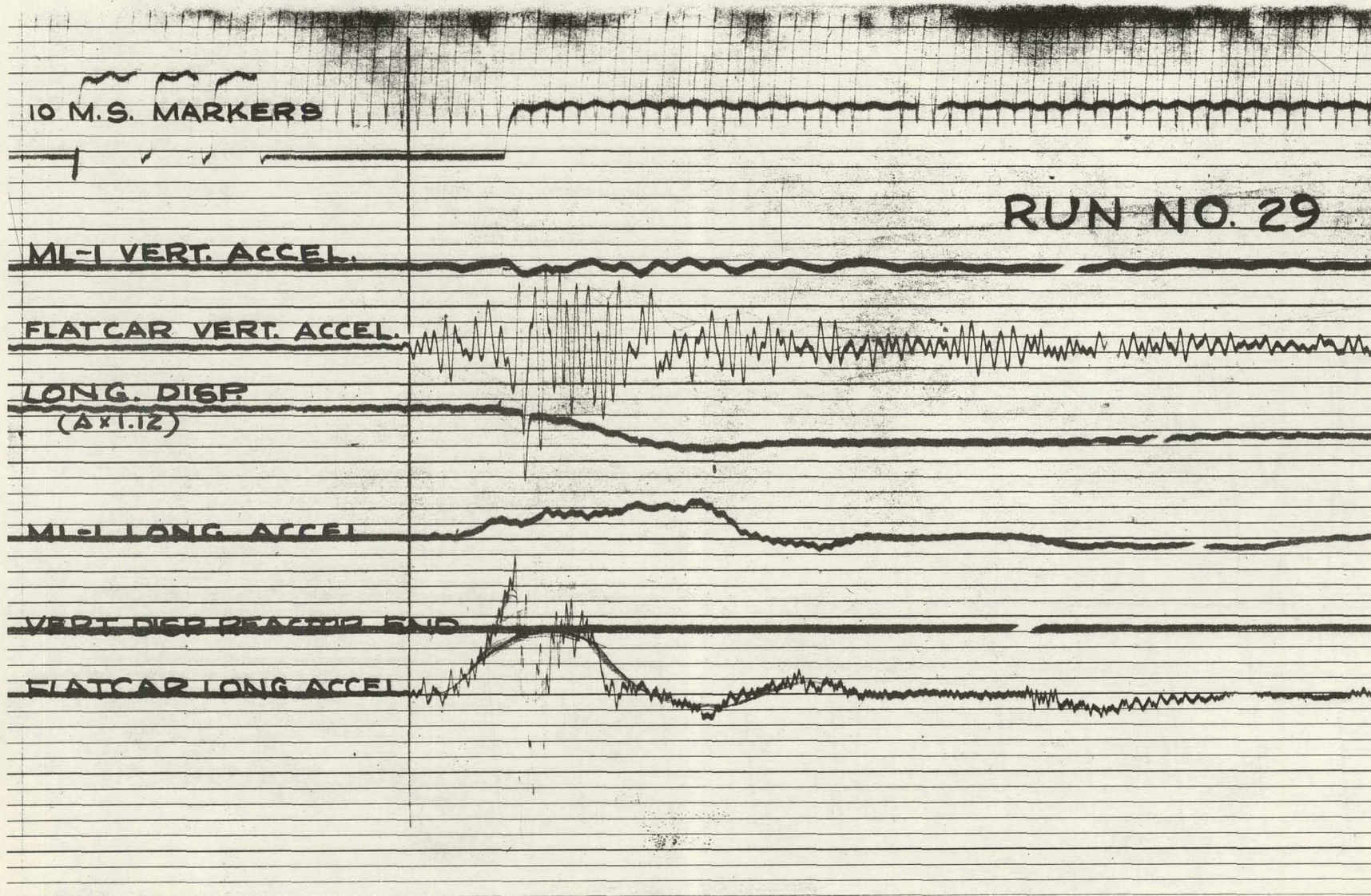


Figure C-5

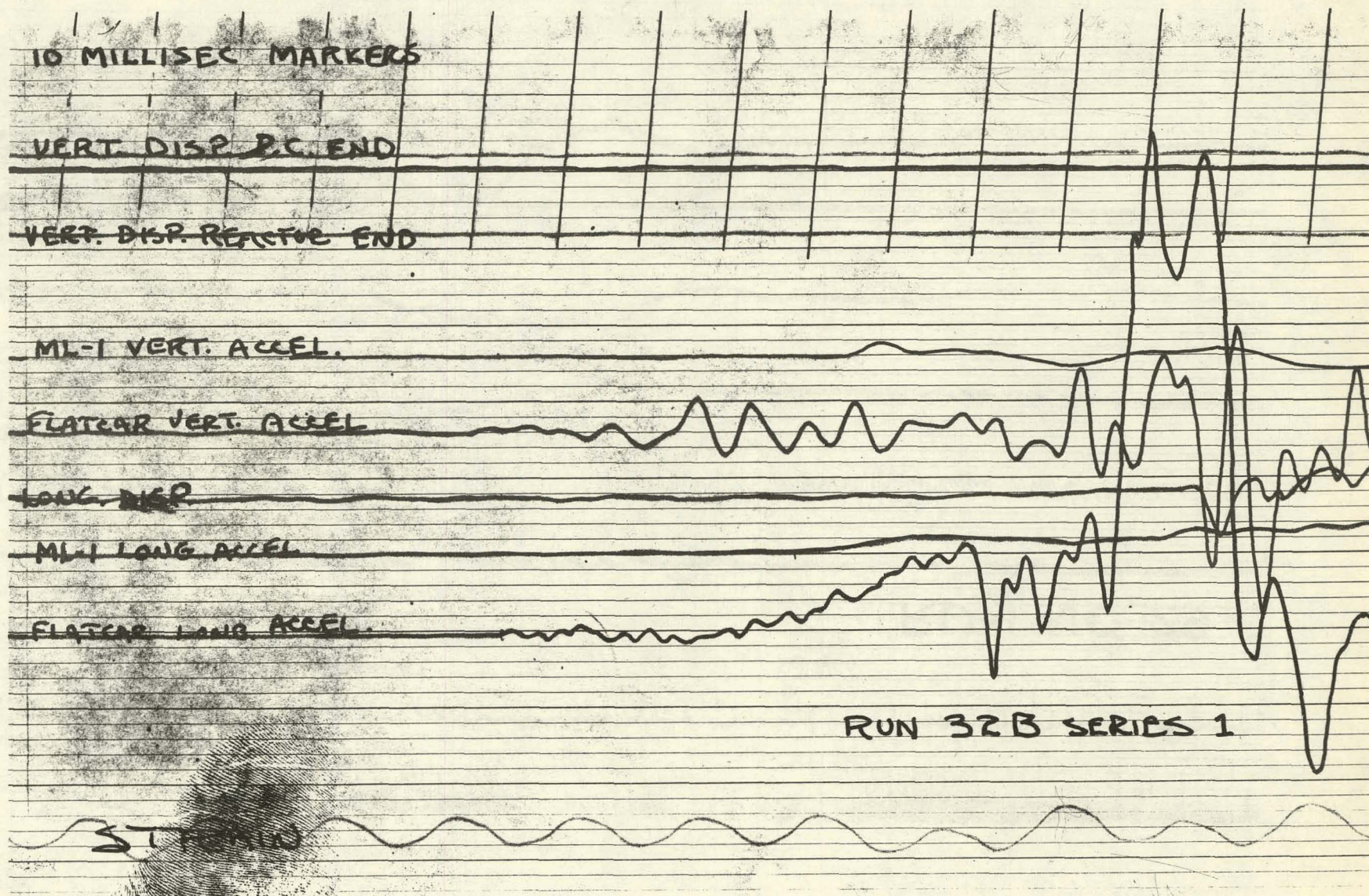


Figure C-6

10 M.S. MARKERS

VERT. DISP. P.C. END

VERT. DISP. REACTOR END

ML-1 VERT. ACCEL.

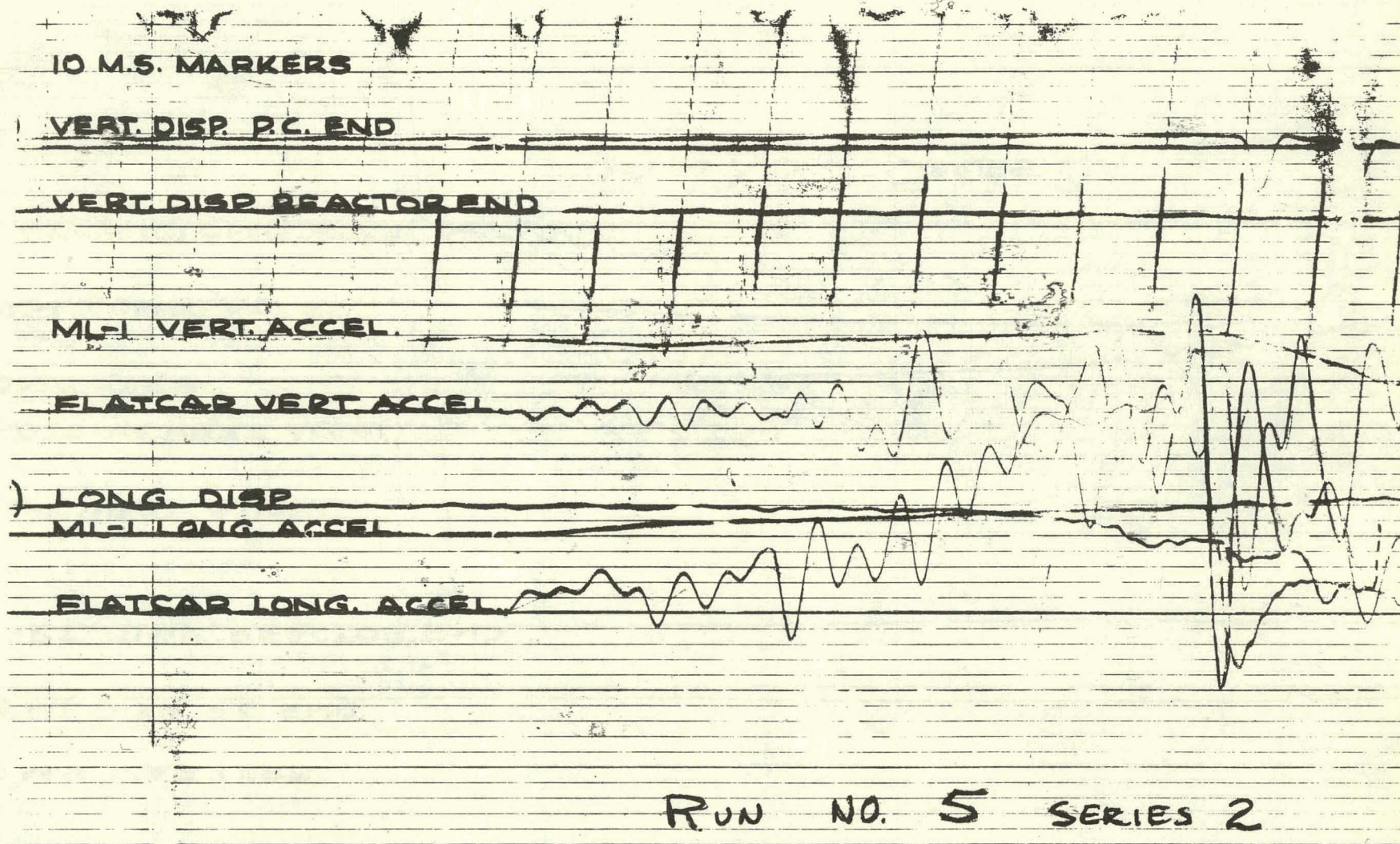
FLATCAR VERT. ACCEL.

LONG DISP.

ML-1 LONG ACCEL.

FLATCAR LONG ACCEL.

