# DINING TABLES: EVALUATION OF TABLE TOPS AND EVALUATION OF LEGS VERSUS PEDESTAL

Stanley T. Athas, et al

Army Natick Laboratories
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# DINING TABLES:
# EVALUATION of TABLE TOPS and EVALUATION OF LEGS versus PEDESTAL

by

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13. ABSTRACT

The objectives of this report are twofold. First is to evaluate the table tops tested by comparing the following characteristics of each: impact resistance, staining resistance, scratch resistance, burn resistance, top flatness, and interchangeability potential. Second is to evaluate four-legged versus pedestal tables and table/chair combinations by comparing the following characteristics of each: survival of interface assembly of pedestals and legs after static loading, deflections of the table top after static loading, stability of table-resistance to tipping, stability of table-resistance to lifting, impact resistance, and ease of use.

The tables used were plastic tops manufactured by Tripro Manufacturing Corporation and Ingersoll Humphrey, a division of the Borg-Warner Corporation, support hardware by other companies, and were assembled by Tripro and Borg-Warner.

The Tripro top is superior to the Borg-Warner top in terms of scratch resistance, stain resistance and burn resistance, and interchangeability potential and equal in terms of impact resistance and top flatness. Damage from impact resistance tests simulating tables being slammed against each other or tipped over consisted of slight cracks and crazing in the laminate or plastic. Under static loading conditions all the pedestal tables, four-legged tables and table/chair combinations are essentially equal - no damage to the support and table top interface hardware. The stability of the pedestal versus the four-legged tables is essentially similar. The combination table/chairs are considerably more stable than either the pedestal or four-legged tables. In no case is the table or table/chair combination tested practical for use with a wheel chair.

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## FOREWORD

The work covered by this report was performed under Project 02, Household and Office Furniture, Furnishings and Appliances, Task 02 - Evaluation of Dining Hall Tables and Task 03 - Evaluation of Dining Hall Tables (Pedestal Base versus Legs).

U.S. Army Natick Laboratories has the technical responsibility for various types of furniture used throughout the army installations including dining hall furniture.

Test materials were provided by the General Equipment & Packaging Laboratory.

The authors gratefully acknowledge the contributions to this report of Messrs. John Durkin and Albert Langevin of the Engineering Evaluation Office. They performed the testing reported herein and were primarily responsible for the design of the test equipment.

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## 1.0 INTRODUCTION:

Current specifications offer a wide selection of dining hall tables in those sizes and styles previously determined necessary by the DoD Food Service Board. These consist of four-legged and pedestal units having square, rectangular, and round tops with a plywood core that is covered with a decorative plastic laminate and has a strip of aluminum extrusion or more laminate as edging. Naval Specification MIL-T-18143* additionally covers a four-legged metal table with stationary seats attached to each leg.

Recent improvements in this line of furniture have seen the introduction of at least two new methods of top construction which eliminate the need for the two-piece application of top and edging and at least two variations in the method of support and seating arrangement. Because it is in the best interest of the government to stay abreast of new developments within the industry, the Office of the Assistant Secretary of Defense requested a project be initiated to determine the potential for these items within military programs. Specifically, programs were initiated to evaluate different table top designs and materials and to compare pedestal type tables against four-legged support type tables. In this latter program combination tables and chairs (chairs being an integral part of the table) were evaluated as well.

The manufacturers in this instance are the Tripro Manufacturing Corporation, a fabricator of tops only; Fixtures Manufacturing Company, a manufacturer of supports; Ingersoll Humphreys, a division of Borg-Warner Corporation, a manufacturer of tops; and Winzler-Pacific Company, Research Tool and Die Company, and J. B. Eye Inc., manufacturers of supports.

## 2.0 EVALUATION OF TABLE TOPS:

### 2.1 OBJECTIVES:

To evaluate the table tops tested by comparing the following characteristics of each:

*Naval Specification MIL-T-18143, Table, Dining, Metal (With Four Bracket Seats)

a. Impact resistance

b. Staining resistance

c. Scratch resistance

d. Burn resistance

e. Top flatness

f. Interchangeability potential

2.2 TABLE TOPS USED:

The table tops used were manufactured by the Tripro Manufacturing Corporation and Ingersoll Humphreys, a division of the Borg-Warner Corporation. They are representative of normal production table tops of the suppliers. The Tripro table has a formica sheet postformed over the top and edging of the core. The core is composition board. The Borg-Warner table is a combination of nylon fibers and thermo-setting plastic resins formed in a compression mold process. Both table tops were 40 in. x 40 in. (102 cm x 102 cm).

2.3 IMPACT RESISTANCE TESTS:

2.3.1 METHOD:

Three weights of 2, 5, and 10 pounds (0.91, 2.27, and 4.54 kilograms) were allowed to free-fall through a distance of one foot (31.5 cm), striking the edges and corners of the two tops in an attempt to simulate such conditions as tables being slammed against one another or tipped over.

2.3.2 RESULTS:

For both the Tripro and Borg-Warner tops, damage was noted during the 5- and 10-pound portion of the test consisting of slight cracks and crazing in the laminate and plastic. No other failure or separation occurred.

2.4 STAIN RESISTANCE:

2.4.1 METHOD:

Several ingredients were applied to the table tops and allowed to dry for a period of four hours. These ingredients included

Italian dressing, mayonnaise, lemon juice, ketchup, coffee, tea, mustard, tomato paste, vinegar, barbecue sauce, Worcestershire sauce, Russian dressing, and Louisiana hot sauce. The dried food was then wiped with a damp cloth and the table top was examined for discoloration or permanent stain.

