NATIONAL BUREAU OF STANDARDS REPORT

5239

BREAKING STRENGTH OF FRANGIBLE
TUBE BASE ADAPTERS

by

L. K. Irwin and J. I. Price

To

Equipment Laboratory
Wright Air Development Center
Department of the Air Force

NBS

U. S. DEPARTMENT OF COMMERCE
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Engineering Mechanics Section
Mechanics Division

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IMPORTANT NOTICE

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1. INTRODUCTION

The tube base adapter detailed on U.S.A.F. Air Materiel Command drawing No. 49B7050 is used to mount standard elevated runway marker lamps for military airports. The MIL series specification covering this item has not been promulgated. The mechanical requirements for the couplings are that they have sufficient strength to withstand the loads due to wind, handling, installation, etc. and also that they be frangible enough to prevent damage to the aircraft and vehicles which may collide with the marker lamps. A weakened cross section is incorporated in the adapters to insure a satisfactorily low energy to fracture.

The results of this report are intended to provide the basic technical data required to supplement procurement specifications for frangible adapters. Included in this report are the results of static load tests, dynamic load tests and chemical analyses of adapters furnished to the Air Force by three manufacturers. Also, a method for measuring the wall thickness under a notch, limitations of dynamic tests to determine energy to fracture, and recommendations for requirements in a specification for this item are discussed.

2. APPARATUS

2.1 Samples

Thirty-nine samples from three manufacturers were tested with thirty-five of the adapters subjected to impact loading and four to static loading. The samples designated as groups A, B and sample C-1 complied with the dimensional requirements given on drawing No. 49B7050, a tracing of which is shown in figure 1. The A and B samples were taken from Air Force stocks and sample C-1 had been removed from service because it had not fractured when struck by a rubber tired vehicle. The samples designated C-2 through C-16 were essentially similar to the other samples except that the unthreaded end was extended approximately 2 inches. These samples were machined to approximately the length given on drawing No. 49B7050 before they were tested.

Table 1 - Dimensions of Frangible Adapters

Sample No.	Wall thickness at the notch			Outside diameter of the top	Distance from top to center of notch	Overall length
	Maximum	Minimum	Average			
	in.	in.	in.	in.	in.	in.
A-1	0.087	0.046	0.065	2.366	2.31	3.70
A-2	0.061	0.044	0.054	2.373	2.34	3.72
A-3	0.078	0.045	0.061	2.367	2.30	3.70
A-4	0.089	0.030	0.061	2.369	2.32	3.69
A-5	0.081	0.038	0.059	2.369	2.34	3.71
A-6	0.080	0.066	0.074	2.365	2.30	3.68
B-1	0.084	0.069	0.076	2.370	2.33	3.70
B-2	0.087	0.079	0.082	2.375	2.33	3.70
B-3	0.083	0.068	0.076	2.366	2.32	3.70
B-4	0.085	0.069	0.078	2.367	2.35	3.70
B-5	0.080	0.073	0.076	2.365	2.30	3.70
B-6	0.081	0.064	0.073	2.374	2.32	3.71
B-7	0.086	0.061	0.074	2.373	2.32	3.71
B-8	0.077	0.070	0.073	2.372	2.32	3.71
B-9	0.079	0.066	0.072	2.367	2.32	3.71
B-10	0.083	0.062	0.074	2.373	2.32	3.71
B-11	0.082	0.063	0.073	2.373	2.31	3.70
B-12	0.080	0.061	0.072	2.363	2.32	3.69
B-13	0.074	0.067	0.071	2.369	2.32	3.69
B-14	0.082	0.058	0.071	2.367	2.32	3.70
B-15	0.081	0.067	0.073	2.371	2.31	3.69
B-16	0.078	0.066	0.072	2.370	2.32	3.70
B-17	0.084	0.063	0.071	2.362	2.32	3.69
C-1	0.059	0.052	0.055	2.368	2.30	3.67
C-2	0.052	0.048	0.050	2.348	2.29	3.66
C-3	0.051	0.049	0.050	2.348	2.29	3.67
C-4	0.056	0.048	0.052	2.348	2.27	3.66
C-5	0.054	0.050	0.053	2.348	2.28	3.64
C-6	0.054	0.048	0.051	2.348	2.27	3.65
C-7	0.055	0.050	0.052	2.348	2.27	3.66
C-8	0.054	0.048	0.051	2.348	2.29	3.66
C-9	0.054	0.049	0.051	2.348	2.27	3.64
C-10	0.055	0.051	0.053	2.348	2.27	3.66
C-11	0.053	0.049	0.051	2.348	2.27	3.66
C-12	0.053	0.049	0.051	2.348	2.27	3.66
C-13	0.054	0.049	0.051	2.348	2.27	3.64
C-14	0.053	0.050	0.052	2.348	2.27	3.67
C-15	0.054	0.048	0.051	2.348	2.28	3.66
C-16	0.056	0.045	0.050	2.348	2.27	3.63

Table 2 - Chemical Compositions of Frangible Adapters, Percent

Sample No.	Cu	Fe	Si	Mg	Mn	Ni	Zn	Ti	Sn	Other Elements Each	Other Elements Total	Other Elements Cr	Other Elements Bi	Other Elements Cd
A-2	4.7	1.00	5.5	0.07	0.33	0.10	0.4	0.05	0.06(a)*	-	<0.50	0.03*	(b)	<0.004*
B-1	4.7	0.90	5.7	<0.01	0.44	0.29	0.4	0.05	0.07(a)*	-	<0.50	0.05*	0.03*	<0.004*
C-1	3.7	1.00	8.2	0.10	0.21	0.10	0.4	0.04	0.05(a)*	-	<0.50	<0.01*	0.06*	<0.004*
C-2	3.5	0.80	8.8	0.04	0.29	0.37	0.4	0.05	0.05(a)*	-	<0.50	<0.01*	(b)	<0.004*
Federal Specification QQ-A-591a Class 5	3.0-4.5	2.0	4.5-5.5	0.1	0.5	0.5	1.0	-	0.3	0.15	0.50	-	-	-
QQ-A-591a Class 10	3.0-4.0	1.3	7.5-9.5	0.1	0.5	0.5	1.0	-	0.3	0.15	0.50	-	-	-
QQ-A-596b Class 5	4.0-5.0	1.0	5.0-6.0	0.10	0.50	-	1.0	0.25	-	-	0.50	-	-	-

Note: Specification percentages are maximum except where indicated as a range

*Detected and estimated as indicated
(a) These amounts of tin included in total of other elements
(b) Not detected by methods sensitive to 0.015 percent.