RUN No. 3 SERIES 2



C-16

Figure C-8

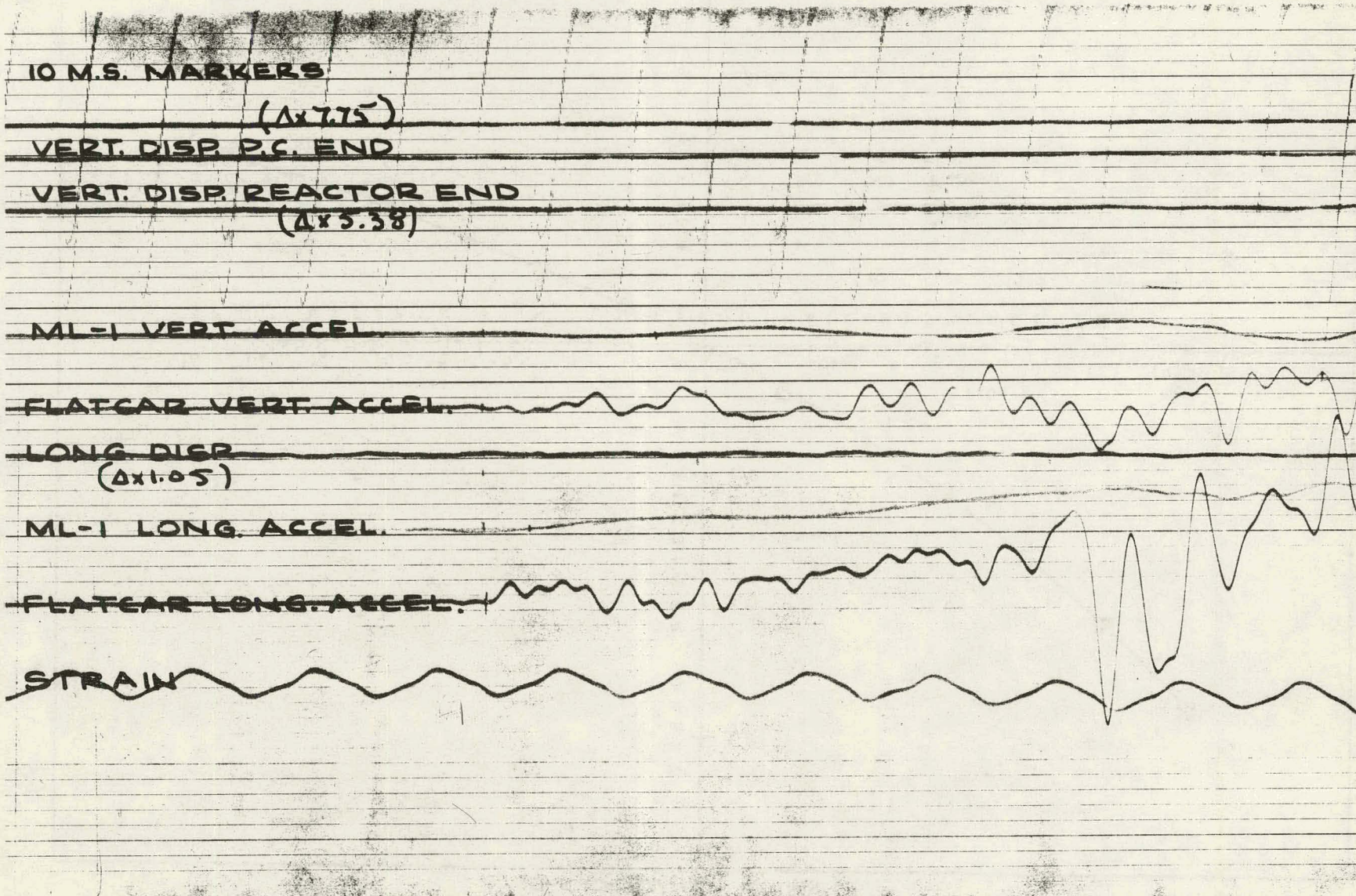
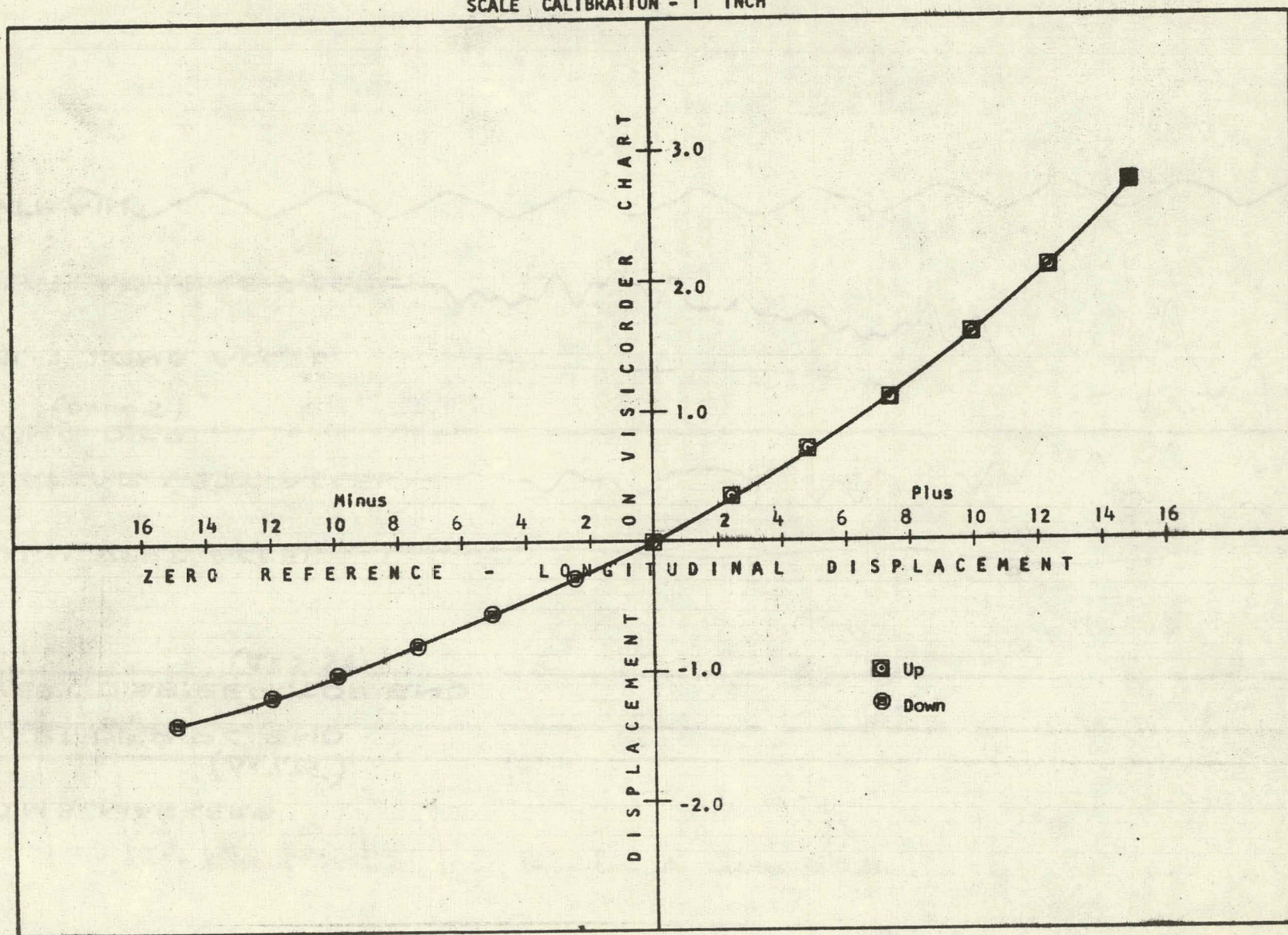


Figure C-9

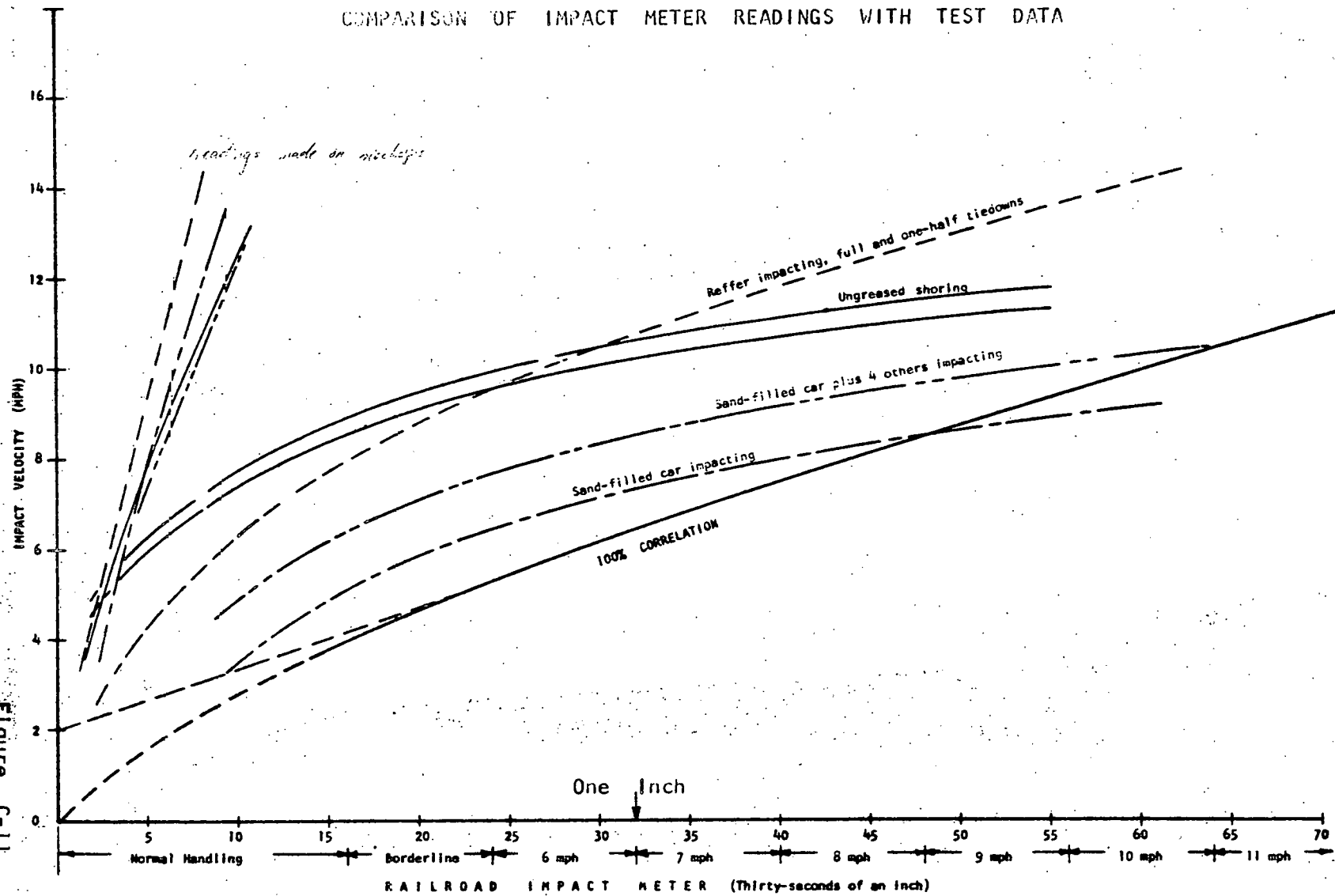
CALIBRATION OF LONGITUDINAL DISPLACEMENT MEASURING INSTRUMENT
SCALE CALIBRATION = 1 INCH