2.4.2 RESULTS:

The following results were determined by visual examination of the table tops:

| Food Item | Tripro | Borg-Warner |
|---|---|---|
| Italian dressing | No stain | No stain |
| Mayonnaise | No stain | No stain |
| Lemon juice | No stain | Permanent stain and bleached |
| Ketchup | No stain | Permanent stain |
| Coffee | No stain | No stain |
| Tea | No stain | No stain |
| Mustard | No stain | Permanent stain |
| Tomato paste | No stain | Permanent stain |
| Vinegar | No stain | Permanent stain |
| Barbeque sauce | No stain | Permanent stain |
| Worcestershire sauce | No stain | No stain |
| Russian dressing | No stain | Permanent stain |
| Louisiana hot sauce | No stain | Permanent stain and discoloration |

It is observed that the Tripro top exhibited no permanent stain after cleaning with all the foods applied, whereas, the Borg-Warner top exhibited permanent stains for a large number of the foods tested.

2.5 SCRATCH RESISTANCE:

2.5.1 METHOD:

The basic approach used here was to draw a variety of sharp objects across the surface.

2.5.2 RESULTS:

By visual observation the Tripro top demonstrated a greater resistance to such damaging influences than did the Borg-Warner top.

2.6 BURN RESISTANCE:

2.6.1 METHOD:

A lit cigarette was placed on each top and allowed to remain for five minutes at which time the tops were examined.

2.6.2 RESULTS:

The Tripro top had been heat-discolored, but with the use of a mildly abrasive cleanser the surface was restored to normal. The Borg-Warner top incurred a melt indentation along with a burn discoloration. The Borg-Warner top, although more severely burned, offers the possibility of repair since the color is impregnated throughout the thickness of the top. The restoration process consists of removing the original burn by using a relatively coarse abrasive followed up by applications of increasingly less abrasive treatments until the damaged area has been blended in with the surrounding surface. Finally, an electric buffing/waxing wheel must be applied to the damaged and adjoining areas until a closely matching finish is attained. Although this operation produces acceptable end results, it is not considered to be within the realm of normal top care because of the work involved and the time consumed. Rather, it is believed to be a severe remedial measure, hopefully, never required.

2.7 TOP FLATNESS:

With both the Borg-Warner and Tripro tops it was noted that the deviation from levelness varied up to 1/2 inch (1.27 cm) when measured diagonally across the table. Currently in Military Specification MIL-T-43463* there is a requirement for a maximum 1/8-inch (.317-cm)

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*Military Specification MIL-T-43463, Table, Dining, Pedestal Base

deviation from levelness across the table top. Very few of the table tops examined met this restriction. It is felt that this requirement should be relaxed to 1/4 inch (.636 cm) to allow acceptance of a higher percentage of tables. It is not felt that this relaxation in the specification will jeopardize good design.

2.8 INTERCHANGEABILITY POTENTIAL:

Holes in the Tripro top are drilled as required, a feature which makes the top usable with a variety of supports. Metal inserts in the Borg-Warner top molded directly into the bottom surface make it necessary to procure a matching base.

3.0 EVALUATION OF FOUR-LEGGED VERSUS PEDESTAL TYPE AND TABLE/CHAIR COMBINATIONS:

3.1 OBJECTIVES:

To evaluate four-legged versus pedestal tables and table/chair combinations by comparing the following characteristics of each:

a. Survival of support assembly of pedestals and legs after static loading

b. Deflection of the table top after static loading

c. Stability of table-resistance to tipping

d. Stability of table-resistance to lifting

e. Impact resistance

f. Ease of use

3.2 TABLES TESTED:

Borg-Warner and Tripro four-legged and pedestal tables and combination table/chairs were tested. They are representative of standard production tables of the suppliers. The Tripro pedestal table has a 40-in. by 40-in. top (102-cm by 102-cm) of a pressed wood core covered by wood-grained laminated plastic sheet. The top is pre-drilled and attached to the factory assembled pedestal with eight wood screws. The Borg-Warner pedestal table has a 40-in. by 40-in. (102-cm by 102-cm) solid nylon/plastic top with four threaded inserts. The top is attached to the factory assembled pedestal with four machine screws. The Tripro four-legged table utilizes the same

top as the Tripro pedestal table with 16 pre-drilled holes at the corners. The legs are attached to the top individually with four wood screws per leg. The Borg-Warner four-legged table utilizes the same type of top as the Borg-Warner pedestal table. The tubular steel legs are pre-assembled by the user and attached to the top with four machine screws. The Tripro chair/table assembly has either a 30-in. by 42-in. (76-cm by 107-cm) or 30-in. by 48-in. (76-cm by 122-cm) top of pressed wood core covered by wood-grained laminated plastic. The tops received for test were not pre-drilled and were attached to the pedestal-like base with four wood screws. The four fiberglass chairs are mounted on weighted pivots which are set into the welded base, allowing the chairs to swivel 180°. The Borg-Warner chair/table assembly has a 30-in. by 42-in. (76-cm by 107-cm) solid molded nylon/plastic top with four threaded inserts and is attached to the welded base by four machine screws. The four chairs are of the same material, each having four threaded inserts and attached to the base with four machine screws.

A series of photographs (Figures 1 to 5) shows the interface between the hardware and the table tops for the different tables tested.