The most significant geometrical feature of the adapter that could be correlated with static and dynamic strength appeared to be the wall thickness at the 60 degree notch. Values are given in table 1 for the minimum, maximum and average wall thicknesses at this reduced section for each sample. The outside diameter of the unthreaded end, the overall length, and distance from the top to the center of the notch for each adapter are also listed in table 1.

The chemical compositions of four samples given in table 2 were determined by spectrographic analysis.

2.2 Pendulum and Extension Posts

A pendulum was constructed by suspending a 31 pound steel bob with two pairs of small wires in such a manner as to keep the axis of the bob parallel to its original position in space. For stability, each pair of supporting wires was spread in a Vee with the anchor points about 3 feet apart. The suspension of the pendulum was designed to minimize rotational motions not required of a simple pendulum and to facilitate measurement of the distance of swing. The pendulum, extension post, and measuring system are shown schematically in figure 2.

Work by Faucett (1) on impact strength of breakable couplings indicated some of the advantages of using an extension post designed so that the center of percussion of the adapter and post coincided with the line of motion of the striking mass. For these tests, the extension posts were designed so that the center of percussion was 12 inches above the notch of the adapter with the portion of the adapter above the root of the notch assumed to be attached rigidly to the post. The post and portion of the adapter above the notch were assumed to rotate about a diameter through the root of the notch and perpendicular to the axis of the post. With these assumptions, loading the post and adapter through the center of percussion and perpendicular to the axis of the post would cause only bending stresses at the root of the notch.

The details of the steel extension post used for this investigation are shown in figure 3. The aluminum posts were similar in appearance but there were small differences in the diameters and wall thicknesses of the components. These differences were accounted for in the final dimensions to insure that the centers of percussion of these two posts were 12 inches above the notch. The first aluminum post fitted the adapters rather loosely and caused some concern about whether or not the

connection made by tightening the set screws was rigid enough to insure reproducible test conditions. A second aluminum post was fabricated with the inside diameter of the base approximately equal to the corresponding diameter of the steel post. These inside diameters and the weights of the posts are given below.

Extension post No.	Material	Inside diameter of the base	Weight
		in.	lb
1	aluminum	2.410	1.65
2	aluminum	2.390	1.62
3	steel	2.385	4.31

2.3 Base Plate and Mounts

A base plate for mounting the couplings was made of a 1-1/2 x 4 x 12 inch steel plate with a centered hole with 2 inch standard pipe threads. For the dynamic load tests, the base plate was clamped to the flange of a heavy I-section anchored in the concrete footings of a large testing machine. The base plate and mounting acted as a single rigid body for the purposes of these tests.

The base plate was mounted on two 1/2 x 4 x 7 inch steel angles with the adapter and extension post horizontal for the static load tests.

3. PROCEDURES

3.1 Measurement of Wall Thickness at the Notch

The method used to determine the thickness of metal at the notch is illustrated in figure 4. A hardened steel wire 0.106 inch diameter was placed in the notch and the distance M was measured with a deep throated micrometer with a ball anvil. When the included angle of the notch is 60°, the wall thickness is given by

$$t = M - 1.5d \qquad (1)$$

where t = the minimum metal thickness
M = the reading indicated by the micrometer
d = diameter of the wire.

For the size notch in the 2-inch adapter detailed on drawing No. 49B7050, the wire diameter should be in the range 0.090 to 0.120 in. The tolerance given for the notch angle is ± 1 degree. In this system of measurement if the notch angle is assumed to be exactly 60° then the error introduced by a ± 1 degree variation will be approximately ∓ 0.002 in. Another source of error is in the assumption that the bottom of the notch tapers to a point. If the bottom of the notch has a radius r, then the wall will be thicker than indicated by an amount equal to r.

3.2 Static Load Test

Each adapter tested by static loading was mounted horizontally in a steel fixture with an extension post attached to the adapter with set screws. Continuously increasing flexural loads were applied twelve inches from the notch through the extension post until failure of the sample occurred. The deflection of the post at the point of loading was observed simultaneously with selected increments of load.

The load-deflection characteristics of the extension posts were determined as described above except that a solid steel mandrel was substituted for the frangible adapter.

3.3 Impact Load Test

Each impact specimen was mounted vertically on a rigid base with an extension post attached to its top as shown in figure 5. It was then broken by a single blow from a 31 pound moving weight suspended as a pendulum. Potential energy was supplied to the pendulum by raising the bob to a selected height above its position of rest. The pendulum was released to swing through its arc and strike the extension post as it passed through the position of rest. An observer recorded the distance of horizontal swing beyond the positon of rest by comparing at the instant of maximum travel a reference line on the bob with a scale located adjacent to the path as shown schematically in figure 2. The maximum vertical displacement of the bob after impact was computed from the formula

$$V = R - \sqrt{R^2 - H^2} \qquad (2)$$

where V = vertical rise of the weight, in.
R = radius of the pendulum, in.
H = maximum observed horizontal travel of the weight past the position of rest, in.

The energy absorbed by the adapter and extension post was computed to be the difference between the potential energy and the final energy after impact. That is,

$$E_t = E_p - E_f \tag{3}$$

where E_t = the total energy absorbed by the adapter and extension post, ft-lb
E_p = the potential energy of the pendulum, ft-lb
E_f = the energy remaining in the pendulum after impact, ft-lb.

4. RESULTS

4.1 Static Tests

The results of static load tests of four adapters and the extension posts are given in table 3. To facilitate comparisons of the load-deflection characteristics of the adapters and extension posts, the deflections of the posts due to 300 lb applied 12 inches from the notch are listed.