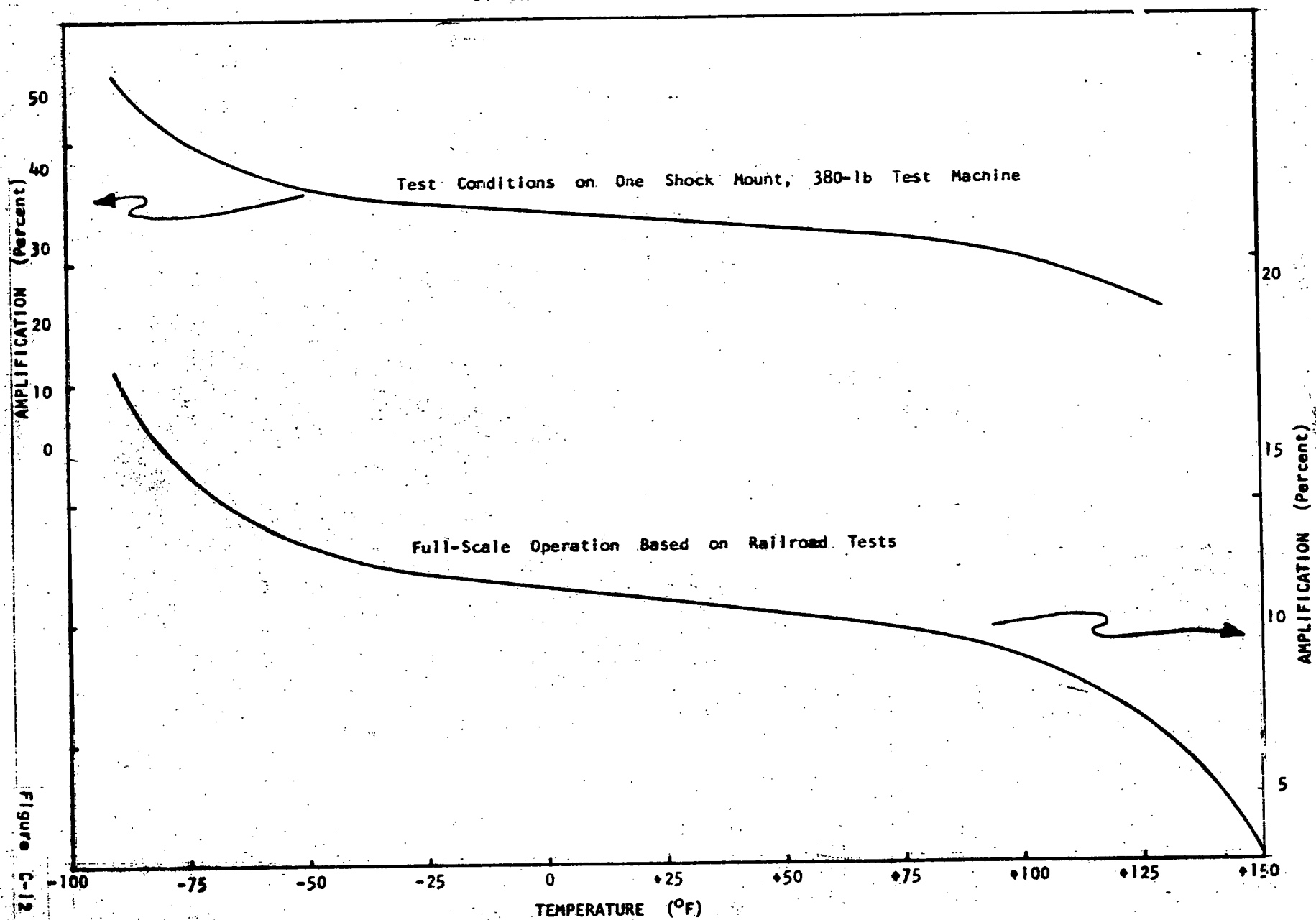
C-18

Figure C-10

COMPARISON OF IMPACT METER READINGS WITH TEST DATA



DYNAMIC AMPLIFICATION vs TEMPERATURE



C-20

Figure C-12

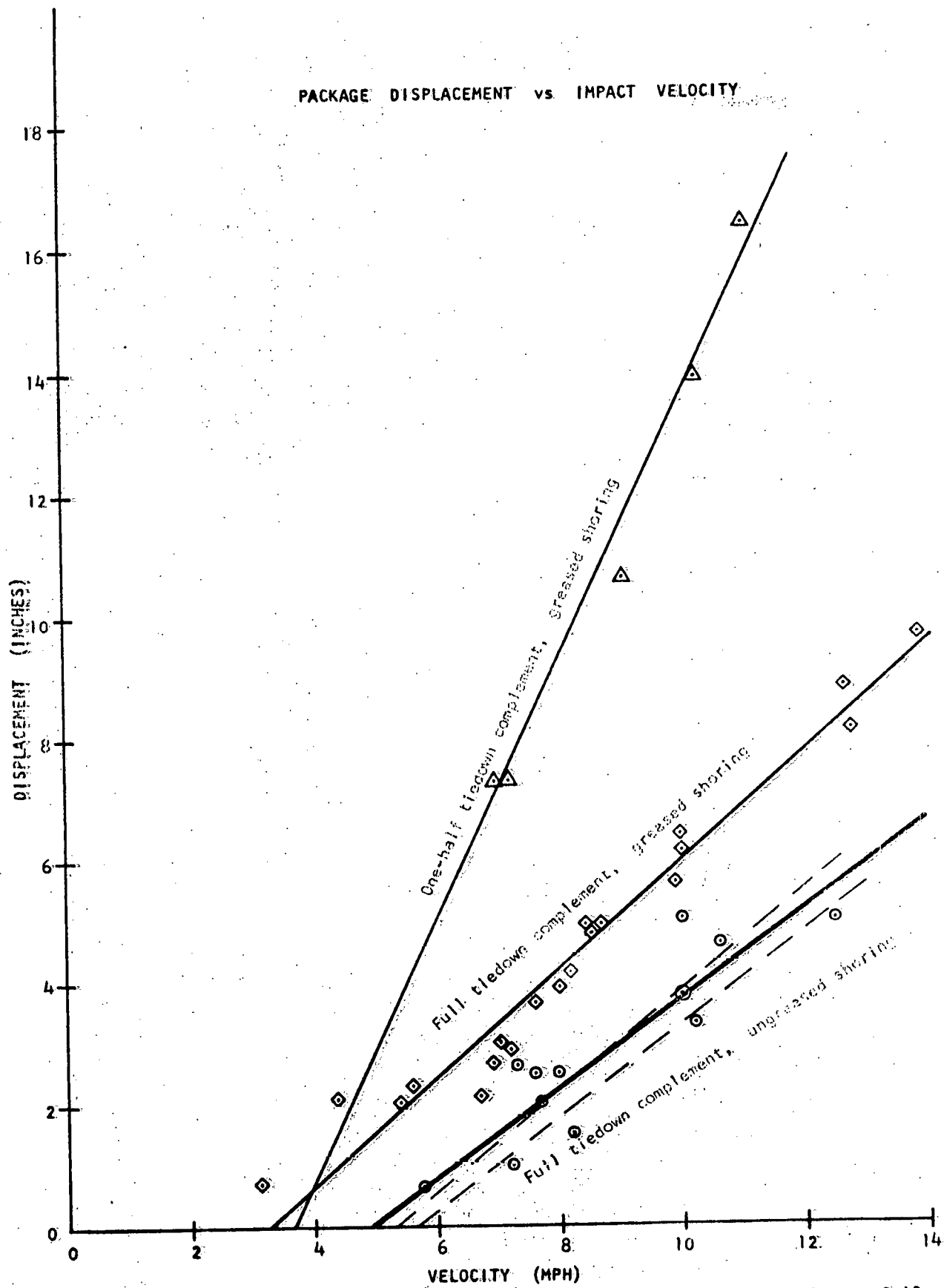


Figure C-13.