## 3.3 INTERFACE EVALUATION — STATIC LOAD TEST:

### 3.3.1 METHOD:

The midpoint of each edge of the tables tested was subjected to loads of 80, 100, 120, 140, and 160 pounds (36, 45, 54, 64, and 73 kilograms), statically, for 1000 cycles at each load level. The height of each edge of the table top was obtained prior to completion of each 1000 cycles. At the completion of 5000 cycles the table was inspected for damage, looseness of the interface hardware, integ ity of support assembly and deflection of the table tops. The tests simulate a man sitting on the edge of the table.

### 3.3.2 SUMMARY OF TEST RESULTS:

| Table | Maximum Deformation After 5000 cycles | |
|---|---|---|
| | (inches) | (centimeters) |
| Tripro four-legged table | 1/8 | .317 |
| Borg-Warner four-legged table | 1/8 | .317 |
| Tripro pedestal table | 1/8 | .317 |

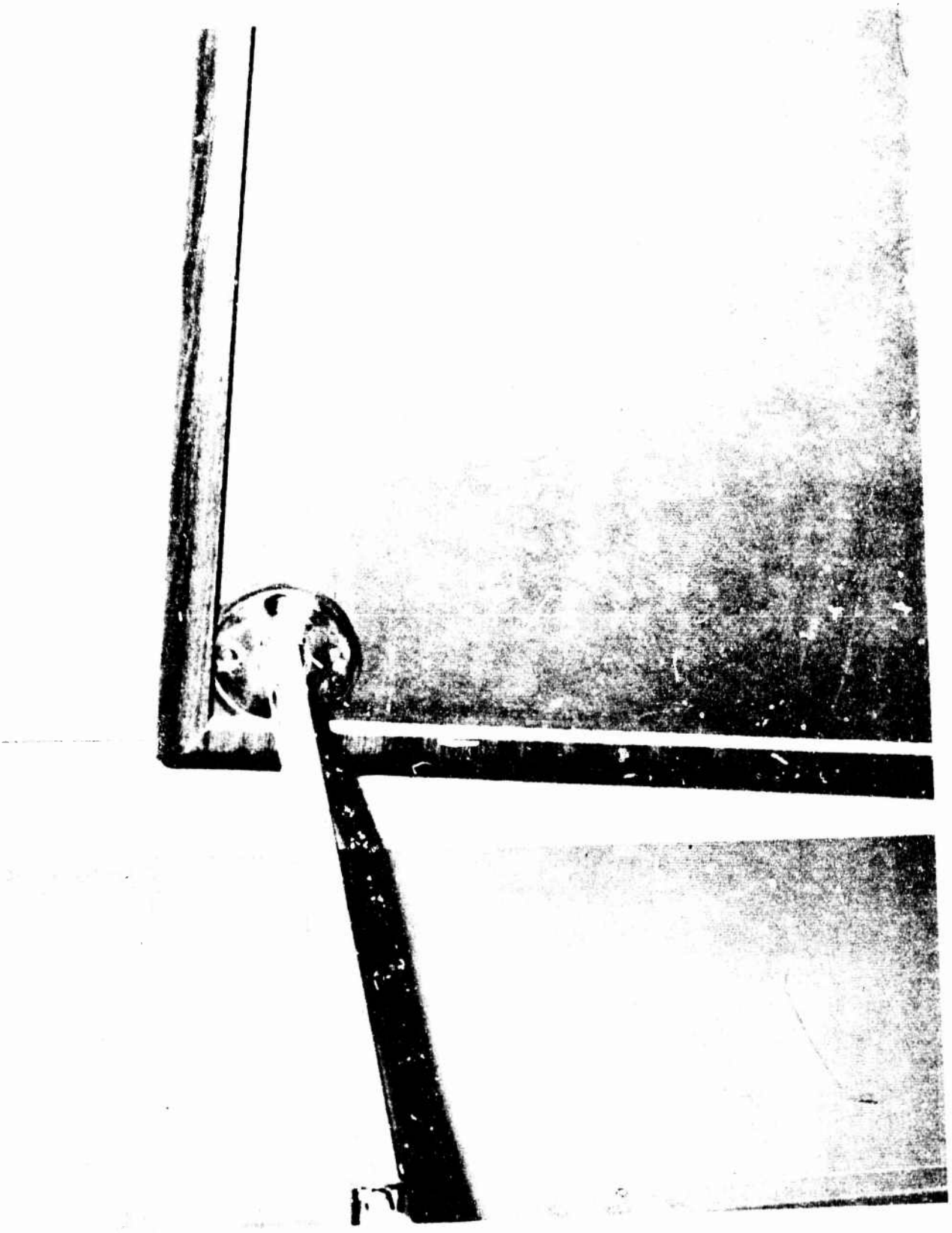


Figure 1. Hardware Assembly, Tripro Four-Legged Table.