Table 3 - Results of Static Tests; Load Applied 12 Inches from Notch

Sample No.	Extension post No.	Breaking strength	Deflection of post 12 inches from notch due to: 300 lb	Breaking load	500 lb
		lb	in.	in.	in.
A-6	1	375	0.29	0.37	-
B-5	1	430	0.34	0.48	-
C-3	3	345	0.08	0.11	-
C-16	2	320	0.13	0.15	-
None (a)	2	-	0.085	-	0.175
None (a)	3	-	0.070	-	0.105

(a) The adapter was replaced with a solid steel mandrel having the outside dimensions shown on drawing No. 49B7050.

The adapters broke across the roots of the notches at the breaking loads shown above without warning that failures were imminent. Visual examination indicated that the fracture occurred in each adapter without discernable plastic deformation in the region of the notch.

The load-deflection data for samples A-6 and B-5 were generally non-linear below about 300 lb. This may have been due to the poor fits between the adapters and extension post No. 1 indicated by the diameters listed in sections 2.1 and 2.2. Reasonably linear load-deflection relations were measured for samples C-3 and C-16 up to the breaking loads, for the steel extension post 3 up to 500 lb and for the aluminum extension post 2 up to 400 lb. Loads greater than 400 lb and up to 500 lb appeared to cause some permanent deformation of extension post 2.

4.2 Impact Tests

The thirty-five samples tested by impact loading fractured at the notch with one blow applied 12 inches above the root of the notch through an extension post. The results of these tests are given in table 4. Each adapter broke into two parts except sample C-1, which broke into three pieces as shown in figure 6. Some typical samples are shown in figure 7 after being tested.

The energy required to deflect an extension post assembled with the upper portion of an adapter from the path of the striker was measured for aluminum post No. 1 and for the steel post with the pendulum bob at various initial heights above the rest position. Also, measurements of the change in kinetic energy of the pendulum during the first half cycle of oscillation without striking an extension post were made. The results of these measurements are shown in figure 8. Each point shown for the pendulum striking the aluminum or steel posts represents the average of three runs. Each point shown for the pendulum swinging without striking a post represents the average of two runs. Values for energy to break (E_t, table 4) were averaged for adapters tested with similar extension posts and equal initial pendulum energy, and are shown on figure 8 for comparison. The energy to break adapter C-1 was excluded from these averages.

Table 4 - Results of Impact Tests. Weight of Pendulum Bob = 31 lb

Sample No.	Extension post No.	Available energy at impact, E_p	Measured energy to break E_t	Measured energy to break Average* E_t
		ft-lb	ft-lb	ft-lb
A-1	1	50	12.4	
A-2	1	50	7.3	
A-3	1	50	9.6	10.3
A-4	1	50	7.7	
A-5	1	50	14.5	
B-1	1	50	7.7	
B-2	1	50	8.4	11.4
B-3	1	50	13.7	
B-4	1	50	16.0	
B-6	3	50	11.8	
B-7	3	50	12.2	12.0
B-8	3	50	12.1	
B-9	3	50	11.7	
B-10	3	25	7.8	
B-11	3	25	7.4	6.9
B-12	3	25	6.1	
B-13	3	25	6.2	
B-14	1	25	6.5	
B-15	1	25	10.6	
B-16	1	25	4.6	7.2
B-17	1	25	7.0	
C-1	1	50	35.6	
C-2	3	50	10.8	
C-4	3	25	9.8	
C-5	3	25	6.5	8.0
C-6	3	25	6.5	
C-7	3	25	9.3	
C-8	1	25	12.7	
C-9	1	25	8.0	9.5
C-10	1	25	9.6	
C-11	1	25	7.8	
C-12	2	25	13.2	
C-13	2	25	9.1	9.8
C-14	2	25	10.9	
C-15	2	25	6.0	

*The energy to break adapters from one manufacturer and broken under similar test conditions.

5. DISCUSSION

The results of this and two previous investigations of the mechanical properties of frangible adapters show some of the difficulties inherent in determining the impact strength of these components. Some of the factors that may affect the results of dynamically loading frangible adapters are as follows:

(a). Resilience and geometry of the striker

(b). Resilience of the extension post and attachment to the adapter

(c). Resilience of the adapter mounting system

(d). Inertia of the extension post and upper portion of the adapter

(e). Geometries of the striker and extension posts

(f). Velocity of impact and modes of propagation of the resultant stress waves

(g). Physical properties of material in the adapters.

The relationships between these factors and the measured energy to break the adapters are complicated and not easily separable such that energies determined with different test procedures and fixtures cannot be compared except qualitatively.

Comparisons between some of the results of these tests and some of the results measured by Faucett (1)(2) and in an earlier investigation in this laboratory (3) are given in table 5. Only the results of samples tested by applying the loads (dynamic or static) twelve inches from the notch through an extension post are included. The results of this investigation that were included in this table were obtained with the pendulum raised approximately 19-1/4 inches before being released. The differences in test samples, procedures and fixtures used for determining the energy to break the adapters appear to preclude direct correlation between the results of different investigators. Only the samples marked Crouse-Hinds HL-P1716 (reference 2) and Crouse-Hinds FL 1561 (reference 3) were similar. For these two groups of samples the static breaking strengths were nearly equal but the energies to break differed by a factor of about 2.3 to 1. Both sets were broken by repeated impacts twelve inches from the notch with increasing increments of energy available in the striker with each successive impact. The test

Table 5 - Comparison of Results of This Investigation with Results of Previous Investigations.