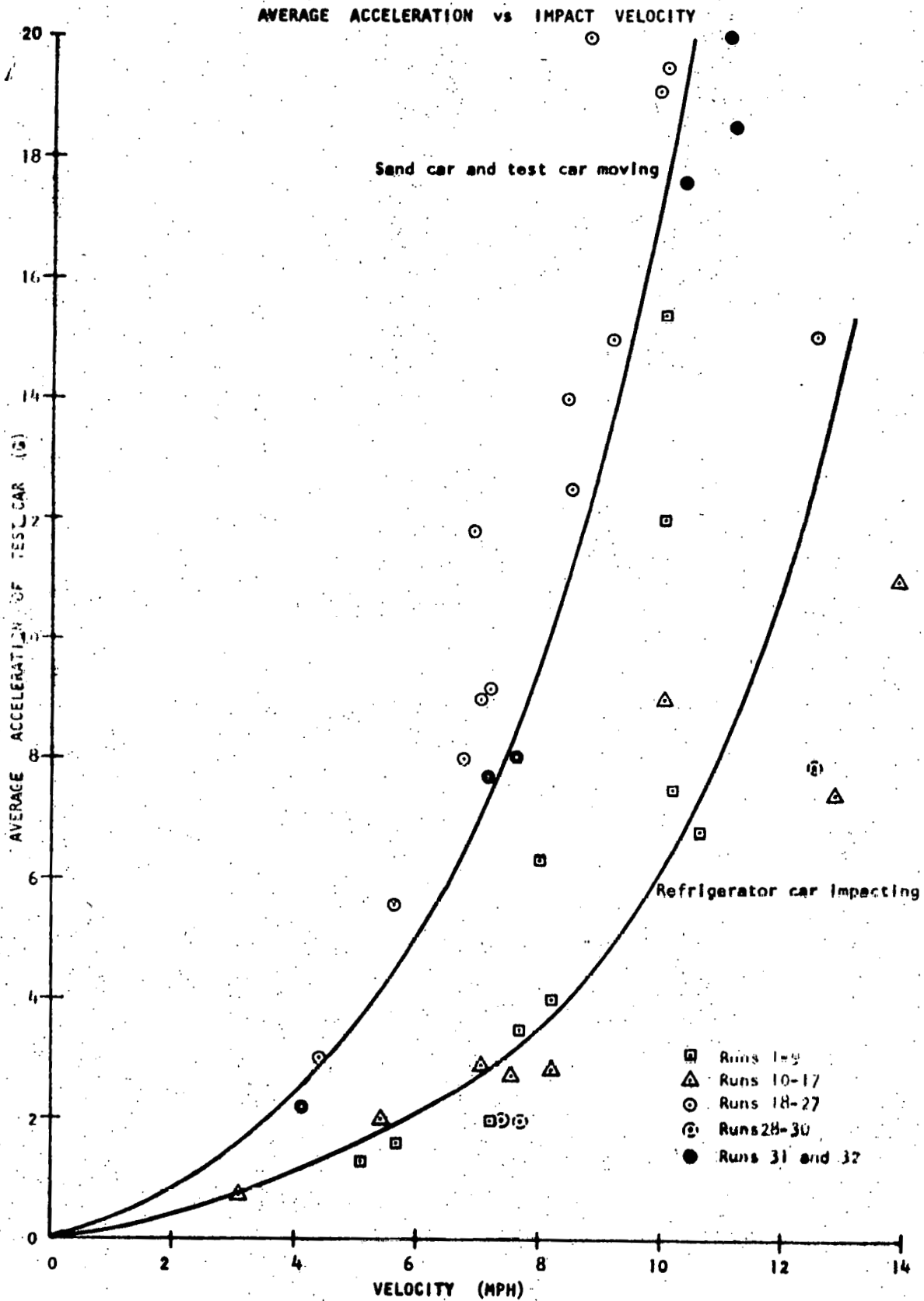


Figure C-14

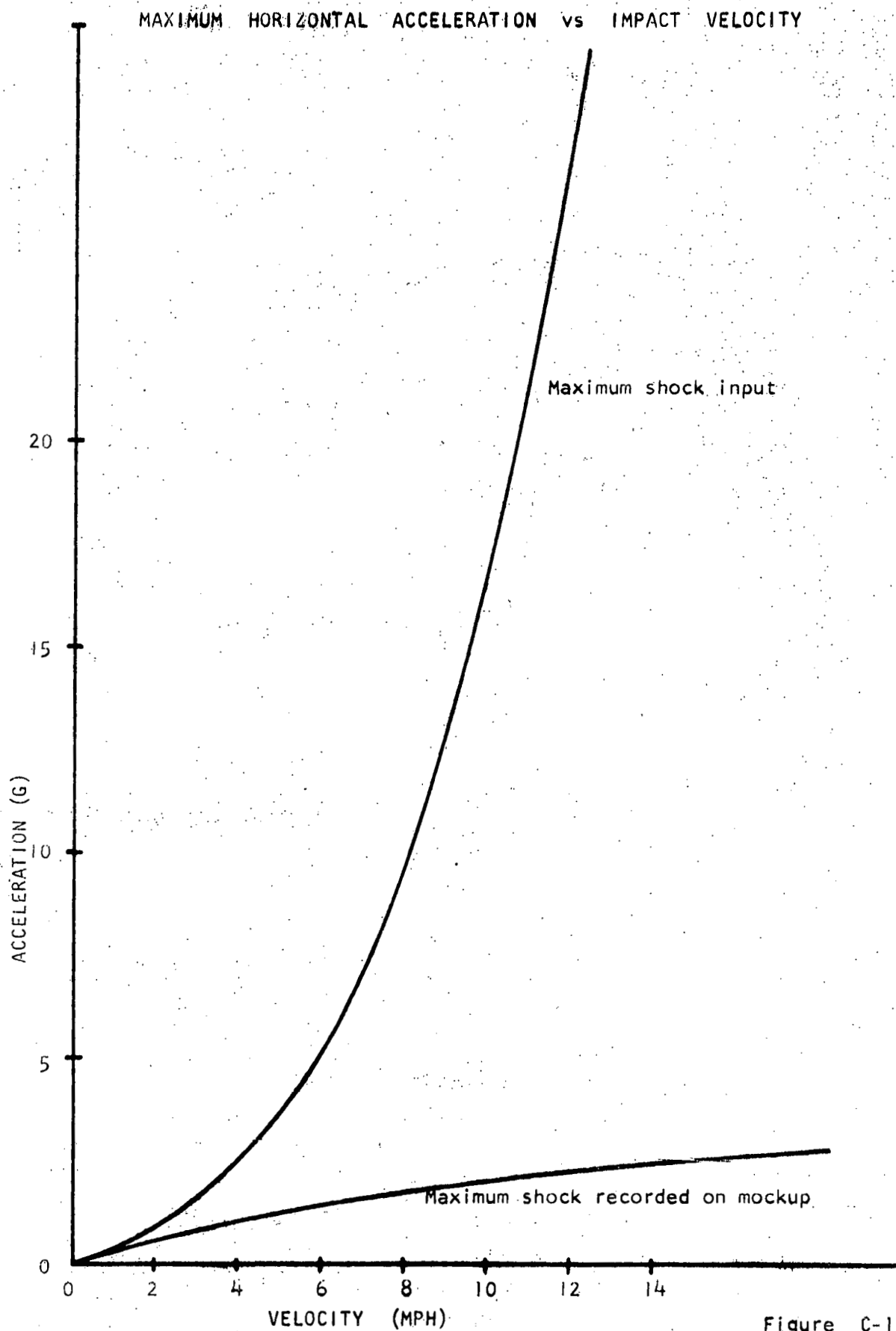


Figure C-15

VERTICAL ACCELERATION vs IMPACT VELOCITY

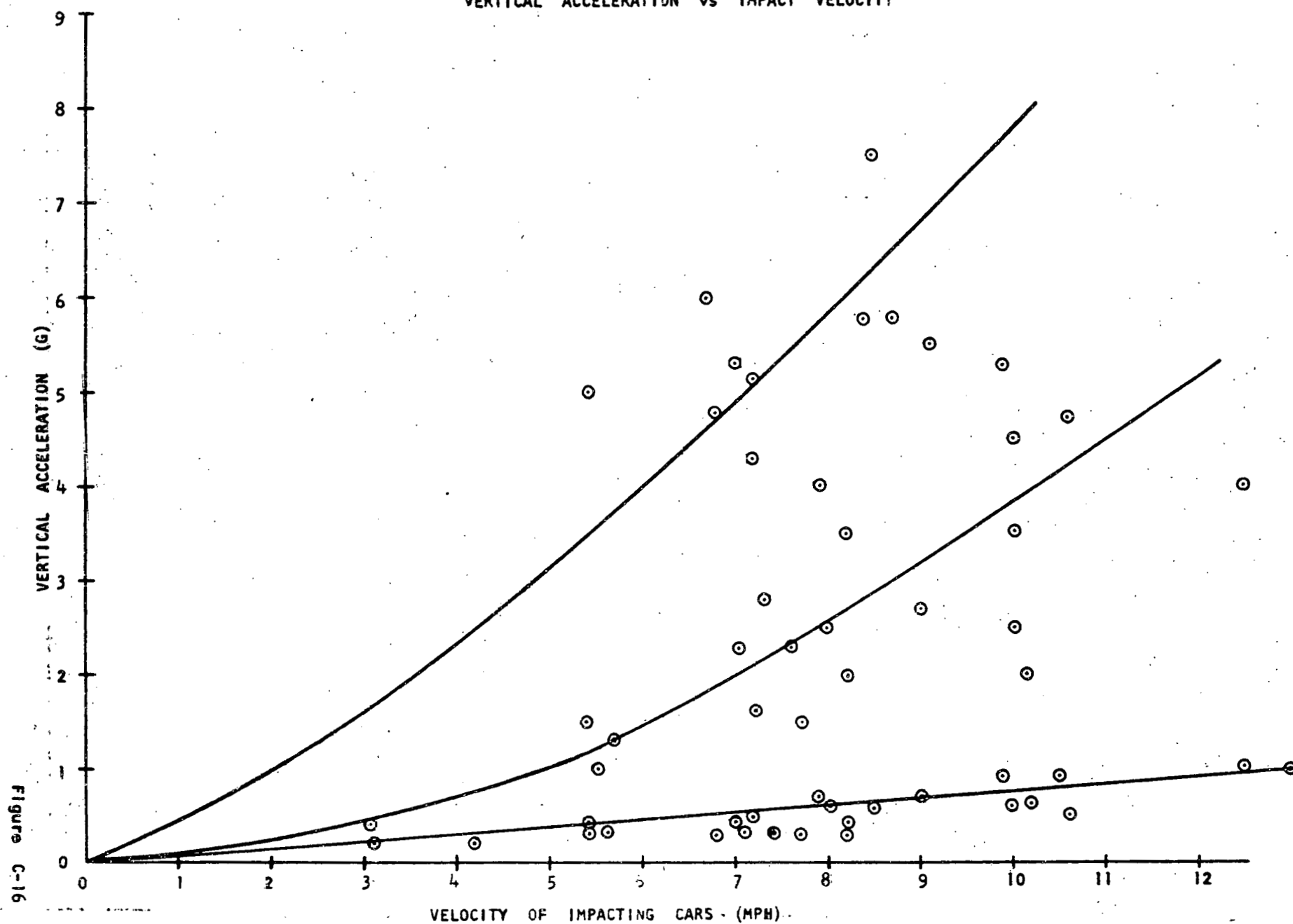


Figure C-16

C-24

COMPARISON OF MAXIMUM VERTICAL ACCELERATIONS
TEST CAR AND ML-1 MOCKUPS

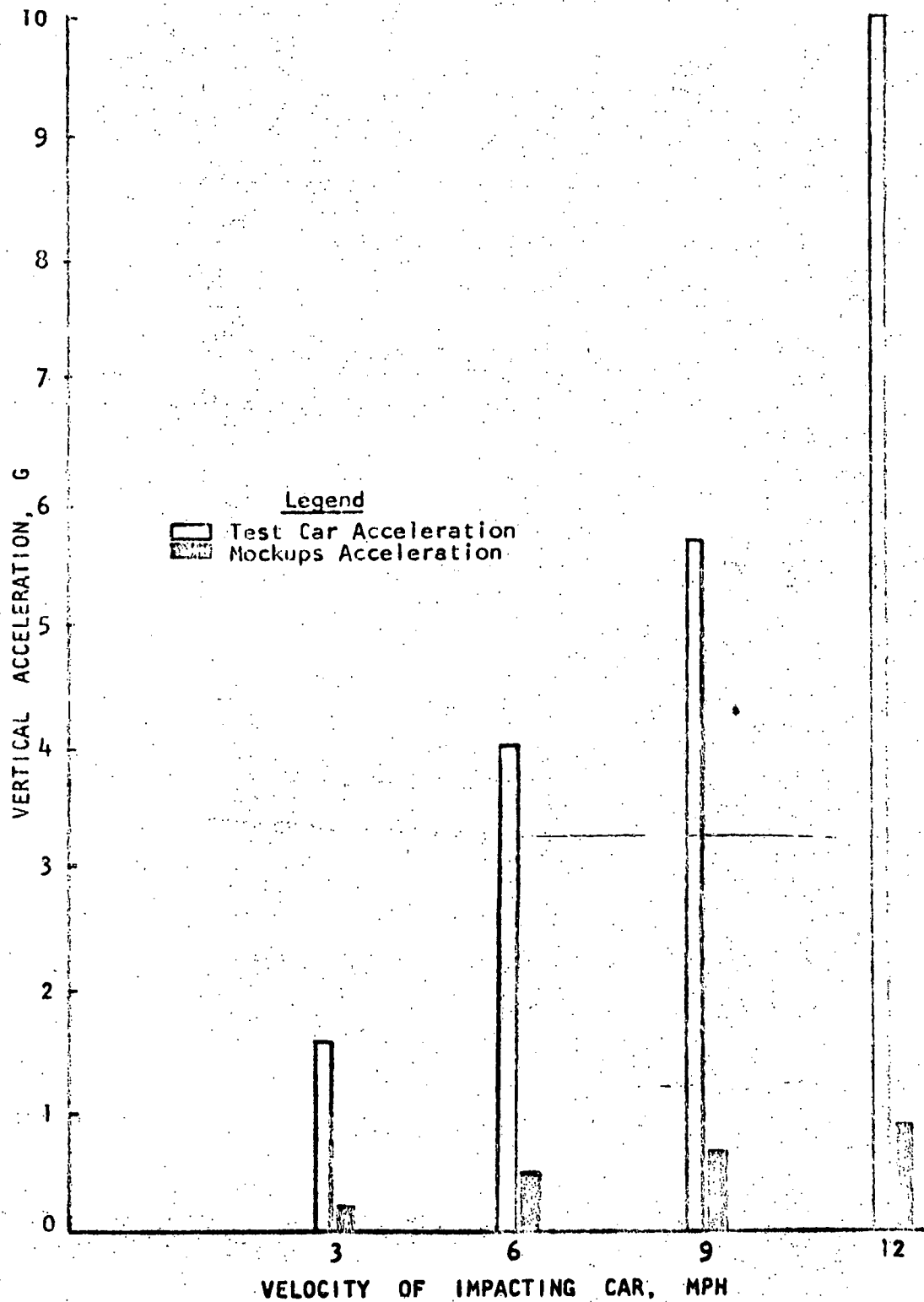


Figure C-17

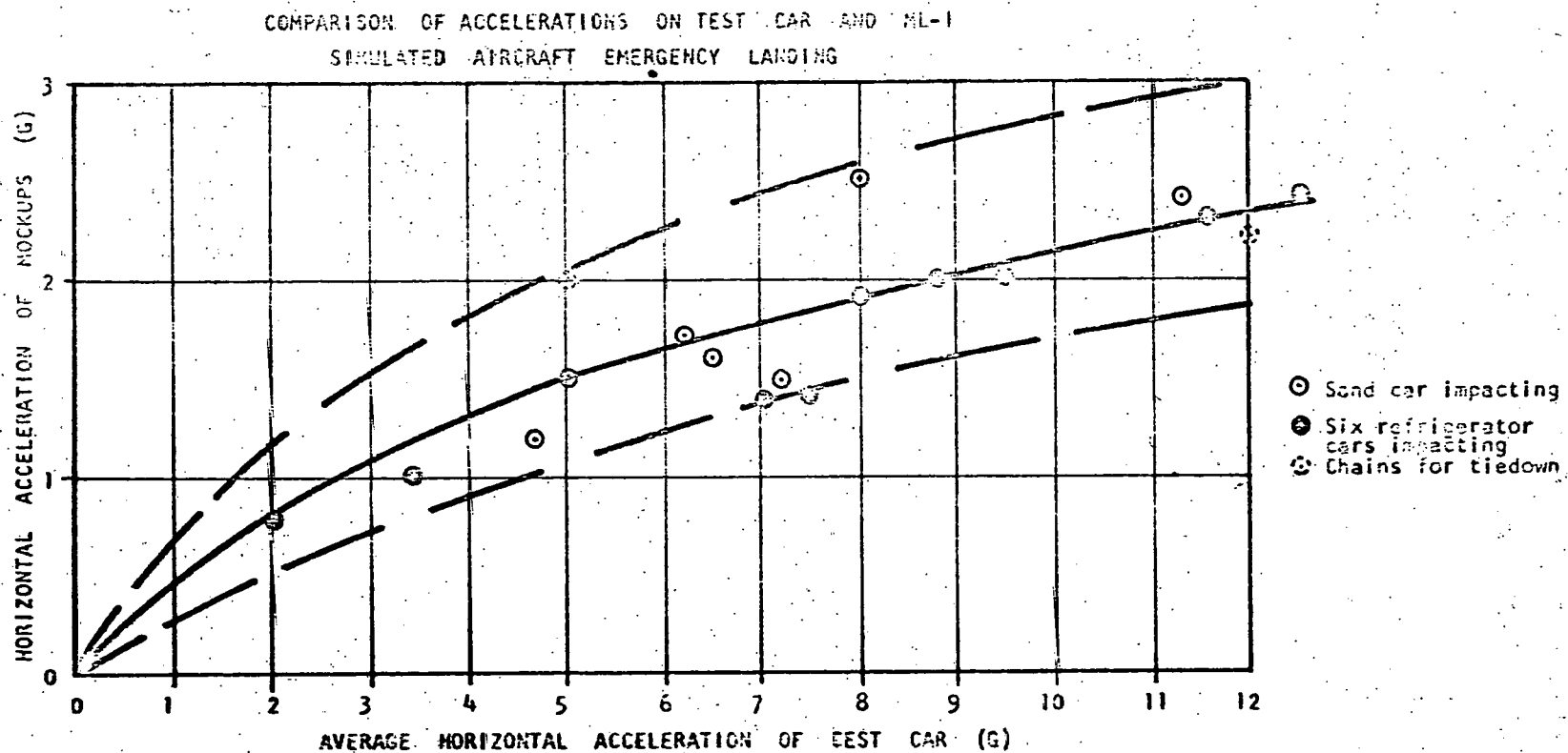
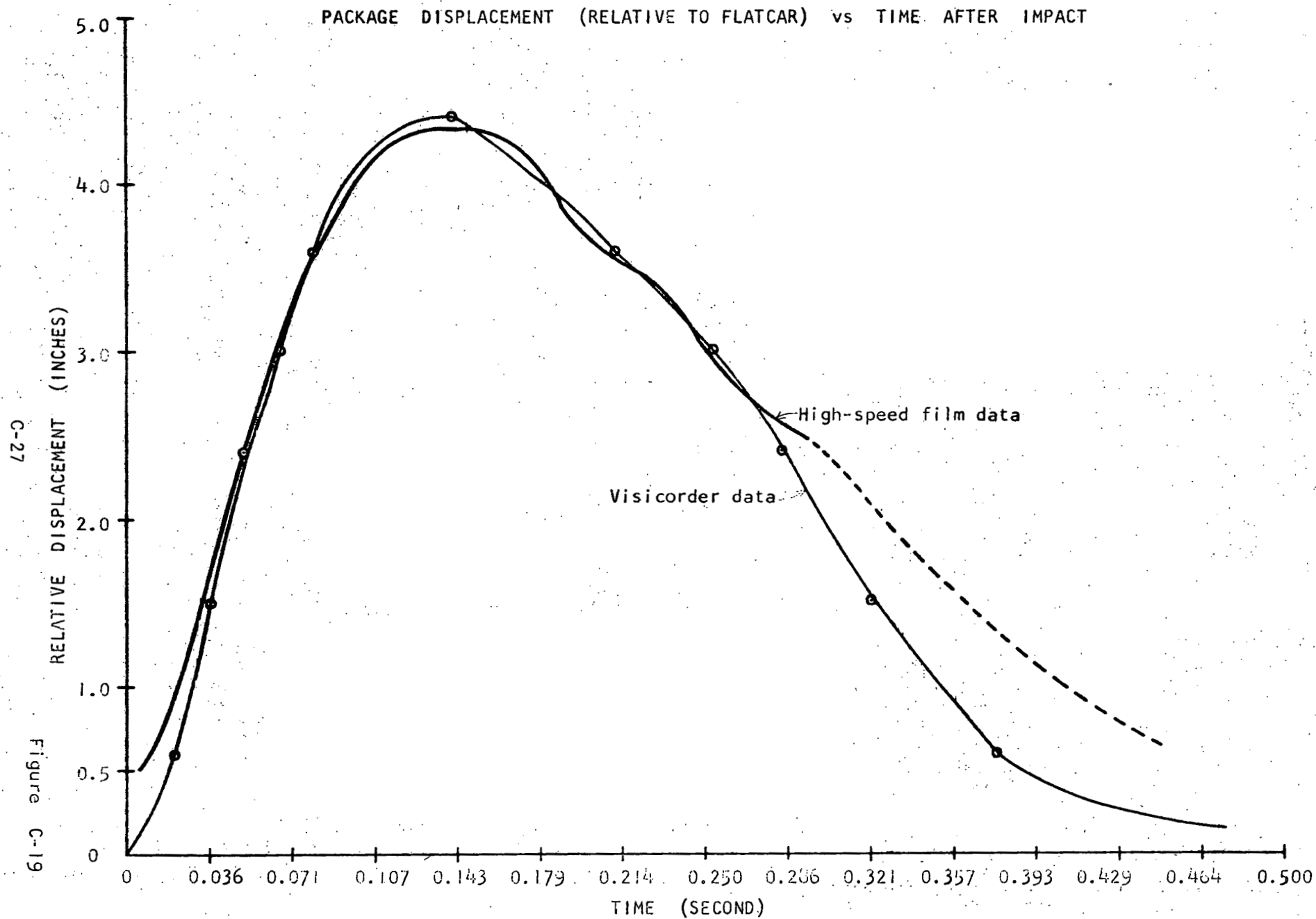