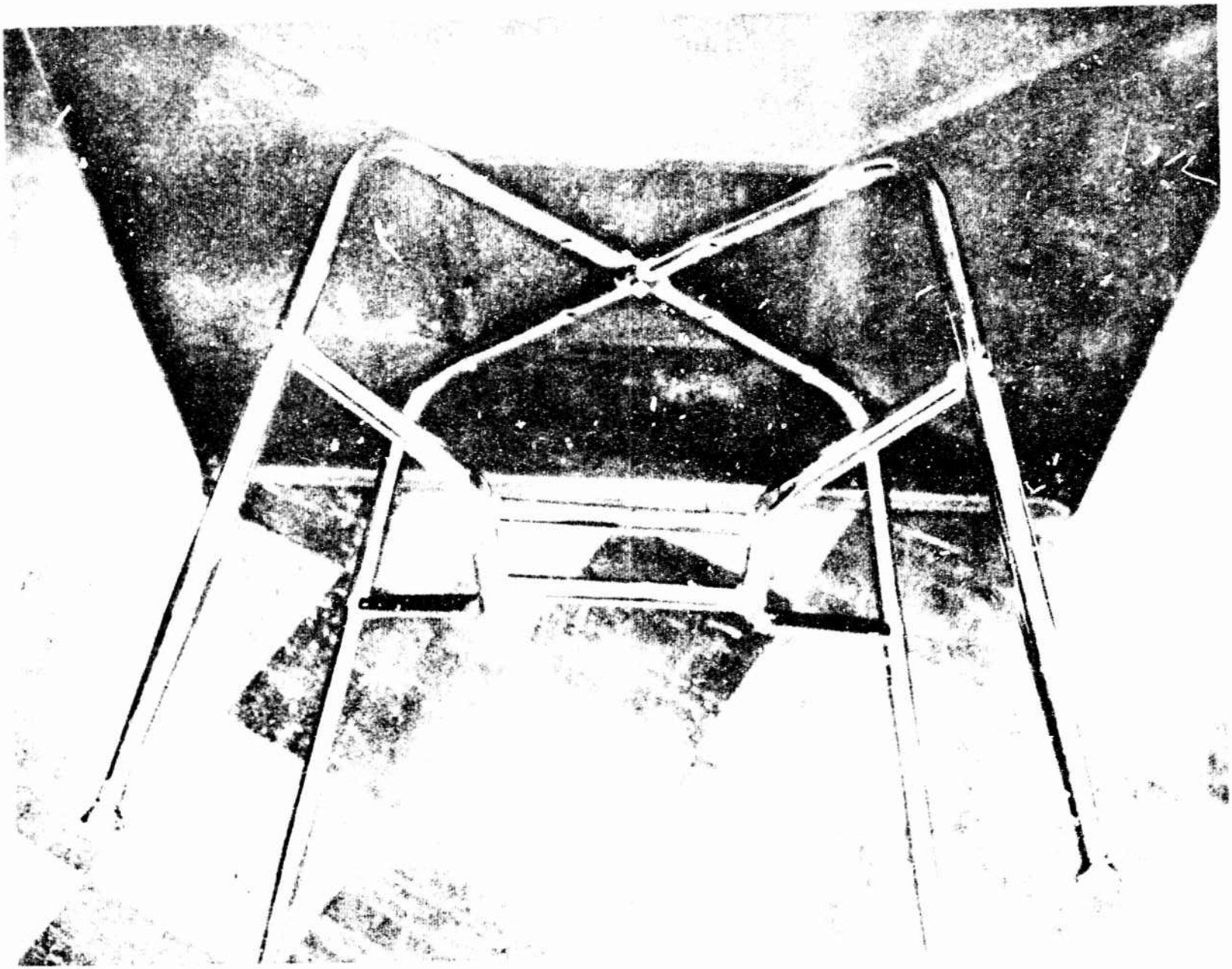


Figure 2. Hardware Assembly, Borg-Warner Four-Legged Table.