Sample Identification	Nominal size	Average static breaking moment	Average energy to break	R*	Reference	Line
	in.	ft-lb	ft-lb			
A-1 thru A-5	2	375	10.3	0.027	-	1
B-1 thru B-9	2	430	11.7	.027	-	2
C-2 thru C-16	2	332	10.8	.033	-	3
AGA 49B7050	2	268	8.33	.031	(1)	4
Crouse-Hinds HL-P1772	2	536	7.58	.014	(2)	5
Line Material AL-1870B	1 1/2	312	12.2	.039	(2)	6
Crouse-Hinds HL-P1716 (FL 1561)	1 1/2	279	11.0	.039	(2)	7
Line Material 700959X1	1 1/2	148	2.35	.016	(3)	8
AGA 1765-22	1 1/2	105	1.49	.014	(3)	9
Crouse-Hinds FL 1518	1 1/2	94	0.99	.011	(3)	10
Westinghouse 5#1374908	1 1/2	111	0.96	.009	(3)	11
Crouse-Hinds FL 1561	1 1/2	274	4.73	.017	(3)	12

*R = ratio of the average energy to break divided by the average static breaking moment.

procedures and fixtures appeared to be comparable except that the striker reported in reference 2 was a 3-inch diameter steel sphere and the striker reported in reference 3 was a 15-inch long bar suspended in a manner somewhat similar to the pendulum bob shown in figure 2. These differences in geometry would cause the duration of the initial pressure pulse applied by the two strikers to an extension post to vary in proportions of about 4 or 5 to 1 and would probably cause significant variations in the magnitudes of the stresses applied to the notch during each loading cycle. This example illustrates some of the difficulties that are encountered in interpreting results of impact tests where all the experimental variables are not known and carefully controlled.

If the results shown in table 5 are considered in groups for which the test conditions were similar (that is; lines 1, 2 and 3, lines 6 and 7 and lines 8 through 12), there is reasonable agreement between the static breaking strength and the measured energy to break frangible adapters due to dynamic loading. This is evident when the ratios, R, of the energy to break to the static breaking moment are examined. For 100 percent agreement, the values of R would be constant for each set of test conditions and groups of adapters made of materials with similar physical properties. There was good agreement between these quantities for the group shown as lines 1, 2 and 3 with the range of ratios from 0.027 to 0.033. Agreement was perfect for the group of samples shown as lines 6 and 7 with R equal to 0.039. There was fair agreement between the results of the group shown as lines 8 through 12 with values of R ranging from 0.009 to 0.017 and a maximum variation of about 33 percent from the average values of 0.0134 for R. The energies to break given on lines 4 and 5 were obtained with different test procedures and fixtures as compared with each other and the other results given in table 5.

The problem of manufacturing frangible adapters with comparable impact strengths is similar to the problem of making notched bar specimens with reproducible energy to fracture characteristics. The literature on notched bar tests (Charpy, Izod, etc.) covers many of the aspects of the relationship between notch shape and sharpness and the capacity of materials to absorb energy imparted by impact. A conclusion reached and strictly adhered to by careful investigators of the impact properties of materials has been that the notch shape and sharpness must be kept as nearly constant as possible if any comparisons between materials are made. A commonly used standard containing these dimensions is A.S.T.M. Designation E23-47T.

It is reasonable to expect that the geometry (dimensions) of the adapters at and in the region near the notch will significantly effect the static breaking strength of an adapter and its capacity to resist impact loads. While the control used to produce the radii in notched bar specimens is not required for frangible adapters, a specified narrow range of allowable radii at the root of the notch along with a narrow range of wall thicknesses at the notch would reduce the likelihood of large differences in the measured mechanical properties of adapters from different manufacturers. The notch root radii were measured for samples B-6 through B-17, C-2 and C-3. The measured radii were in the range of 0.009 to 0.013 inches. The notches of the B samples had been machined while the notches of the C samples were as cast. Cross plotting the energy to break (table 4) against the measured radius of the root of the notch indicated there was little or no correlation between these quantities. Also, there was very little evidence of correlation indicated by the cross plots of the wall thicknesses, table 1, versus the energy to break. Probably, the previously listed factors which influence the indicated energies to break obscured the effects of measured differences in wall thickness and notch root radii.

The chemical compositions of the samples A-2 and B-1 given in table 2 complied with the requirements given in Federal Specification QQ-A-596b, "Aluminum Alloy Permanent and Semi-permanent Mold Castings", class 5. The compositions of samples C-1 and C-2 complied with the requirements given in Federal Specification QQ-A-591a, "Aluminum Alloy Die-Castings", class 10 but did not comply with requirements for percent silicon listed in this specification for the class 5 material. The material designated on drawing No. 49B7050 is as follows: "Alum. Casting Spec. QQ-A-591 Class-5--Option--Permanent Mold Cast'g Spec. QQ-A-596".

6. SUMMARY

The results of impact tests of thirty-five frangible adapters, static load tests of four samples, dimensional measurements of the thirty-nine samples and the chemical compositions of four of these samples are presented and discussed. The test procedures and test fixtures used to determine the energy to break the adapters are described. Also, a method for measuring the wall thickness under the notch is shown.

The measured energy to break sample C-1 was 35.6 ft-lb and the energies to break the other thirty-four adapters ranged from 4.6 to 16.0 ft-lb. That is, C-1 was found to be from 2.2 to 7.7 times more resistant to impact loading than the other adapters tested. The causes for the higher impact strength measured for sample C-1 were not apparent from considerations of the dimensions and chemical composition of the sample. The alloy used for this sample (QQ-A-591a, class 10) is considered to be more susceptible to precipitation hardening than the alloys for samples A-2 and B-1.

There was little or no evidence of a relationship between the measured values of energy to break and the dimensions of these adapters. This was probably due to the small range in the differences in the dimensions of the adapters from one manufacturer and scatter inherent in the methods used to determine the energies to break.

The test procedures and test fixtures used for determining the energies to break were very important. Results of table 4 show that higher initial energy of the pendulum caused higher measured energy to break adapters from the same source. Also, there was some evidence that the measured energies to break were higher with the aluminum extension posts than with the steel post.

There was good agreement between the values of static moment to break and impact energy to break adapters of the same manufacture under similar test conditions. The results of some previous investigations were compared for the relationships between the static breaking strengths and dynamic breaking strengths.

For the samples tested by static loading, the moments required to break the adapters ranged from 320 to 430 ft-lb.

7. RECOMMENDATIONS

To reduce the probability of large variations in the static and dynamic strengths of adapters from the same lot, the range of allowable wall thicknesses at the notch and radii at the root of the notch should be shown on the detailed drawing for these adapters. Suggested dimensions and tolerances are shown in figure 9.