Figure C-18



***SHOCK MOUNT ENERGY ABSORPTION
for Successive Impacts by Free Falling
Weight In Test Machine***

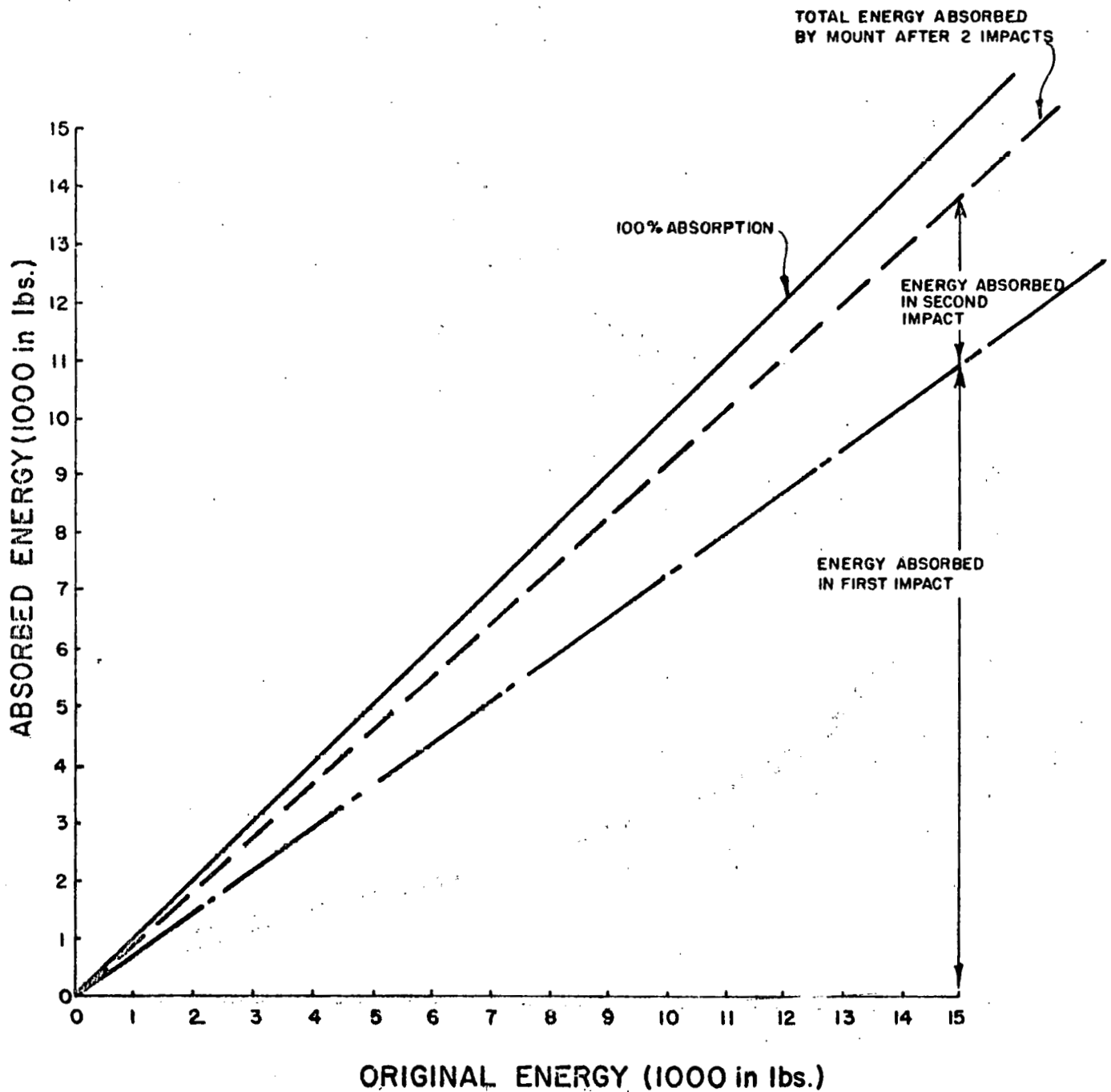


Figure C-20

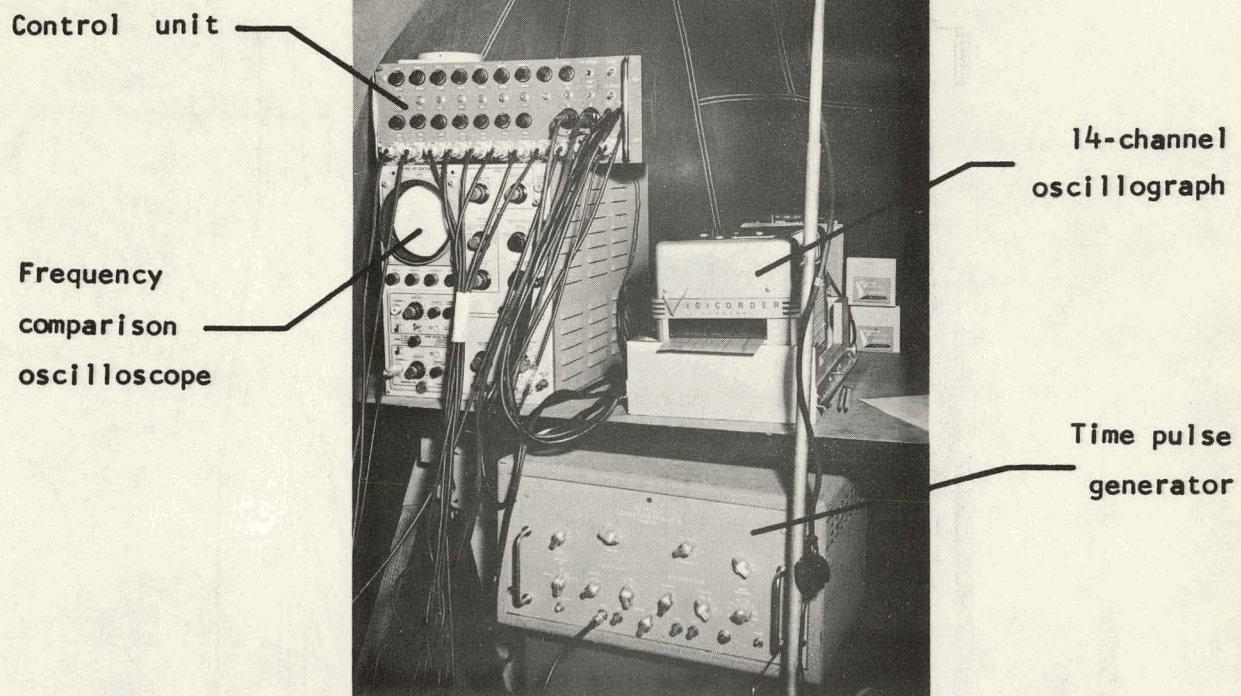


Figure C-21 : Control equipment

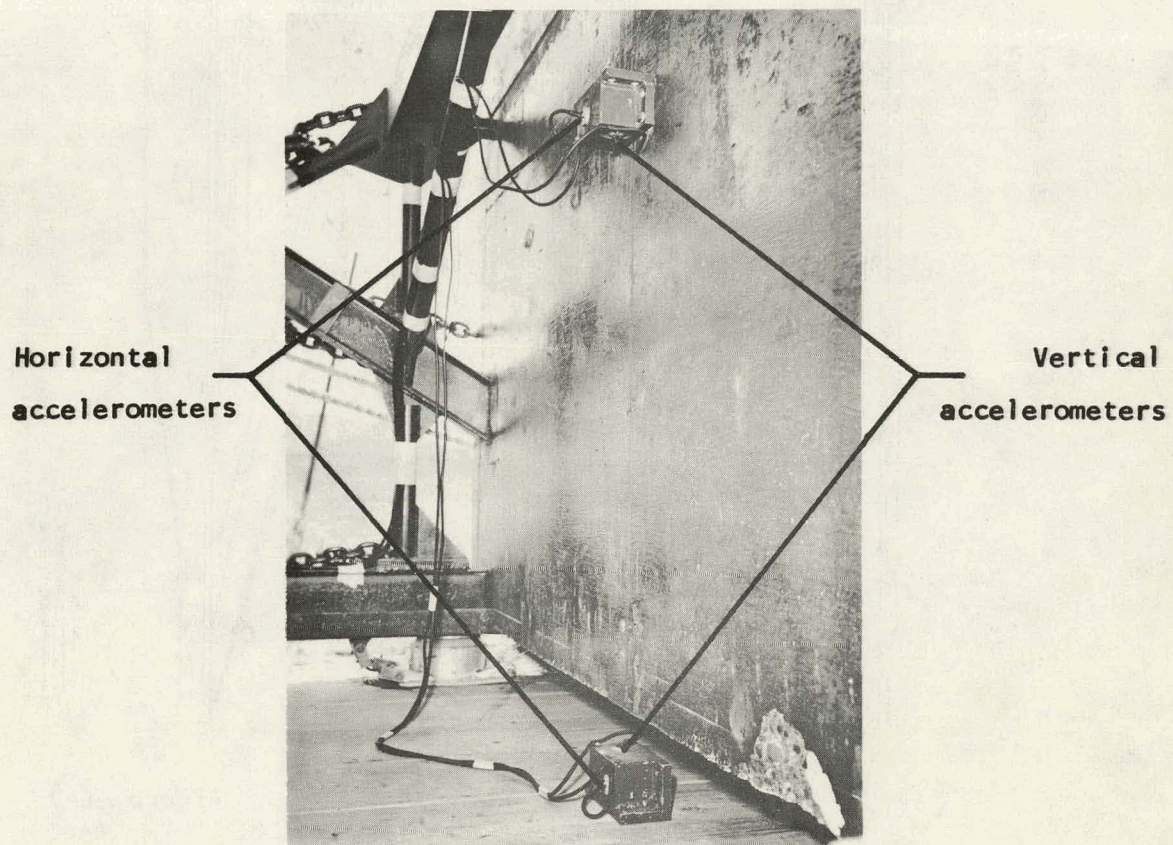
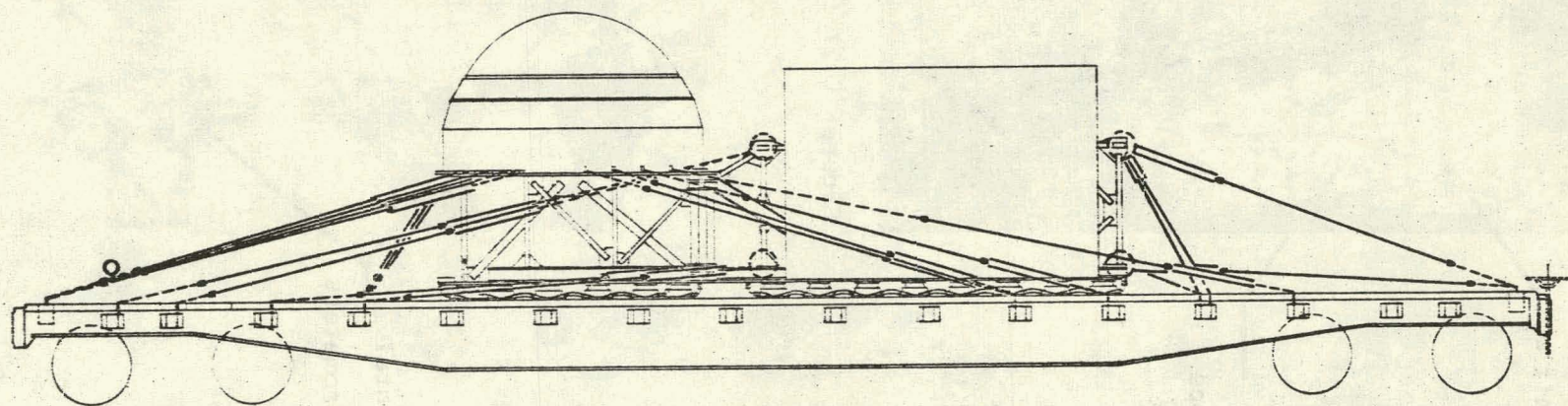
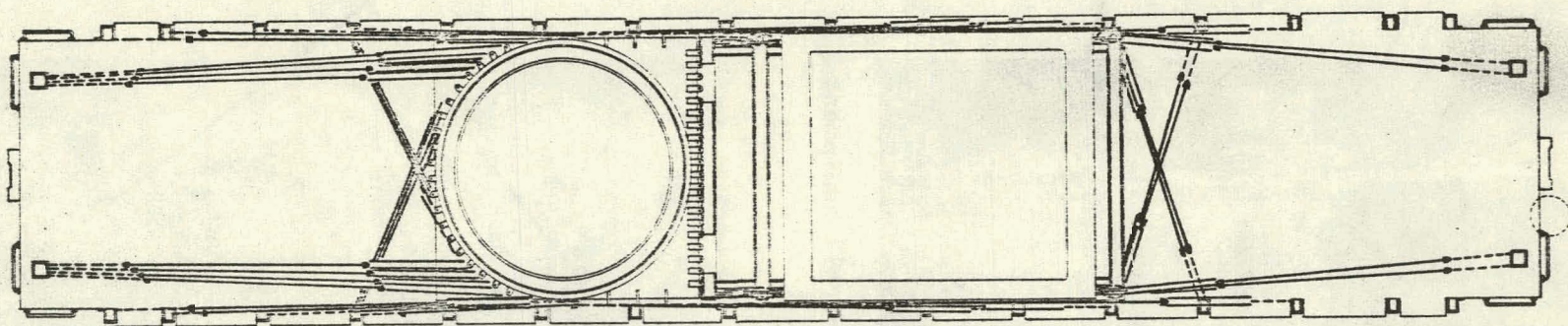


Figure C-22 : Accelerometer mountings

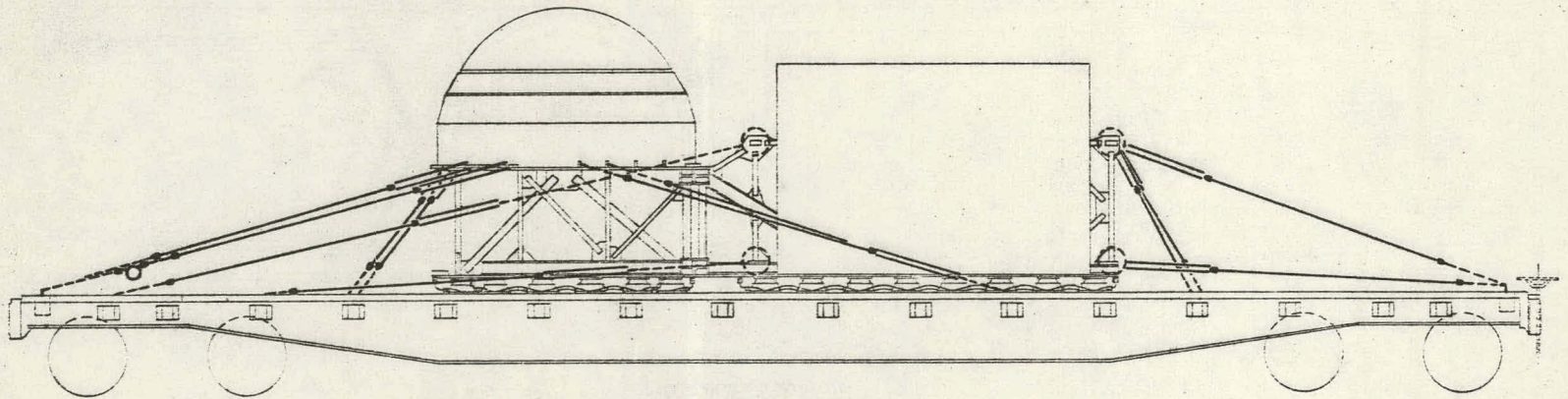
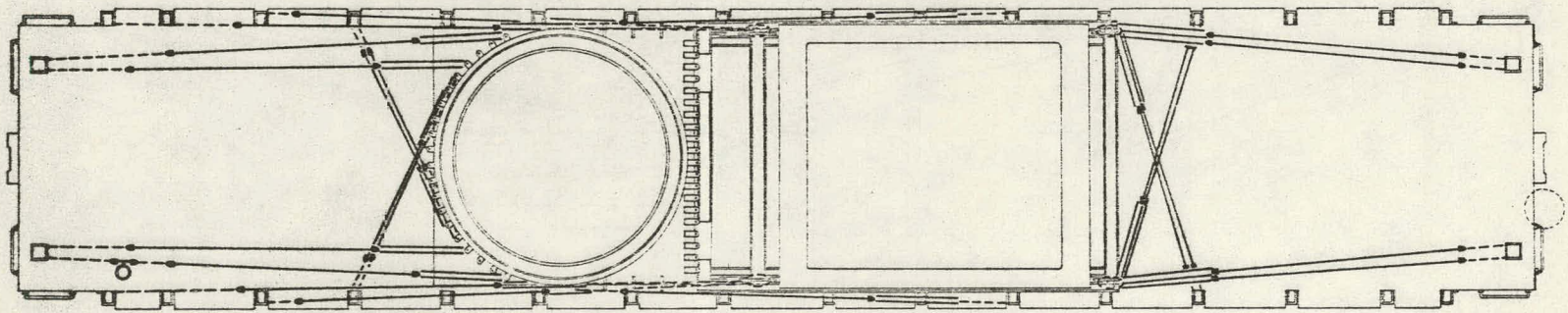
ML-1 REACTOR & POWER CONVERSION
PACKAGES, COUPLED
(16 ROPE/PKG. TIEDOWN)



--- CHAIN
--- TURNBUCKLE
--- NYLON ROPE

Figure C-23

ML-1 REACTOR & POWER CONVERSION
PACKAGES, COUPLED
(8 ROPE/PKG. TIEDOWN)