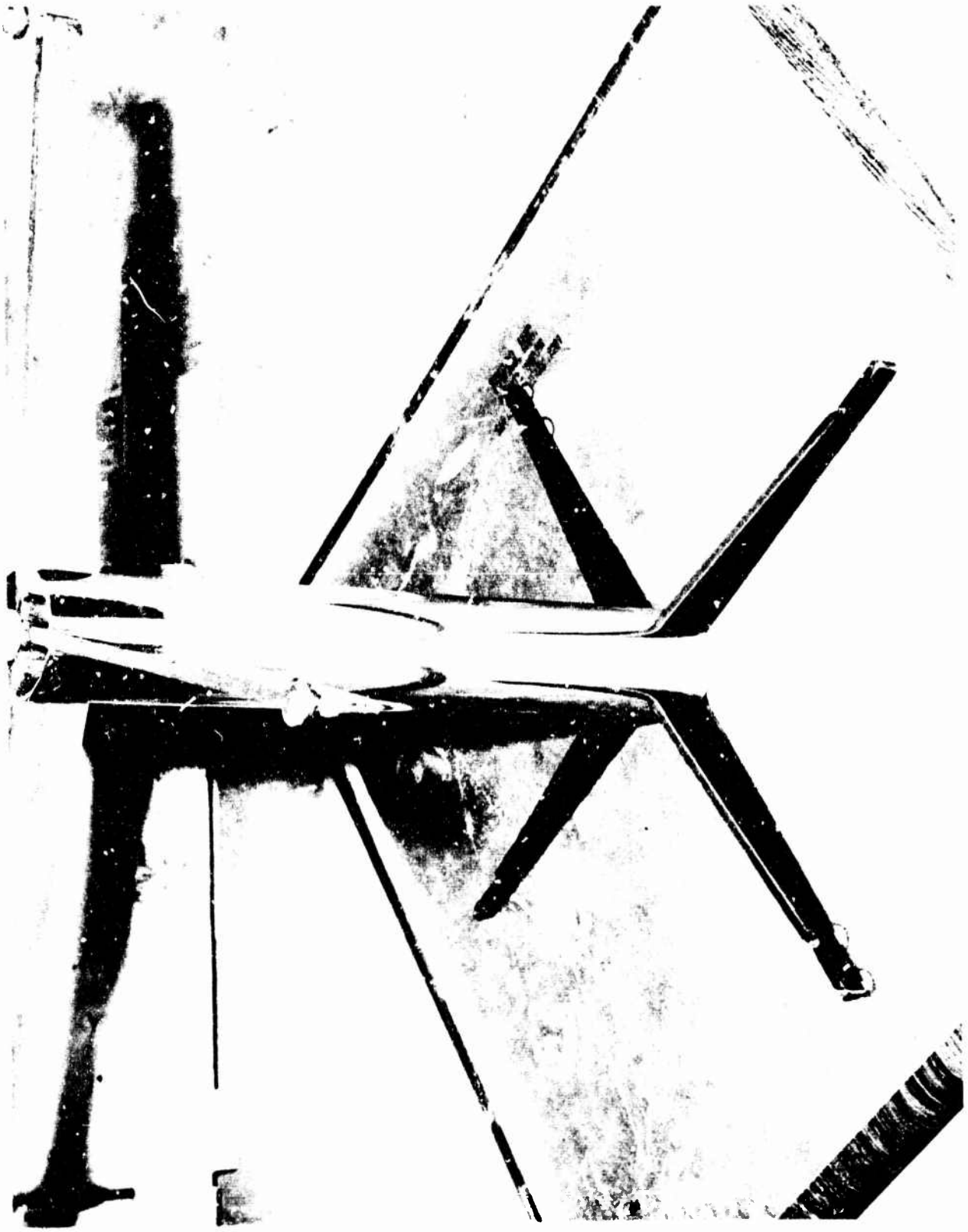


Figure 3. Hardware Assembly, Tripro Pedestal Table.