The static moment required to break the four samples tested varied from 320 to 430 ft-lb. It is believed that a range 375 ±75 ft-lb would be satisfactory for adapters of

suitable materials manufactured to the dimensions shown in figures 1 and 9.

The impact test results for 31 of the 34 samples (91 percent of the samples tested excluding sample C-1) were within the range 10.0 ±4.0 ft-lb. It is believed that this range would be satisfactory for adapters of suitable materials manufactured to the dimensions shown in figure 1 and 9.

Since for a given manufacturing process, material and geometry of frangible adapter, there is a relationship between the static breaking moment and the impact breaking strength, the use of the static breaking moment only should be considered for procurement specifications. However, when the manufacturing process, material or geometry of the adapter is changed, both the static and impact strengths should be determined.

For the Director,

B L Wilson

B. L. Wilson, Chief,
Engineering Mechanics Section,
Division of Mechanics.

Washington, D. C.
April 1957

REFERENCES

1. Faucett, Robert E., "Static and Dynamic Tests of Frangible Couplings", Test X (Mechanical); Civil Aeronautics Administration, Technical Development and Evaluation Center, Indianapolis, Indiana; September 1952.

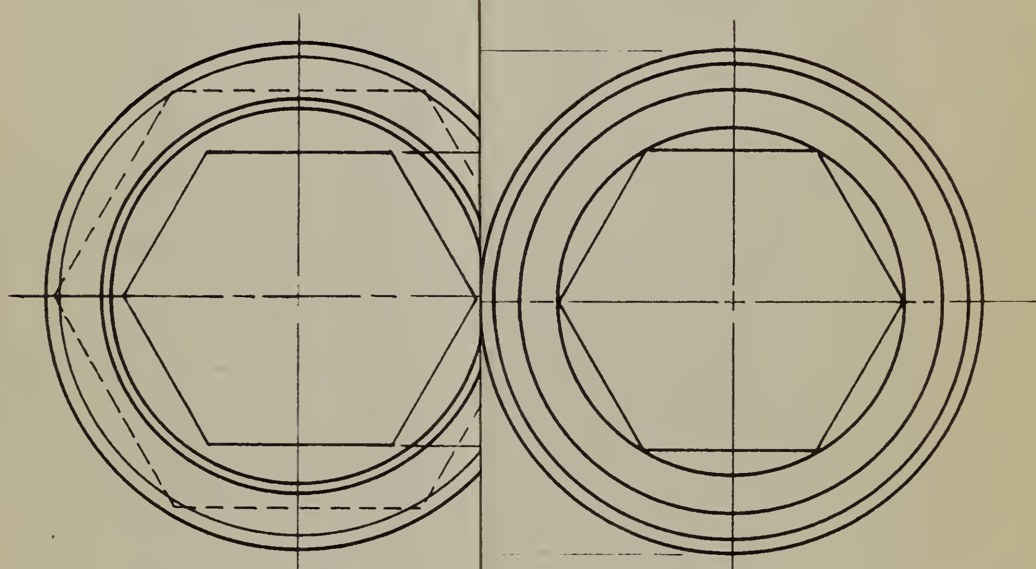
2. Faucett, Robert E., "Static and Dynamic Tests of Frangible Couplings", Test Series XVIII (Mechanical); Civil Aeronautics Administration, Technical Development and Evaluation Center, Indianapolis, Indiana; 1953.

3. Anonymous, National Bureau of Standards Report on Breakable Couplings; Lab. No. 6.4/6-123-35, Washington, D. C.; January 30, 1950.