--- CHAIN
--- TURNBUCKLE
--- NYLON ROPE

Figure C-24

SHOCK TEST INSTRUMENTATION
ML-1 REACTOR & POWER CONVERSION
PACKAGE, COUPLED

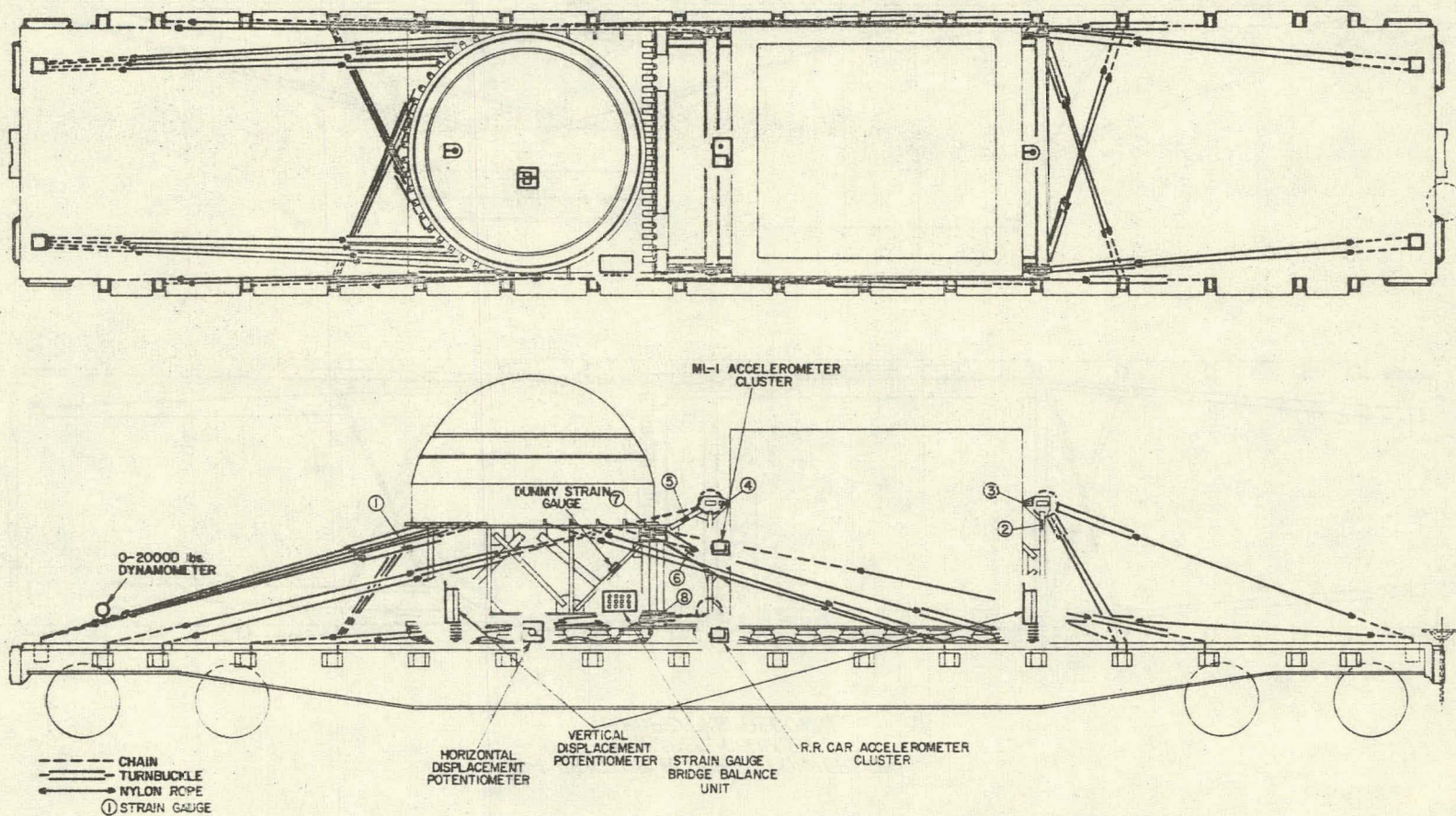


Figure C-25

ML-1 POWER CONVERSION PKG.
(SIMULATED AIRCRAFT TIEDOWN)

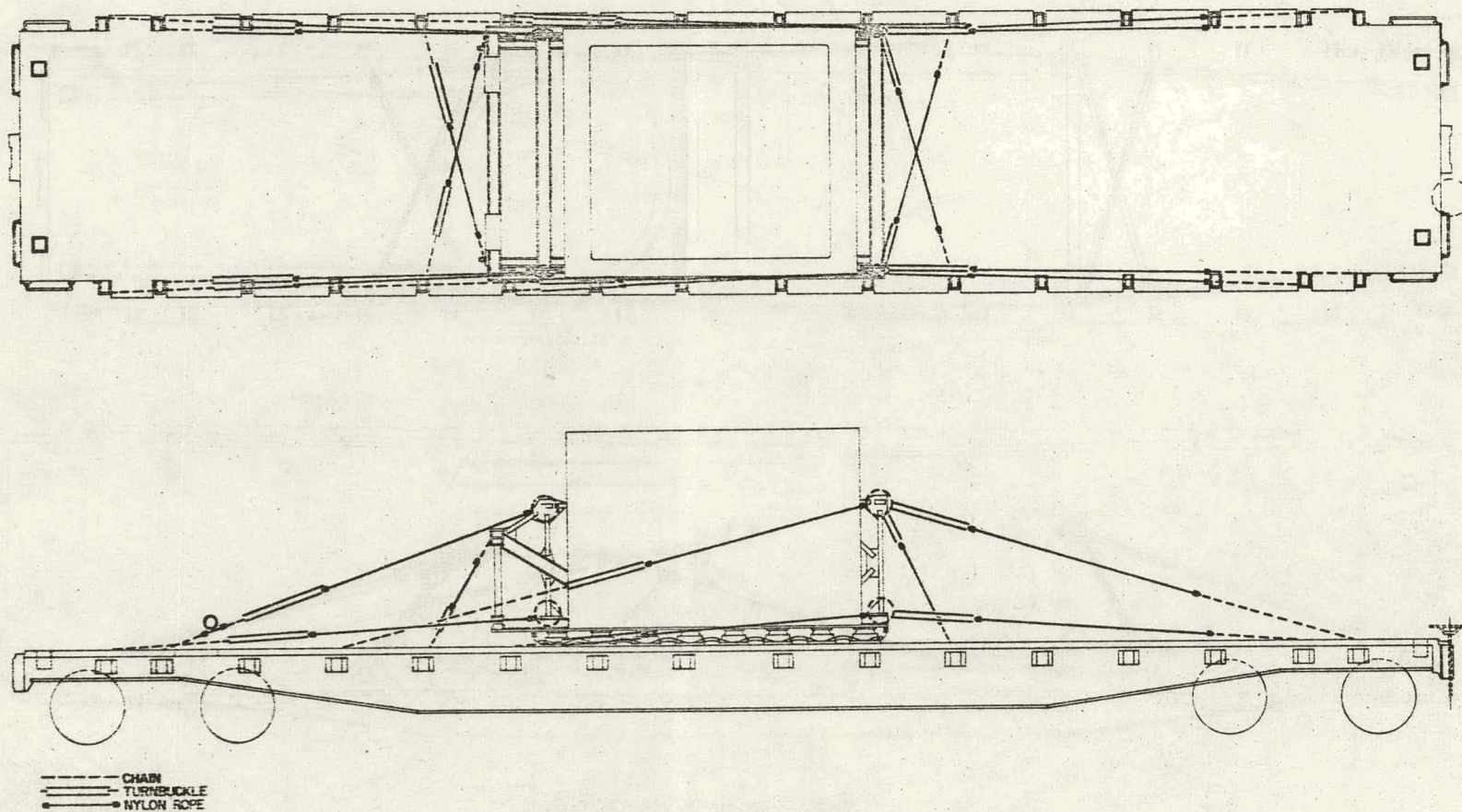


Figure C-26

SHOCK TEST INSTRUMENTATION
ML-1 POWER CONVERSION PKG.

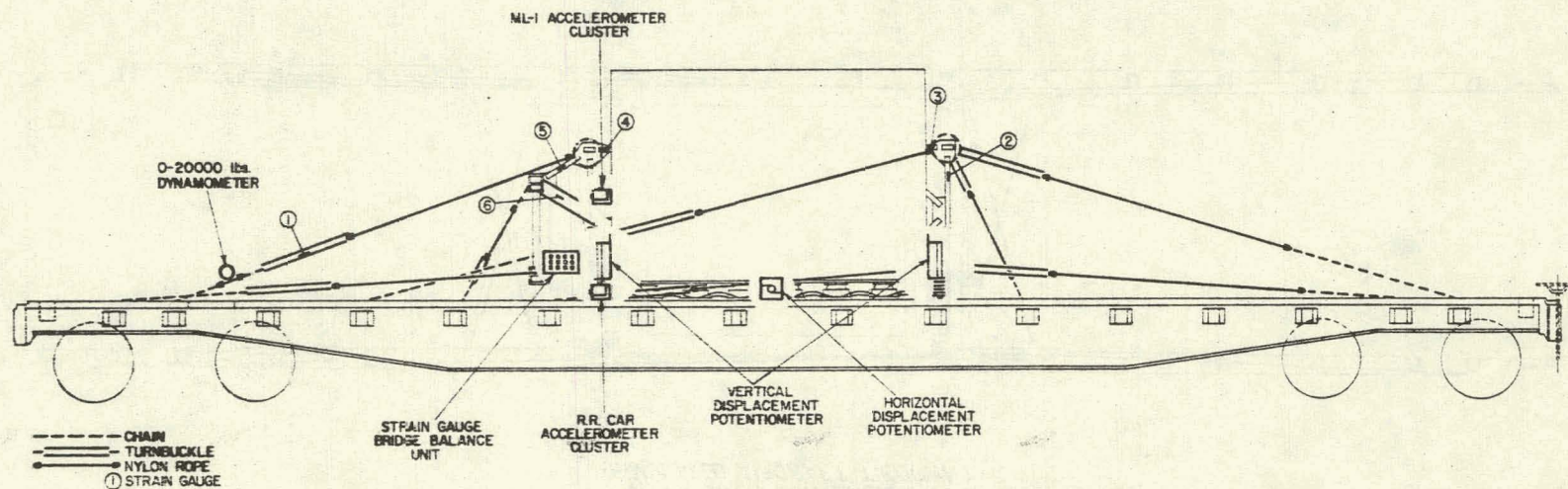
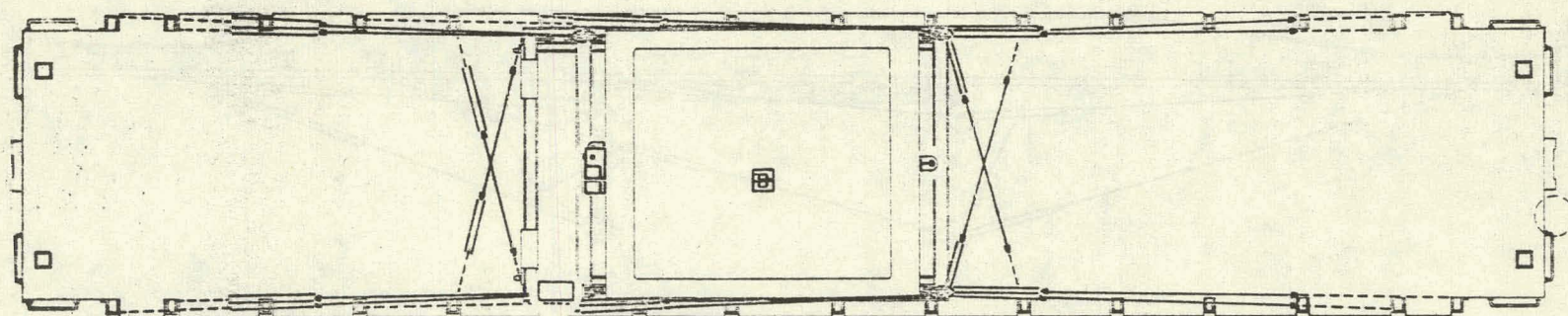


Figure C-27

LEGEND

TABLE C-1

MASTER DATA SHEET
RAILROAD SWITCHING AND "HUMPING" TESTS

R P-C	Both mockups on flatcar	X(S)	Sand-filled refrigerator car	P-C	Power conversion mockup on car
←	Direction of Impact	X	Refrigerator car		

Pictorial Description of Conditions	Run No. (2)	Date (3)	Impacting Velocity (4)	Weight of Impacting Cars (5)	Number of Impacting Cars (6)	Condition of Shoring (7)	Status of Flatcar (8)	Nylon Tension Pounds		Package Horizontal		Displacement Vertical		Transverse		Railroad Horizontal		Car Freq. cps (24)	Acceleration Vertical or Transverse		Package Horizontal		Acceleration Vertical or Transverse		No. Tie-Downs (38)	Run No. (2)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
								Orig (9)	Max (10)	Scratch Gauge (11)	Visi-cord (12)	Time - msec Start (13)	Time - msec Max (14)	Reactor Gauge In. (15)	Freq. cps (16)	PConv Scratch Gauge In. (17)	Inches End (18)		PConv In. (19)	Time msec Pulse Delay (20)	Time msec Peak (21)	Acceleration g (22)	Avg. g (23)	Shock Dur. msec (25)			Peak g (26)	Avg. g (27)	Freq. cps (28)	Time - msec Pulse Delay (29)	Time - msec Peak (30)	Peak Accel g (32)	Avg Vel Rel to Flatcar (33)	Time - msec Pulse Delay (34)	Time - msec Peak (35)	Peak Accel g (36)	Freq. cps (37)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

(CONTINUED)

TABLE C-1 (CONTINUED)