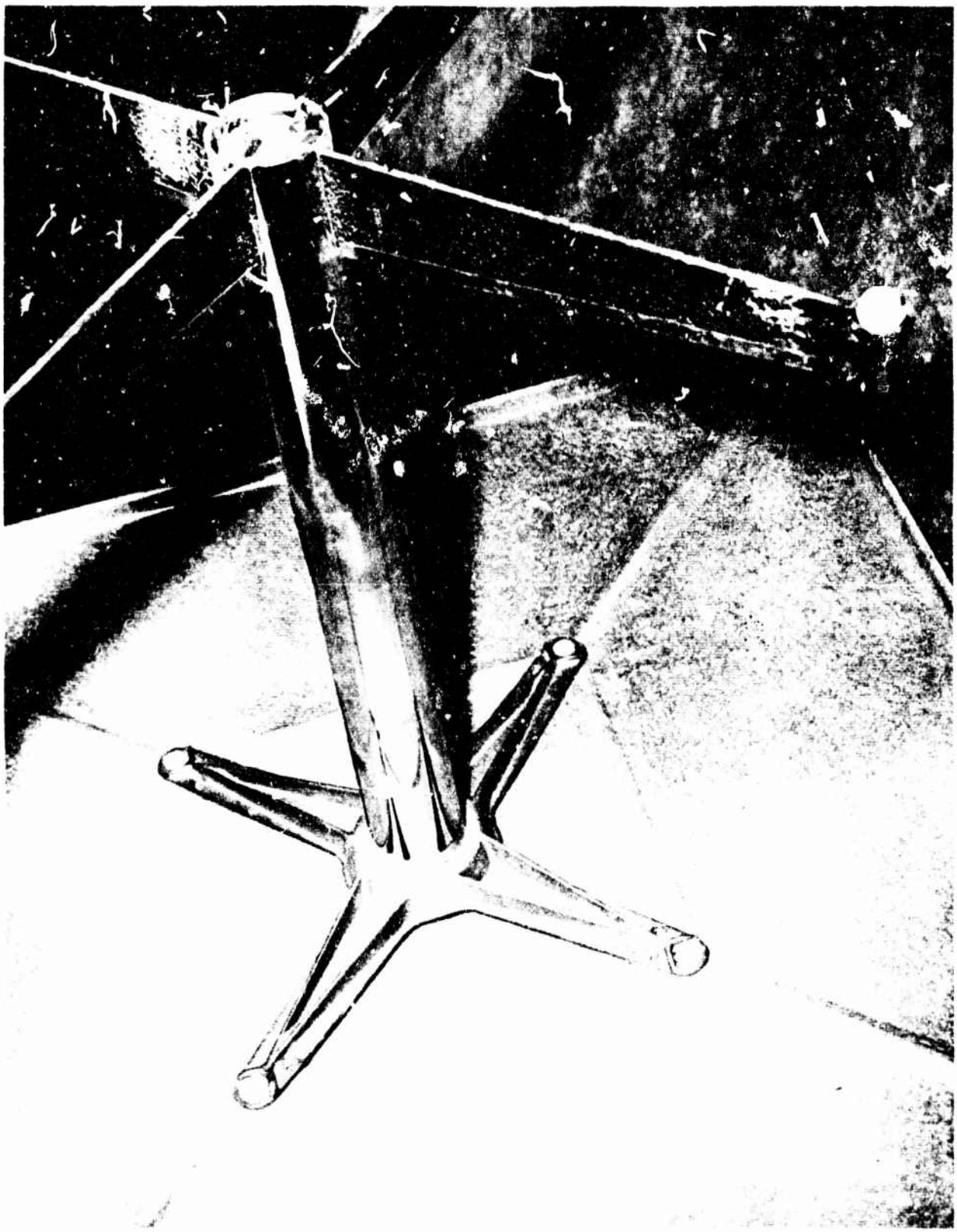
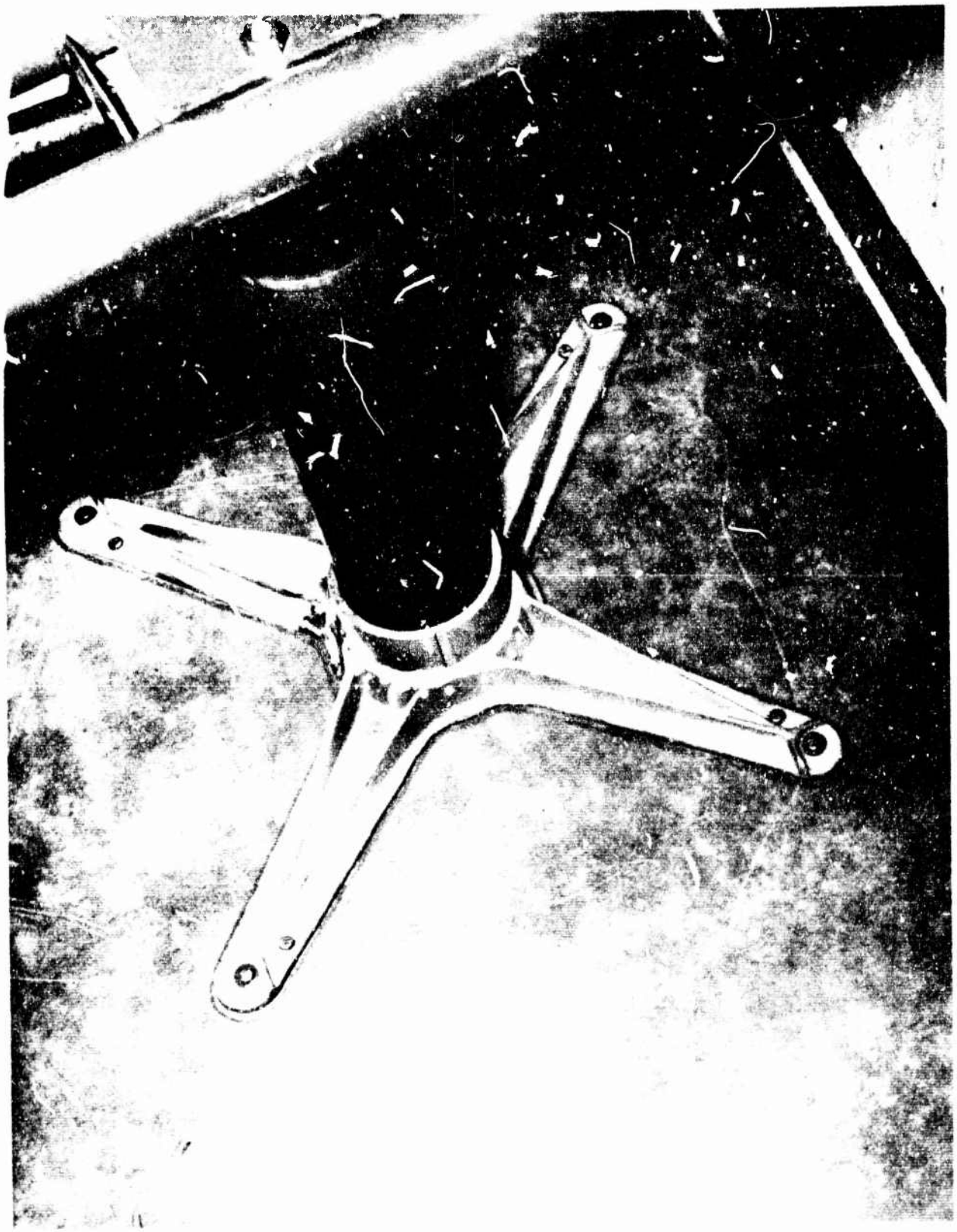


Figure 4. Hardware Assembly, Long-Barrier Pedestal Table.



| Table | Maximum Deformation After 5000 cycles (inches) | (centimeters) |
|---|---|---|
| Borg-Warner pedestal table | 1/4 | .635 |
| Borg-Warner combination chair/table assembly | 1/8 | .317 |
| Tripro combination chair/table assembly | 1/8 | .317 |

All of the above tables completed static load testing with no permanent damage or loose hardware. All support assemblies remained secure and undamaged.

3.4 STABILITY-RESISTANCE TO TIPPING TEST:

3.4.1 METHOD:

The midpoint of one edge of each table was subjected to increasing downward and outward loads at 30°, 45°, 60°, and 90° to the table top until the table tipped past its equilibrium point. The maximum force reached during three such tips was recorded using a calibrated load cell and the Brush Mark 200 recorder. One corner of each table was then subjected to the same forces and the maximum tipping force recorded. The tests simulated a table being tipped over by a man sitting on the edge or corner of the table or by some other means.