$\frac{1}{16}$ R

OLERANCES ON FRACTIONS $\pm \frac{1}{64}$
ANGLES $\pm$ 1°

x $\frac{1}{16}$

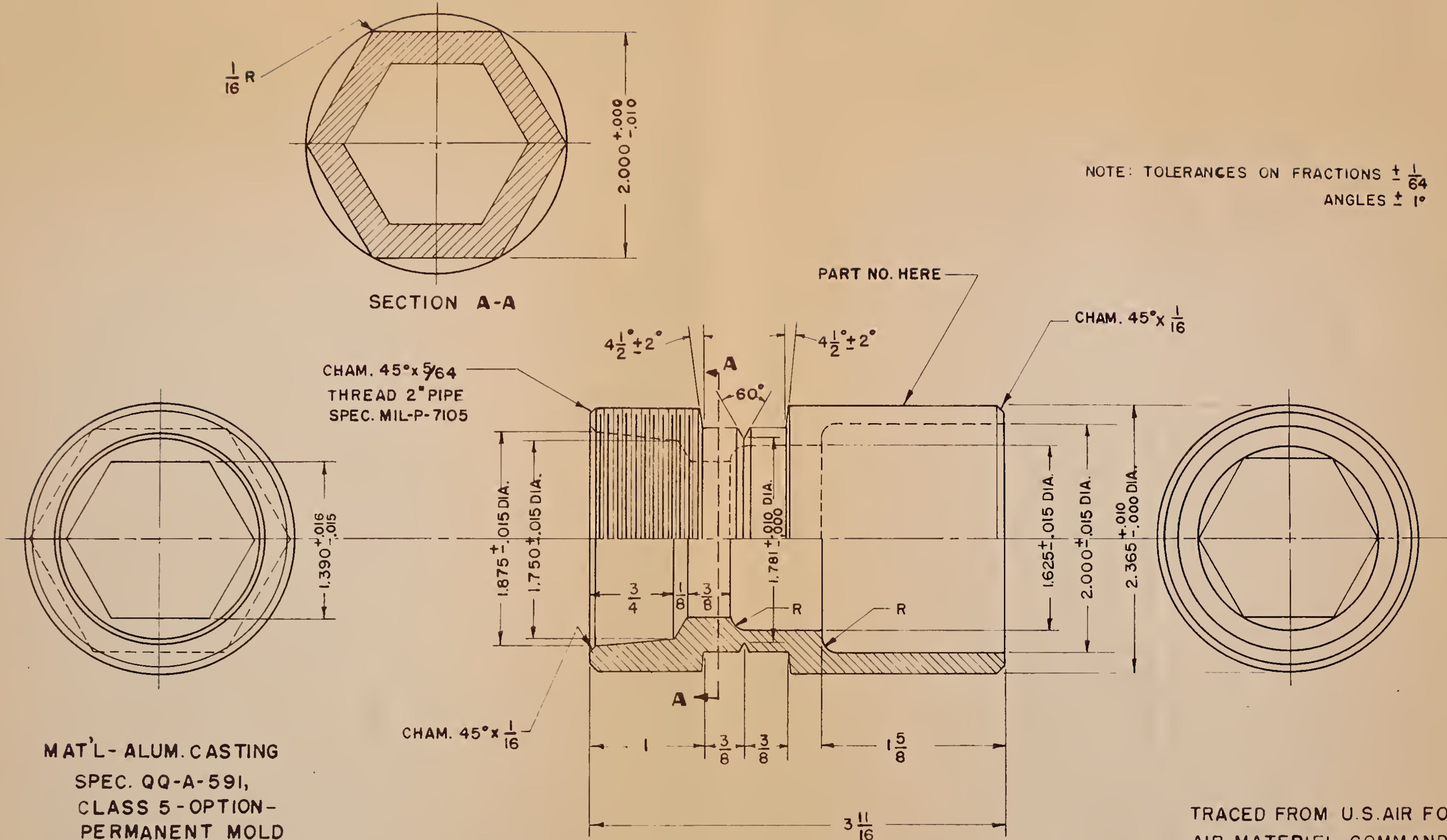


MAT'L- ALUM. CASTI
SPEC. QQ-A-591,
CLASS 5-OPTIO
PERMANENT MO
CAST'G SPEC. C

TRACED FROM U.S. AIR FORCE
AIR MATERIEL COMMAND
DRAWING 49B7050

FIGURE 1