Pictorial Description of Conditions	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(2)
<div><div><div>R</div><div>P-C</div></div><div>← X (S)</div><div>Brakes Set</div></div>	31A	10/21	4.2	169.0	1	X	X	X	700 800 800	2300 (2300) 4900	2.4	2.5	60	170	+ .10 -0.0 + .12	XXX	+ .05 - .15 + .15	0.1	0.2	80	74	2.3	2.2		250	0.2	-		10	240	170	0.8	-	20	220	0.2		31A
	31B		7.6						600 600	4900	6.0	4.4	40	170	- .06 + .15 - .15		0.2	0.2	72	72	8.5	8		400	2.5	-		15	320	160	1.5	-	10	280	0.5		31B	
	31C		11.0						500 500	5500	8.5	5.3	50	200	+ .15 - .06 + .15		0.2	0.6	24	52	21.0	20		320	11	-		15	355	150	1.7	-	30	280	0.7		31C	
	31D		10.0						500 450	7700 (6200)	10.7	6.4	48	200	+ .06 - .26 + .19		0.2	0.7	25	53	19.0	17.5		300	8	-		10	370	160	2.0	-	30	260	0.8		31D	
	32A	10/23	7.2						1500 800	5700	7.3	12.4	35	230	+ .10 - .06 + .12		0.3	0.1	48	50	-	7.7		400	5.1	-	185	-	360	200	1.2	2.4	20	300	0.5	19.5 44 28 48	ONE HALF	32A
	32B		8.5*						900 800	6500	9.9	5.8	90	218	+ .20 -0.0 + .25		0.4	0.2	30	80	16.6	15.4	333	444	3.5	-	159	30	315	193	1.4	3.3	66	176	0.8		32B	
	32C		10.5*						800 750	(8200)	12.6	18.0	50	220	-0.0 + .25 - .15		0.7	0.7	25	58	21.0	18.7		400	6.4	-		10	430	200	1.7	4.0	40	170	0.8		32C	
	32D		11.0*						900 650	10250	14.0	-	60	268	+ .25 - .05 + .70		0.2	0.4	25	55	20	18.3		410	6.8	-		20	410	215	1.8	-	30	240	0.6		32D	
	32E		13.7*						800 600	11000 (10500)	-	-	64	230	+ .25 -0.0 + .27		-	0.6	25	63	20.0	18.2		460	7.2	-		15	415	190	2.0	-	25	92	0.8		32E	
	32F		14.0*						800 500	14350	17.4	-	40	282	+ .27 - .10 + .27		-	0.6	24	57	22.0	17.5		432	8.5	0.25		10	420	210	2.3	4.5	15	110	0.8		32F	
	33A		9.2						700 500	8400	13.8	14.1	64	260	+ .24 - .06 + .25		0.4	0.5	23	64	23.0	18.5		264	2.7T	1.3T		30	430	200	1.6	4.0	100	30	0.2T		33A	
	33B		10.3						600 400	9100	13.9	15.1	45	260	+ .25 - .05 + .24		0.2	0.6	26	52	22.0	17.5		120	2.3T	1.0T		5	410	200	1.8	4.0	40	120	0.2T		33B	
	33C		11.1						500 500	9500	16.4	17.0	30	268	+ .60 - .10 + .22		0.5	-	22	56	25	18.5		132	3.5T	1.0T		20	440	-	1.9	4.3	108	16	0.2T		33C	

TABLE C-2
MASTER DATA SHEET
SIMULATION OF AIRCRAFT EMERGENCY LANDING

Pictorial Description of Conditions	Run No. (2)	Date (3)	Impacting Velocity (4) mph	Weight of Impacting Cars (5) lb x 1000	Number of Impacting Cars (6)	Condition of Shoring (7)	Status of Flatcar (8)	Nylon Tension lb		Scratch Gauge Inches		Delay Time msec		Displacement Vertical		Transverse		Railroad Car Horizontal		Acceleration		Package Horizontal		Acceleration		Run No. (2)						
								Orig (9)	Max (10)	Fore (11a)	Aft (11b)	Start (13)	Max (14)	Reac (15)	End (17)	Reac (18)	End (19)	Time - msec Pulse Dur (20)	Delay to Peak (21)	Peak (22)	Avg (23)	Equip Per (24)	Shock Dur msec (25)	Peak Accel g (26)	Time msec Delay Peak (29)		Pulse Dur (30)	to Peak (31)	Peak Accel g (32)	Time Delay Peak (34)	Pulse Dur (35)	Peak Accel g (36)
P-C ← X (Sand Car) Brakes Set	1	10/25	7.1	169.0	1		Brakes On	1100	3200	6.6	1.6	79	310	+ .13 - .07	+ .3 - .1	0.5	0.5	205	125	7.0	4.7	-	580	2.6	20	400	230	1.2	40	390	0.75	1
Same, except brakes not set	2		8.8				Brakes Off	600	3200					+ .18 - .07	+ .15 - .15	1.0	0.5	170	95	0.0	7.2	.092	380	3.5	5	385	205	2.5	55	210	1.0	2
	3		8.5				Brakes On	350	7700	11.2	12.6	46	280	+ .28 - .1	+ .2 - .2	1.3	2.2	180	98	9.9	6.5	.074	350	4.5	7	440	240	1.6	10	280	0.5	3
P-C ← X(S) X X X 3/4 Brakes	4		8.6	342.2	4		Brakes On	700	9500	11.3	15.4	64	298	+ .25 - .25	+ .2 - .4	2.3	2.8	200	98	6.8	5.0	.102	320	2.5	5	480	253	1.5	50	387	1.0	4
	5		12.1				Brakes On	1000	12500	15.3	21.5	42	244	+ .5 - .65	+ .4 - .7	3.1	3.2	180	85	10.3	8.0	.099	360	5.7	6	460	230	2.5	10	380	1.3	5
	6	10/28	10.7				Brakes On	200	8400					+ .4 - .4	+ .3 - .3	0.6	2.2	133	108	9.0	6.2	.125	633	4.5	4	520	298	1.7	55	390	1.0	6
	7		12.9				Brakes On	500	8250	12.1	10.2	70	-	+ .52 - .4	+ .35 - .3	1.6	2.5	90	75	13.0	11.3	.085	710	7.3	8	500	250	2.4	6	350	1.5	7
	8		13.1	353.5	6		Brakes On	800	9200	16.0	11.4	34	-	+ .5 - .3	+ .3 - .2	0.5	1.6	150	108	10.7	8.0	.077	780	6.0	5	615	280	1.9	10	370	1.2	8
	9		11.1				Brakes On	700	9400	13.6	7.9	-	-	+ .4 - .3	+ .4 - .1	0.6	2.1	160	92	9.3	7.5	.072	555	6.8	5	580	245	2.4	6	400	1.4	9
	10		11.1				Brakes On	1150	7350	10.6	9.4	-	-	+ .75 - .45	+ .35 - .35	1.5	2.5	160	80	10.2	8.8	.094	480	6.7	5	540	272	2.0	6	390	2.5	10
	11		9.8				Brakes On	700	7500	13.4	11.9	-	-	+ .35 - .3	+ .3 - .3	0.5	2.2	140	115	8.8	7.0	.070	640	9.0	10	570	250	1.4	8	400	0.9	11
	12		8.8				Brakes On	1000	6000	10.1	8.8	-	-	+ .25 - .25	+ .3 - .15	0.7	1.7	96	83	4.5	3.4	.096	410	5.2	5	720	260	1.0	8	270	0.5	12
	13		7.5				Brakes On	750	5100	6.9	8.6	-	-	+ .3 - .3	+ .2 - .2	0.3	1.5	170	130	4.0	2.0	.089	390	2.5	10	570	270	0.8	6	360	0.3	13
P-C ← X X X X X X X 3/4 Brakes	14	10/29	12.3				Brakes 3/4 On	1000	2900	6.1	6.5	-	-	+ .6 - .3	+ .4 - .7	0.4	0.9	150	70	11.7	9.5	.093	460	3.0T	5	340	270	2.0	40	240	0.5T	14
	15		13.8				Brakes On	900	8700	10.5	6.8	38	307	+ .7 - .35	+ .38 - .6	0.6	0.9	230	71	18.0	11.5	.062	400	3.2T	5	500	240	2.3	30	290	0.2T	15
	16		13.8				Brakes On	500	11500	12.8	6.1	38	286	+ .72 - .38	+ .4 - .7	0.5	1.1	85	65	16.0	12.5	.037	440	2.5T	5	520	250	0.5	110	250	0.4T	16
	17		9.0				Brakes On	500	13000	14.3	11.1	43	284	+ .25 - .25	+ .3 - .2	0.2	0.2	130	120	6.8	5.0	.083	370	2.5	5	220	140	2.0	6	400	0.6	17
	18		11.1				Brakes On	300	DYNAMOMETER REMOVED	1.6	1.4	112	166	+ .45 - .3	+ .1 - .15	0.3	0.2	170	107	18.3	12.0	.116	760	7.3	8	460	260	2.2	13	530	1.8	18
	19		16.6				Brakes On	500	10100	4.2	3.0	64	154	+ .5 - .6	+ .4 - .38	0.7	0.6	130	90	11.5	8.0	.114	510	7.7	-	-	-	8	480	3.0	19	
	20		14.3				Brakes On	750	10100	4.4	2.5	56	141	+ .2 - .4	+ .2 - .4	0.7	0.6	120	100	13.5	12.0	-	560	4.5	10	300	100	4.6	50	390	3.6	20

APPENDIX D

MIL-A-8421A(USAF)
6 November 1956
Superseding
MIL-A-8421 (USAF)
10 November 1955

MILITARY SPECIFICATION

AIR TRANSPORTABILITY REQUIREMENTS,
GENERAL SPECIFICATION FOR

1. SCOPE

1.1 This specification covers the general requirements for air transportability of military equipment.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and publication, of the issue in effect on date of invitation for bids, form a part of this specification:

SPECIFICATIONS

Military

MIL-T-7270	Tiedown, Cargo, Aircraft, Type D-1
MIL-M-8090	Mobility Requirements, Ground Support Equipment, General Specification For
MIL-T-8652	Tie Down; Cargo, Aircraft, 5,000-Lb Capacity, Type MC-1

PUBLICATION

Air Force-Navy Aeronautical Bulletin

143 Specifications and Standards; Use of

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 SPECIFICATIONS AND STANDARDS.- Specifications and standards for all materials, parts, and Government certification and approval of processes and equipment, which are not specifically designated herein and which are necessary for the execution of this specification, shall be selected in accordance with Bulletin 143.

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3.2 GENERAL.- Ordinarily, equipment shall be capable of shipment by air. The size and configuration of equipment items shall be such that they can be loaded into the aircraft as a unit. If necessary, partial disassembly and packaging shall be permissible.

3.2.1 To facilitate handling, compactness and light weight shall be design objectives provided ease of maintenance and serviceability are not impaired.

3.2.2 Equipment shall be capable of being loaded into aircraft and readily positioned without damage to the aircraft structure and with the use of a minimum amount of handling equipment.

3.2.3 Equipment shall be capable of being secured against all loads encountered during flight, taxiing, and ground handling of aircraft without damage to the aircraft or equipment.

3.3 DESIGN.- Design features of equipment shall be such that they meet the following general requirements:

3.3.1 AIRCRAFT FLOOR LOADING.- Equipment incorporating pneumatic tires may be required to reduce the tire pressure to 35 psi for air transport. In addition, individual wheel or axle loads and general floor loading, as determined from the plan view of the equipment, shall conform to the fuselage zone and compartment limitations for the aircraft concerned. Such limitations are contained in the cargo loading handbook; that is the -9 section of the technical order for the applicable aircraft.

3.3.2 LOADING RAMP NEGOTIATION.- Wheeled equipment shall be capable of negotiating a loading ramp at least as long as the wheelbase and having a slope of 20° with the ground and aircraft floor plans without interference with equipment structure.

3.3.3 FLIGHT AND TAXIING LOADS.- The equipment shall be designed to withstand, without loss of serviceability, an acceleration of 3g for a minimum of 0.1 second applied dynamically and independently along each of the longitudinal and vertical axes in each direction, and 1.5g for a minimum of 0.1 second applied dynamically and independently along the lateral axis in each direction. (See 6.5.1)

3.3.4 EMERGENCY LANDING LOADS.- Equipment shall be designed to withstand the following loads encountered in crash

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landings, without any of the major components of items being transported breaking loose. The item need not be serviceable after being subjected to such accelerations.

a. A minimum of 8g in either direction applied independently along each horizontal axis for a minimum of 0.1 second. When the equipment is of such size or configuration that it can be loaded only into cargo aircraft with a particular axis parallel to the longitudinal axis, the 8g requirement need be met only along this axis and in only the forward direction when the loading position is fixed or specified.

b. A minimum of 4-1/2g vertically downward for a minimum of 0.1 second in such a direction that (1) equipment carried in a cargo compartment imposes a load on its wheels or supports in a downward direction, and (2) equipment hung in a bomb bay imposes a load in an upward direction on attachment points located on the equipment.

3.3.5 ATTACHMENTS

3.3.5.1 ATTACHMENT DEVICES.- Equipment shall be provided with attachment points which will accommodate both ends of the standard tiedown devices specified in 3.3.5.1.1, and shall be marked in accordance with 3.4. These attachment points shall be suitable for use in conjunction with the attachment points on the aircraft floor, which, in general, have a capacity of 10,000 pounds and are placed on 20-inch centers. The attachment points shall permit the application of adequate restraint to the equipment when subjected to the accelerations specified in 3.3.3 and 3.3.4 during flight, taxiing, and emergency landing.

3.3.5.1.1 If the configuration of the equipment permits the use of the following standard tiedown devices of the appropriate rated capacity and provides adequate strength in a particular tiedown location without the use of standard attachment fittings, provisions for the attachment fitting specified in 3.3.5.1 in such locations may be deleted:

<u>Item</u>	<u>Nomenclature</u>	<u>Specification</u>	<u>Rated Capacity (Lb.)</u>
Tie Down, Cargo, Aircraft,			
Type MC-1		MIL-T-8652	5,000
Tie Down, Cargo, Aircraft		(see 6.4)	10,000
Type MB-1			
Tie Down, Cargo, Aircraft,			
Type D-1		MIL-T-7270	25,000

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3.3.5.2 LOCATION OF ATTACHMENTS.- The location of provisions for attachment fittings shall be determined after considering the following:

a. Tiedown grid patterns for the particular aircraft in which the equipment is to be transported, including the number and location of higher capacity tiedown points

b. The accessibility of attachment points on the aircraft in view of requirements for personnel escape clearances and flight aisleway clearances

c. Position of attachment points around the horizontal periphery of the equipment

d. Position of attachment points with reference to the vertical center of gravity of the equipment

e. Angle of tiedown with horizontal plane

f. Accessibility of attachment points on both equipment being transported and aircraft in which equipment is transported

g. Typical loading diagram of the equipment to be transported in each aircraft providing air transport capability

3.3.5.3 NUMBER OF ATTACHMENTS.- The number of locations for attachment fittings shall be not less than four.

3.4 MARKING

3.4.1 EQUIPMENT.- Equipment shall be suitably marked to provide the information necessary to facilitate loading in the aircraft. Unless otherwise specified, the marking shall be stenciled in an appropriate location on the exterior of the equipment. Marking shall include at least the following:

3.4.1.1 TIEDOWN FITTINGS.- Tiedown attachments or fittings shall be identified and the allowable load shall be indicated.

3.4.1.2 GROSS WEIGHT AND CENTER OF GRAVITY LOCATION.- The gross weight of the equipment in air transportable condition shall be marked in a conspicuous location. The location of the center of gravity along each axis influencing the method of tiedown shall be specified.

3.4.1.3 HOISTING FITTINGS.- Hoisting fittings shall be identified and the required hoisting capacity marked. The locations where fork lifts may be applied shall be identified.