3.4.2 SUMMARY OF RESULTS:

3.4.2.1 INDIVIDUAL TABLES:

Results are presented only for angles of applied force of 60° and 90°.

| Table | Location of Force | Angle of Applied Force | Maximum Tipping Force (lbs) | (kg) |
|---|---|---|---|---|
| Tripro four-legged | Midpoint of edge | 90° | 140 | 63 |
| " " " | " " " | 60° | 45 | 20 |
| " " " | Corner | 90° | 130 | 59 |
| " " " | " | 60° | 55 | 25 |
| Borg-Warner four-legged | Midpoint of edge | 90° | 115 | 52 |
| " " " " | " " " | 60° | 50 | 23 |
| " " " | Corner | 90° | 120 | 54 |

| Table | Location of Force | Angle of Applied Force | Maximum Tipping Force (lbs) | (kg) |
|---|---|---|---|---|
| Borg-Warner four-legged | Corner | 60° | 55 | 25 |
| Tripro pedestal | Midpoint of edge | 90° | 125 | 57 |
| " " | " " " | 60° | 55 | 25 |
| " " | Corner | 90° | 140 | 63 |
| " " | " | 60° | 70 | 32 |
| Borg-Warner pedestal | Midpoint of edge | 90° | 95 | 43 |
| " " " | " " " | 60° | 50 | 23 |
| " " " | Corner | 90° | 90 | 41 |
| " " " | " | 60° | 60 | 27 |
| Borg-Warner combination | Midpoint of edge | 90° | >250 | >114 |
| " " " | " " " | 60° | 130 | 59 |
| " " " | Corner | 90° | >250 | >114 |
| " " " | " | 60° | 130 | 59 |
| Tripro combination | Midpoint of edge | 90° | 150 | 68 |
| " " | " " " | 60° | 95 | 43 |
| " " | Corner | 90° | 150 | 68 |
| " " | " | 60° | 100 | 45 |

3.4.2.2 AVERAGE RESULTS:

| Table | Location of Force | Angle of Applied Force | Maximum Tipping Force (lbs) | (kg) |
|---|---|---|---|---|
| Pedestal | Midpoint of edge | 90° | 110 | 50 |
| " | " " " | 60° | 53 | 24 |

| Table | Location of Force | Angle of Applied Force | Maximum Tipping Force (lbs) | (kg) |
|---|---|---|---|---|
| Pedestal | Corner | 90° | 115 | 52 |
| " | " | 60° | 65 | 30 |
| Four-legged | Midpoint of edge | 90° | 128 | 58 |
| " " | " " " | 60° | 55 | 25 |
| " " | Corner | 90° | 122 | 55 |
| " " | " | 60° | 47 | 21 |
| Combination | Midpoint of edge | 90° | > 200 | >91 |
| " | " " " | 60° | 113 | 51 |
| " | Corner | 90° | > 200 | >91 |
| " | " | 60° | 115 | 52 |

3.4.3 DISCUSSION OF RESULTS:

It may be observed from the data in Section 3.4.2.1 that of the units tested the Borg-Warner combination had the greatest resistance to tipping. With the angle of applied force of 90° the Borg-Warner combination was followed by the Tripro combination, four-legged and pedestal units, then the Borg-Warner four-legged unit, and finally the Borg-Warner pedestal unit. With the angle of applied force of 60°, resistance to tipping of the Tripro combination unit followed the Borg-Warner combination, followed by the Tripro pedestal unit, then the Tripro four-legged and Borg-Warner four-legged and pedestal units. As would be expected, the maximum tipping force applied at an angle of 60° is substantially less than the maximum tipping force applied at an angle of 90°, since the applied force at an angle of 60° is more nearly tangent to the direction of rotation of the units tested.

It is observed in the average results in Section 3.4.2.2 that there is little difference in tipping resistance between the pedestal and the four-legged tables at both angles of applied force. It may also be seen that the combination units have a substantially higher tipping resistance than either the pedestal or four-legged tables.

## 3.5 STABILITY-RESISTANCE TO LIFTING:

### 3.5.1 METHOD:

The midpoint of one edge of each table was subjected to increasing vertical lifting forces until the table tipped past its equilibrium point. The maximum lifting force reached during three such lifts was recorded using a calibrated load cell and the Brush Mark 200 recorder. One corner of each table was then subjected to the same forces and the maximum lifting force recorded. The test simulated the upset of the table by a man suddenly rising or by some other means.

### 3.5.2 SUMMARY OF RESULTS:

#### 3.5.2.1 INDIVIDUAL TABLES:

| Table | Location of Force | Maximum Lifting Force (lbs) | (kg) |
|---|---|---|---|
| Tripro four-legged | Midpoint of one edge | 25 | 11 |
| " " " | Corner | 25 | 11 |
| Borg-Warner four-legged | Midpoint of one edge | 35 | 16 |
| " " " " | Corner | 35 | 16 |
| Tripro pedestal | Midpoint of one edge | 35 | 16 |
| " " | Corner | 35 | 16 |
| Borg-Warner pedestal | Midpoint of one edge | 30 | 14 |
| " " " | Corner | 30 | 14 |
| Borg-Warner combination | Midpoint of one edge | 60 | 27 |
| " " " | Corner | 60 | 27 |
| Tripro combination | Midpoint of one edge | 50 | 23 |
| " " | Corner | 50 | 23 |

3.5.2.2 AVERAGE RESULTS:

| Table | Location of Force | Maximum Lifting Force (lbs) | (kg) |
|---|---|---|---|
| Pedestal | Midpoint of one edge | 32 | 15 |
| " | Corner | 32 | 15 |
| Four-legged | Midpoint of one edge | 30 | 14 |
| " " | Corner | 30 | 14 |
| Combination | Midpoint of one edge | 55 | 25 |
| " | Corner | 55 | 25 |

3.5.3 DISCUSSION OF RESULTS:

It may be observed in the results presented in Section 3.5.2.1 that the Borg-Warner combination unit has the greatest resistance to lifting, followed by the Tripro combination unit, then by the Borg-Warner four-legged and Tripro pedestal tables, and finally by the Borg-Warner pedestal and Tripro four-legged tables. It is seen in the average results presented in Section 3.5.2.2 that the lifting forces required to topple the pedestal and four-legged tables tested are essentially equal, and the lifting forces required to topple the combination units are substantially higher than those required to topple the pedestal and four-legged tables.