NOTE: TOLERANCES ON FRACTIONS ± 1/64
ANGLES ± 1°

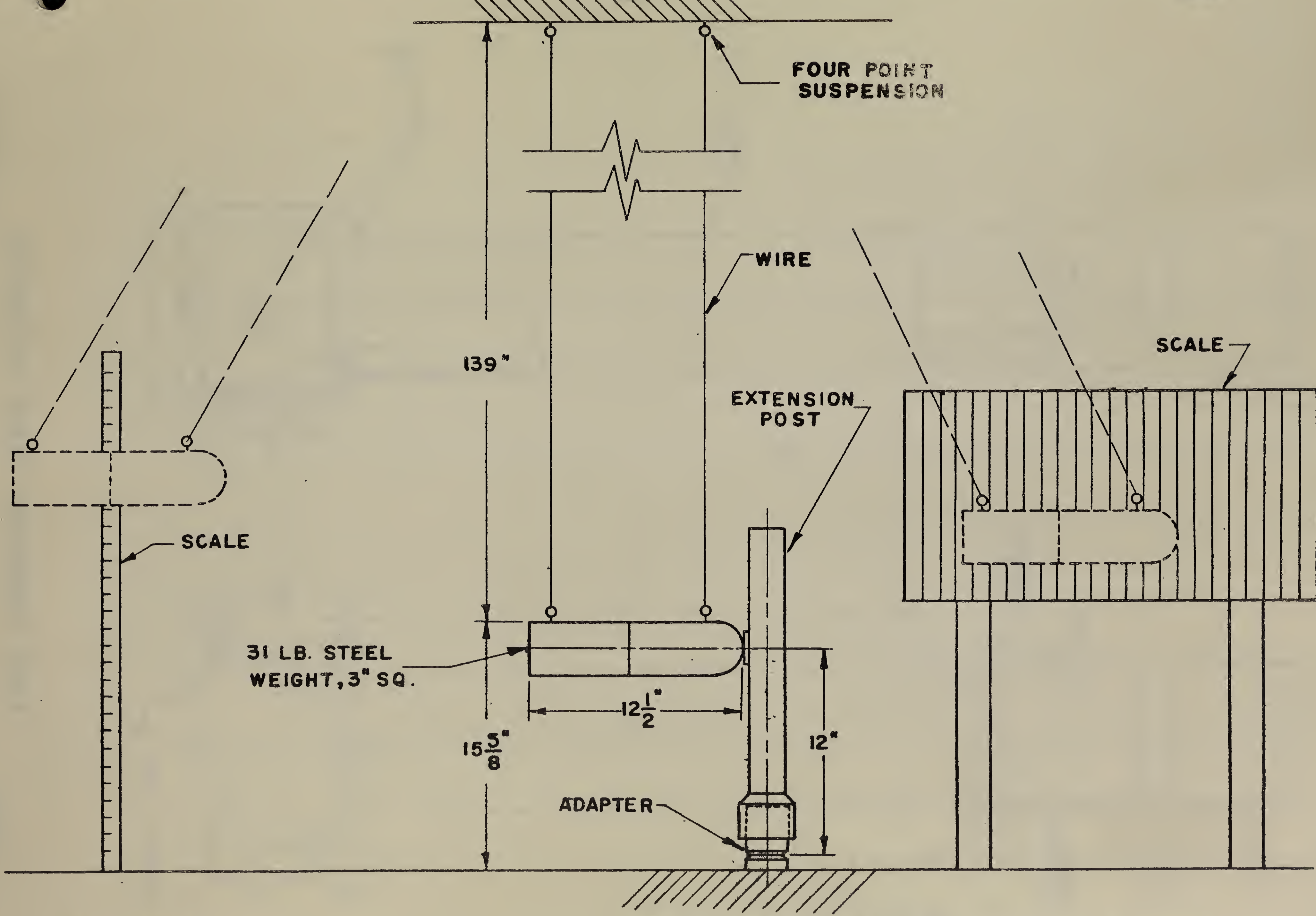


MAT'L - ALUM. CASTING
SPEC. QQ-A-591,
CLASS 5 - OPTION -
PERMANENT MOLD
CAST'G SPEC. QQ-A-596

TRACED FROM U.S. AIR FORCE
AIR MATERIEL COMMAND
DRAWING 49B7050

TUBE-BASE ADAPTER, RUNWAY MARKER LAMP

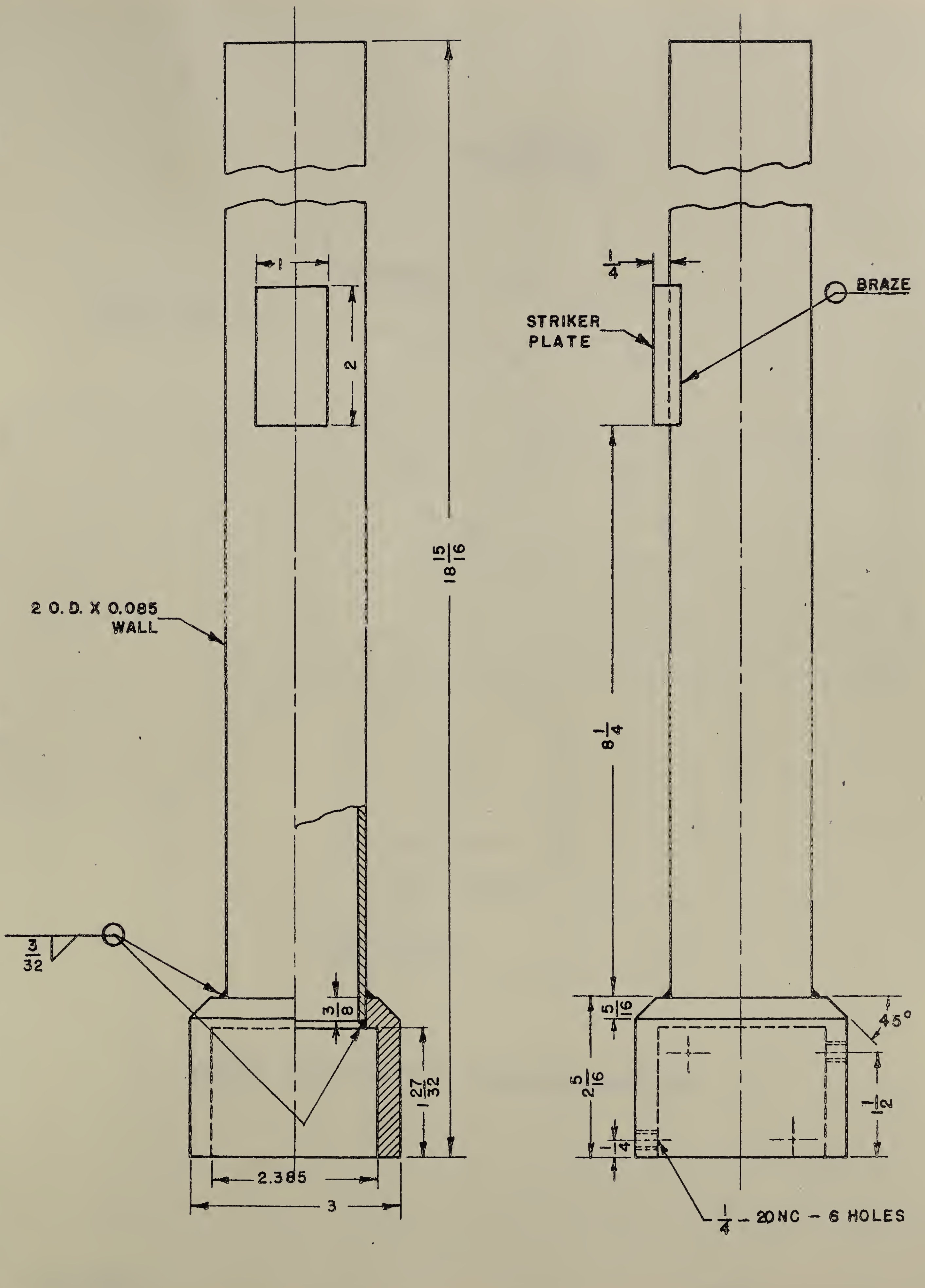