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3.4.1.4 OTHER MARKINGS.- Other markings shall be provided to cover the following, where applicable:

- a. Reduction of tire pressure to meet floor loading limitations
- b. Instructions for retraction of wheels or casters to provide greater bearing surface or clearance
- c. Installation of special struts or braces to meet flight loads
- d. Orientation in aircraft when critical
- e. Instructions for special servicing or other preparation for air shipment
- f. Other precautions to be observed during loading, flight, or unloading

4. QUALITY ASSURANCE PROVISIONS

4.1 ACCEPTANCE TESTS.- Air transportability acceptance tests shall be performed on developmental test items, preproduction test items, qualification test items, or sample items as provided for in the detail specification.

4.1.1 EXAMINATION OF PRODUCT.- The item of equipment, drawings, or other data defining the item shall be examined to determine conformance to the requirements of this specification. Any deviation from these requirements not specifically permitted by the detail specification shall be cause for rejection.

4.1.2 RAMP TEST.- For mobile equipment, the ramp test specified in MIL-M-8090 shall be performed.

4.1.3 ACCELERATION LOAD TESTS.- The following tests shall be performed to determine compliance with the acceleration load requirements specified herein:

4.1.3.1 FLIGHT AND TAXIING LOAD TESTS.- The equipment shall be attached to a pallet in the manner specified for loading in an aircraft. The palletized item shall be slid or rolled down an inclined plane or otherwise accelerated and stopped in such a manner as to produce the accelerations specified in 3.3.3, as measured by an accelerometer mounted on the pallet. Following these tests, the equipment shall be examined, operated, and subjected to performance tests specified in the detail specification. Evidence of permanent deformation of structural members

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or failure to operate and meet the performance requirements of the detail specification shall be cause for rejection. If application of the dynamic load to equipment along the vertical axis imposes undue complications on test equipment, the vertical acceleration may be applied statically.

4.1.3.2 EMERGENCY LANDING LOAD TEST.- Upon successful completion of the tests specified in 4.1.1, 4.1.2, and 4.1.3.1, the equipment shall be subjected to the accelerations listed below in the order specified. Following these tests, the equipment shall be examined. Breaking loose of the equipment from the tiedowns, or separation of a component from the main body of the equipment shall be cause for rejection. The item need not be serviceable after being subjected to these accelerations. If it can be shown by computation that the equipment and all components will conform to the requirements specified herein, the computation may be substituted for the test.

.a. 4-1/2g as specified in 3.3.4(b)

b. 8g as specified in 3.3.4(a)

4.1.3.2.1 If application of the dynamic load to equipment along the vertical axis imposes undue complications on test equipment, the vertical acceleration may be applied statically. (See 6.5.1 and 6.5.2)

4.1.4 LOADING DEMONSTRATION.- The equipment shall be loaded into an aircraft typical of those in which it could normally be carried and in the manner specified by the loading handbook for the aircraft. Any difficulties encountered in this loading operation shall be noted with particular reference to interference with aircraft structure, damage to cargo floor, or unusual positioning operation required. The equipment shall then be tied down in accordance with the restraint criteria specified in the loading handbook of the aircraft. Further details on the arrangement of tiedown attachments to the aircraft floor shall be included in test instructions.

4.1.4.1 Any difficulty in achieving a satisfactory tiedown shall be noted. Following the tiedown demonstration, the equipment item shall be unloaded and any difficulties encountered during the operation shall be noted. When an aircraft cannot readily be secured in the case of contractor-conducted tests, demonstrations of satisfactory loading, tiedown, and unloading characteristics may be made by means of scale models or comprehensive scale drawings showing each stage of operation.

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5. PREPARATION FOR DELIVERY

5.1 Not applicable to this specification

6. NOTES

6.1 USE.- This specification is intended to establish uniform requirements and tests for air transportability characteristics to be incorporated in the design of Air Force equipment.

6.2 GENERAL APPLICATION.- Prior to use of this specification, the required operating conditions of the particular item of equipment should be reviewed to determine the air transportability criteria which are applicable. The tests of this specification may be modified or supplemented to meet the individual air transportability requirements of the equipment; for instance, bomb bay transportability, modification of aircraft, or special handling methods which must be applied.

6.3 OPTIONS.- The following options should be indicated in the detail specification to further define the degree and type of air transportability required:

a. Individual aircraft type, or types, or general class, such as large cargo aircraft in which equipment will be transportable.

b. Special loading conditions, such as transporting in bomb bay or carrying external to the aircraft structure.

c. Amount and kind of disassembly permissible to achieve loading in particular aircraft; for example, removal of wheel assembly to load a van-type semitrailer in Type C-119 aircraft.

d. Special provisions, such as auxiliary wheels or full-swiveling casters necessary to meet a particular loading configuration or positioning requirement.

e. Loading and unloading time allowable to achieve a particular aircraft turn-around time. Also, time required for equipment to be operational after air landing, in the case of assault or staging operations.

f. Detailed structural limitations of the attachment provisions on the item being transported for equipment designed to transport other items.

g. Overall weight and size limitation imposed by aircraft. Also, weight and size limitations imposed by air cargo ground

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handling equipment should be considered. Limitations of internal aircraft cargo handling provisions should also be considered if these are to be used.

6.4 TYPE MB-1 TIEDOWN.- When required, a sample Type MB-1 tiedown or applicable data may be obtained from the procuring activity or as directed by the contracting officer.

6.5 DEFINITIONS

6.5.1 DYNAMIC LOAD.- Dynamic load refers to the application and release of load within a short time interval, such as 0.1 second.

6.5.2 STATIC LOAD. - Static load is defined as a load that is slowly applied and held for at least 3 minutes.

Notice: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any invention that may in any way be related thereto.

KLM/BLW/mt
WCLE

WADC

APPENDIX E

MILITARY CHARACTERISTICSMOBILE NUCLEAR POWER PLANT, ML-1

November 30, 1959

- I. Title: Mobile Nuclear Power Plant, 300-500 KW, ML-1
- II. Security Classification:
 - A. Existence of project: Unclassified
 - B. Military Characteristics: Unclassified
 - C. Reactor Design and Performance: Unclassified
- III. Proposed Use: There are requirements within the military services for general purpose portable nuclear power plants with electric power outputs in the range from 300 to 500 KW. The ML-1 is the prototype of field units which will be procured to meet these requirements. Examples of military operations requiring a power source without dependence on continuous fuel or cooling water supply are: support of tactical missile systems, air head operations including field hospitals, remote locations, etc.
- IV. Environmental Characteristics: The plant shall have the inherent capability for acceptable performance under the Basic Operating Conditions, Extreme Cold Weather Operating Conditions, and Extreme Hot Weather Operating Conditions as established in paragraphs 7a, 7b, and 7c of AR 705-15; and shall be capable of safe storage and transportation under conditions as established in paragraph 7d of AR 705-15.
- V. Power Characteristics:
 - A. Nominal Output at "Design Conditions" (Ambient temperature -65°F to 100°F)
 - (1) Electrical power output in the range of 300-500 KW, .8 Power Factor
 - (2) 2400/4160 volts, 3 phase, 60 cycles per second
 - B. Output at "Off Design Conditions"
 - (1) Net output of the system in the event of hot weather (> 100°F or high altitude operation shall be limited only by precooler performance and/or moderator coolant heat exchanger performance.

Military Characteristics (Cont'd)

- 2 -

- (2) Operation shall be possible up to 500 KW net output except as limited by precooler performance.

C. Power Quality

- (1) Objective: Steady state and transient frequency and voltage control characteristics as specified by MIL G-14609 (CE).
- (2) Minimum requirement: Steady state and transient frequency and voltage control characteristics as specified by MIL G-10328A (CE).

D. Other Requirements:

- (1) Automatic power level control is required
- (2) The power plant shall operate satisfactorily in parallel with other units of similar rating.
- (3) The power plant shall be capable of 50 cycle operation
- (4) The power plant shall be treated for the elimination of interference with radio communication in accordance with applicable Signal Corps specifications.

VI. Field Operating Characteristics:

- A. The plant shall be assembled on a standard military semi-trailer (M-172 or M-172A1) and all preparations completed for relocation to an operating site within six (6) hours after unloading from any aircraft.
- B. The plant shall be capable of being installed and delivering rated power within twelve (12) hours after arrival at an operating site.
- C. The plant shall be capable of relocation to a new site beginning twenty-four (24) hours after reactor shut down following operation for extended periods at full power.
- D. Nuclear Radiation allowed:
 - (1) Allowable radiation, twenty-four (24) hours after shutdown at twenty-five (25) ft. from the reactor in the direction of the cab (without water shield), is fifteen (15) mr/hr.
 - (2) No personnel shall receive greater than 3 rem/quarter.

Military Characteristics (Cont'd)

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- E. Equipment may be operated in any plane within five degrees (5°) from level.
- F. Control of the power plant will be from a separate shelter which shall be transportable as a unit on a standard 2½ ton truck (M-35) which, during plant operation, shall be connected to the power plant by quick disconnect electrical cables of sufficient length (up to 500 ft.) to permit flexibility in the relative locations of the power plant and control shelter.
- G. Plant design shall include necessary safety features for protection of personnel in the immediate area from results of reasonably conceivable mechanical, electrical, or nuclear malfunctions.
- H. During plant operation, radiation shielding integral to the plant may be supplemented by field expedient materials (earth, gravel, wood, water) sufficient to reduce radiation levels outside the combined shield to within dosage levels prescribed by the Surgeon General, D/A. The integral plant shield (excluding supplemental expedient shielding) shall be adequate to reduce the residual radiation level following full power operation for extended periods to safe levels in time to permit relocation twenty-four (24) hours after reactor shutdown.
- I. The operating crew for three-shift operation of the field unit shall consist of no more than seven (7) men (one operator per shift plus mechanic-electrician, radiological safety technician and officer or NCO in charge). The crew will be specially trained for operation, maintenance, and plant installation at the site.

VII. Transportability Characteristics:

- A. Objective: Capability of being transported overland (highway and cross-country), by rail, by water, and by aircraft in accordance with AR 705-8, Transportability.
- B. Requirements: The ML-1 plant shall be consistent with the following transportation requirements:
 - (1) General: The "power plant unit" is defined for transportability as the complete integral power plant including reactor, shutdown shielding, power conversion equipment and skid mounting. Control unit, auxiliary power unit, auxiliary equipment package and trailer are not included in this definition. Required modes of transport are indicated below.

Military Characteristics (Cont'd)

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(2) Primary mode of transportation:

- (a) The primary mode of transport of the power plant unit shall be overland on standard military semi-trailer. Power plant unit integrity is required.
- (b) The control unit shall be one package which can be transported intact and which is suitable for both operation and transport on a standard military 2½ ton truck.

(3) Secondary modes of transportation: (power plant unit integrity required).

- (a) Secondary modes of transport for the power plant unit where unit integrity is required include:
 - 1. Normal railway freight service U. S. and foreign.
 - 2. Water freight by ship or barge.
- (b) In addition, when necessary and where satisfactory clearances can be arranged, the power plant unit shall be transportable trailer-mounted on the above transit types.
- (c) Similarly, when truck-mounted, the truck and control unit shall be transportable as one package when necessary and where satisfactory clearances can be arranged for the above transit types.

(4) Secondary modes of transportation: (power plant unit integrity not required).

- (a) The power plant unit may be separated into two packages for transport by:
 - 1. USAF C-130
 - 2. USAF C-124C
 - 3. Sled
- (b) Trailer mounting is not required for (a) above.
- (c) The control unit shall be transportable intact. Truck mounting is not required for (a) above.
- (d) The complete power plant including the control unit and auxiliary equipment shall be transportable in one USAF C-133.

Military Characteristics (Cont'd) - 5 -

(5) Other Requirements:

- (a) The power plant shall be transportable in Phase III of airborne operations.
- (b) Design for air transport shall conform to requirements of USAF Specification MIL A-8421A for transportation of materiel in military cargo aircraft.
- (c) Provisions shall be made to permit rapid loading and unloading of each unit by standard weight handling techniques.
- (d) Shock and vibration protection shall be provided integral with the plant consistent with each transport type as indicated below:

- 1. Shock loading in transit by rail, semi-trailer, or ship without loss of serviceability:

<u>Direction</u>	<u>Load Factor, g</u>	<u>Duration of versed sine pulse, sec.</u>
Fore & Aft	15	.030
Lateral	2	.030
Vertical	4	.030

The maximum shock load transmitted to components in either direction will be reduced to 8g, fore and aft, by shock mounts provided on the skid.

- 2. Emergency landing shock loads during transit by air, with questionable plant serviceability:

Horizontal -- 8g for .1 sec.
 Vertical -- 4.5g for .1 sec.
 Lateral -- 1.5g for .1 sec.

- 3. Emergency landing shock loads during transit by air, without loss of plant serviceability:

Horizontal -- 5g for .1 sec.
 Vertical -- 4.5g for .1 sec.
 Lateral -- 1.5g for .1 sec.

- 4. Steady vibrations in transit, without loss of serviceability:

<u>Source</u>	<u>Peak Amplitude, Inches</u>	<u>Frequency, cps</u>
Railroad Flatcar	.12	20-30
Semi-trailer	.05	> 20
Ship	.05	15-20
Aircraft	.05	> 20

Military Characteristics

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(e) Weight:

1. Heaviest package for air transport is 15T
2. Trailer load (M-172 or M-172A1) is 30T
3. Control Shelter is 2.5T

(f) Size:

1. Largest package shall be transportable on C-124, C-130, and C-133 aircraft; and on railroad with limits as prescribed by the Berne International Clearance Diagrams.
2. Reactor and power conversion skids shall be transportable as a unit on the M-172 or M-172A1 semi-trailer.
3. Maximum height when trailer-mounted is 150 inches. Power plant height when trailer-mounted may be reduced to 132 inches for the purpose of passing low clearance obstacles outside CONUS.
4. Length and width shall be compatible with a standard military semi-trailer (M-172 or M-172A1).

- (g) When trailer-mounted and in transit, the plant shall have the capability of shallow fording in fresh or salt water, as defined in SR 705-125-10. Extreme caution must be taken to avoid a nuclear accident due to core flooding.

VIII. Logistical Characteristics:

- A. The plant shall operate with no more than periodic field maintenance service for 10,000 hr. between major overhaul.
- B. The plant shall have 50,000 hr. total life.
- C. The plant shall be capable of full power operation for 10,000 hours between refueling operations. Refueling may be accomplished in the field.
- D. The plant shall be capable of operation without a continuous water supply. Any initial quantity of water (for shielding or reactor moderator) will be kept to a minimum and of a quality which can be supplied by standard military water purification equipment capable of delivering 600 GPH.