3.6 INTERFACE EVALUATION - IMPACT TEST:

3.6.1 METHOD:

Each table was tipped to its equilibrium point and allowed to free-fall 100 times from that point to impact on an asphalt tile floor of the type used in dining halls. The support assembly and hardware were then inspected for looseness and damage. This test simulated damage to a table being knocked over.

3.6.2 SUMMARY OF RESULTS:

Hardware loosened on all tables except the Borg-Warner four-legged table. The only table to have permanent support assembly damage was the Tripro pedestal table. Damage occurred after the fiftieth drop.

## 3.7 NLABS USE TESTS:

### 3.7.1 WHEEL CHAIR USE TEST:

#### 3.7.1.1 METHOD:

A standard wheel chair and occupant with leg supported parallel to the floor (to simulate "leg in cast" condition) was placed at each table near the middle of one side. Also a standard wheel chair and occupant with both feet touching the floor was placed at each table near the middle of one side. The Borg-Warner combination table/chair unit was deleted from these tests due to the nature of its construction and impracticality of wheel chair use.

#### 3.7.1.2 RESULTS:

It was found that in all cases the test subject's foot (supported parallel to the floor) would not slide under the table top without twisting, which would eliminate use of any of these tables for subjects with leg casts. An attempt was made to place the wheel chair and test subject at the corner of each table with the supported leg beyond the table edge but this was found to be impractical and awkward for proper table use.

For test subjects without simulated leg casts the wheel chair arm height prevented close approach to the table top, requiring the test subject to sit forward in the wheel chair in order to reach the table top. This was considered extremely uncomfortable for proper table use.

The distance between the floor and bottom of the table top for the units tested varied between 26 1/4 in. and 28 1/2 in. (66.9 cm and 72.4 cm). A distance of 32 in. (81 cm) would allow for convenient use of a wheel chair with the table tested.

### 3.7.2 POST CAFETERIA USE TEST:

A use test was performed in the NLABS post cafeteria. One four-legged and one pedestal table (Tripro), one four-legged and one pedestal table (Borg-Warner), and one Borg-Warner combination table/chairs were tested. Questionnaires were issued with each table. In the case of the combination table/chairs, the question asked was what features of the unit did the user like or dislike. In the case of the pedestal and four-legged tables, the question asked was what features of the legs of the table did the user like or dislike.

With the combination table/chairs the comments were that the chairs were comfortable for the average person, but were not comfortable for the stout person. Insufficient responses were received to draw any conclusions on the pedestal versus the four-legged tables.

## 4.0 CONCLUSIONS:

A. The present 1/8-inch (.317-cm) flatness requirements for pedestal tables is considered unnecessarily restrictive for larger tops and could be relaxed to at least 1/4 inch (.635 cm) without jeopardizing good design.

B. The Tripro top displayed those qualities most desired for practically all areas investigated and should therefore prove quite adequate for use within a military dining hall.

C. The Tripro top was far superior to the Borg-Warner top in terms of scratch resistance, stain resistance and burn resistance.

D. Under static loading conditions all the pedestal tables, four-legged tables and table/chair combinations are essentially equal - no damage to the support assembly.

E. The stability of the pedestal versus the four-legged tables is essentially similar.

F. The combination table/chairs were considerably more stable than either the pedestal or four-legged tables.

G. The combination table/chairs are not comfortable for stout people.

## 5.0 RECOMMENDATIONS:

A. Initiate a project to revise Military Specifications MIL-T-43463, Table, Dining, Pedestal Base and MIL-T-43417, Table, Dining, 4-Place to:

1. Include the Tripro Manufacturing Corporation top construction, the Borg-Warner top construction with modifications to pass proposed Quality Assurance Provisions 5.0A4a and b, and other top constructions of similar materials in all sizes covered.

2. Relax the top flatness requirement to 1/4 inch (.635 cm) for tables 40 inches (102 cm) and up.

3. Include specification of a 32-inch (81-cm) leg for hospital use.

4. Include under Quality Assurance Provisions the following tests and criteria for article rejection:

a. Draw sharp objects across the table top. If significant scratches appear, reject the table.

b. Leave a burning cigarette for five minutes on the table top. Wash any burn marks or discoloration with a mildly abrasive soap. If the burn marks or discoloration remain, reject the table.

c. Subject the midpoints of the edges of the table top to a static load of 200 pounds (87 kilograms) for 1000 cycles. If any damage, looseness of the interface hardware, or loss of integrity of the support assembly occurs, reject the table.

d. Tip the table to its equilibrium point and allow to free-fall ten times on a tile floor. If more than slight cracks or crazing of the top occur or if looseness of the interface hardware and loss of integrity of the support assembly occur, reject the table.

B. The combination table/chairs should be given consideration for inclusion in Army specifications.