FIGURE 1



6.4/295-3

IMPACT TEST FIXTURES

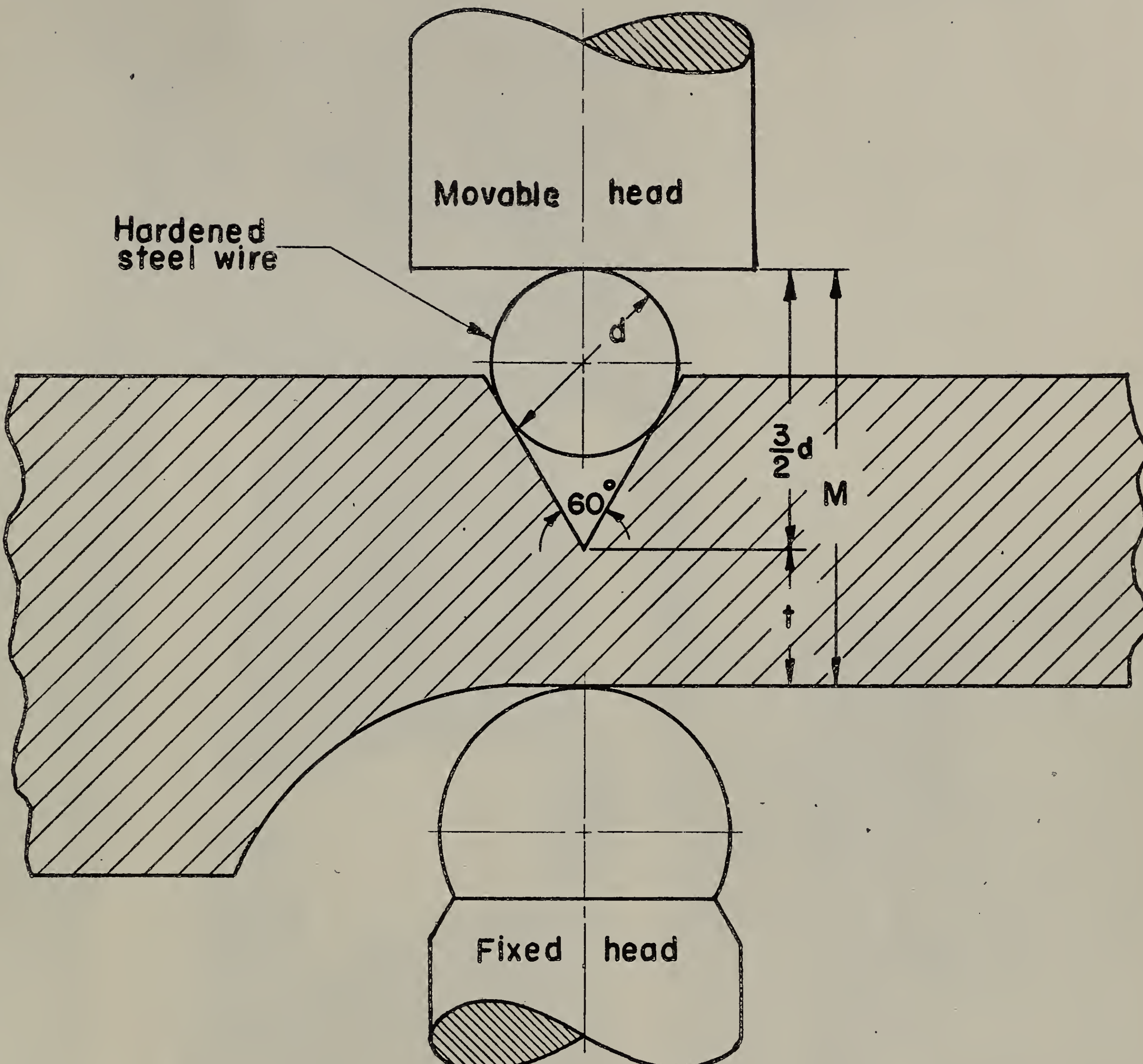
FIGURE 2



6.4/295-3

DETAILS OF STEEL EXTENSION POST

FIGURE 3



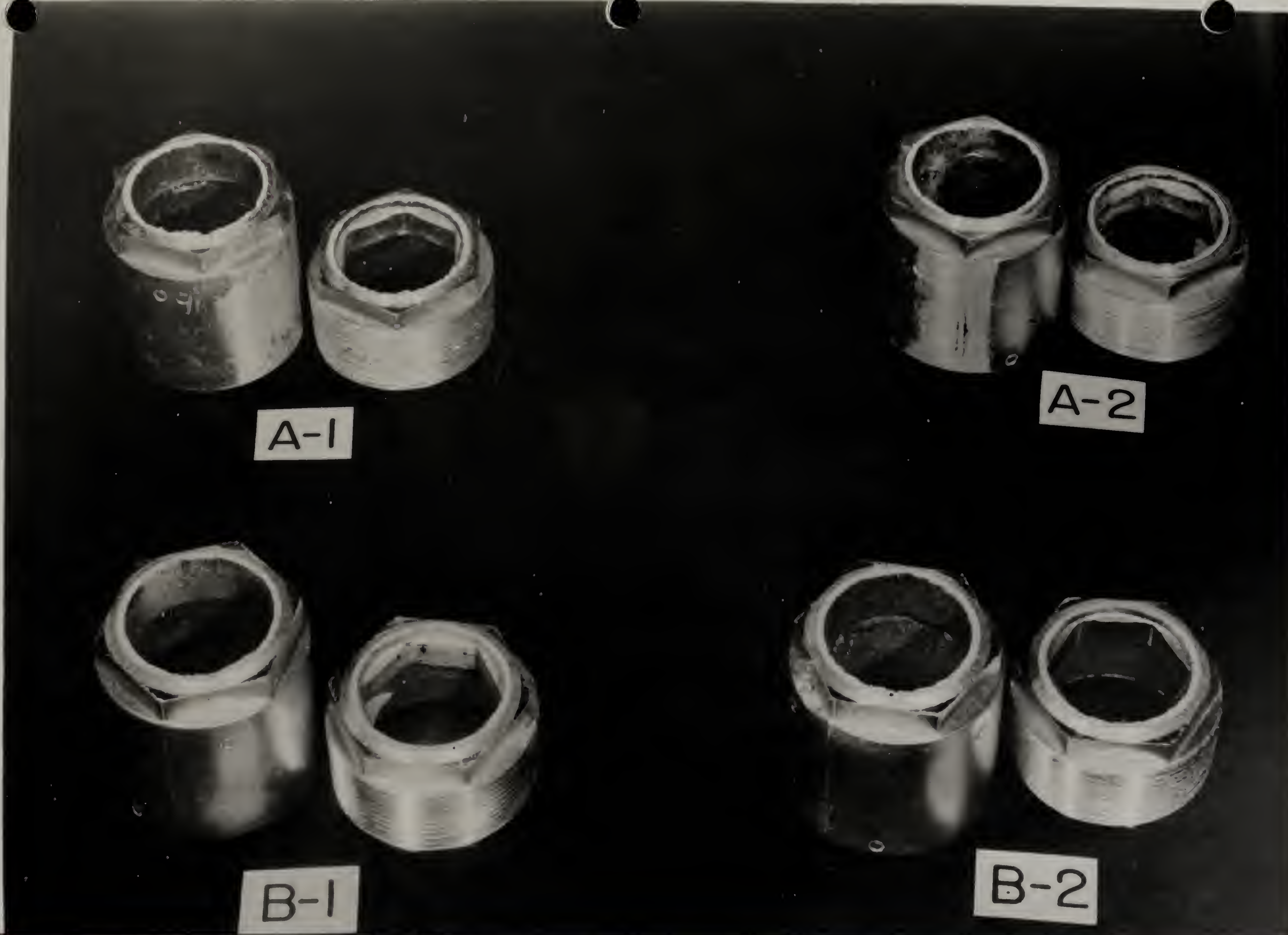
WALL THICKNESS MEASUREMENT


Laboratory Set-up for Impact Test of Frangible Adapters
6.4/295-3
Figure 5

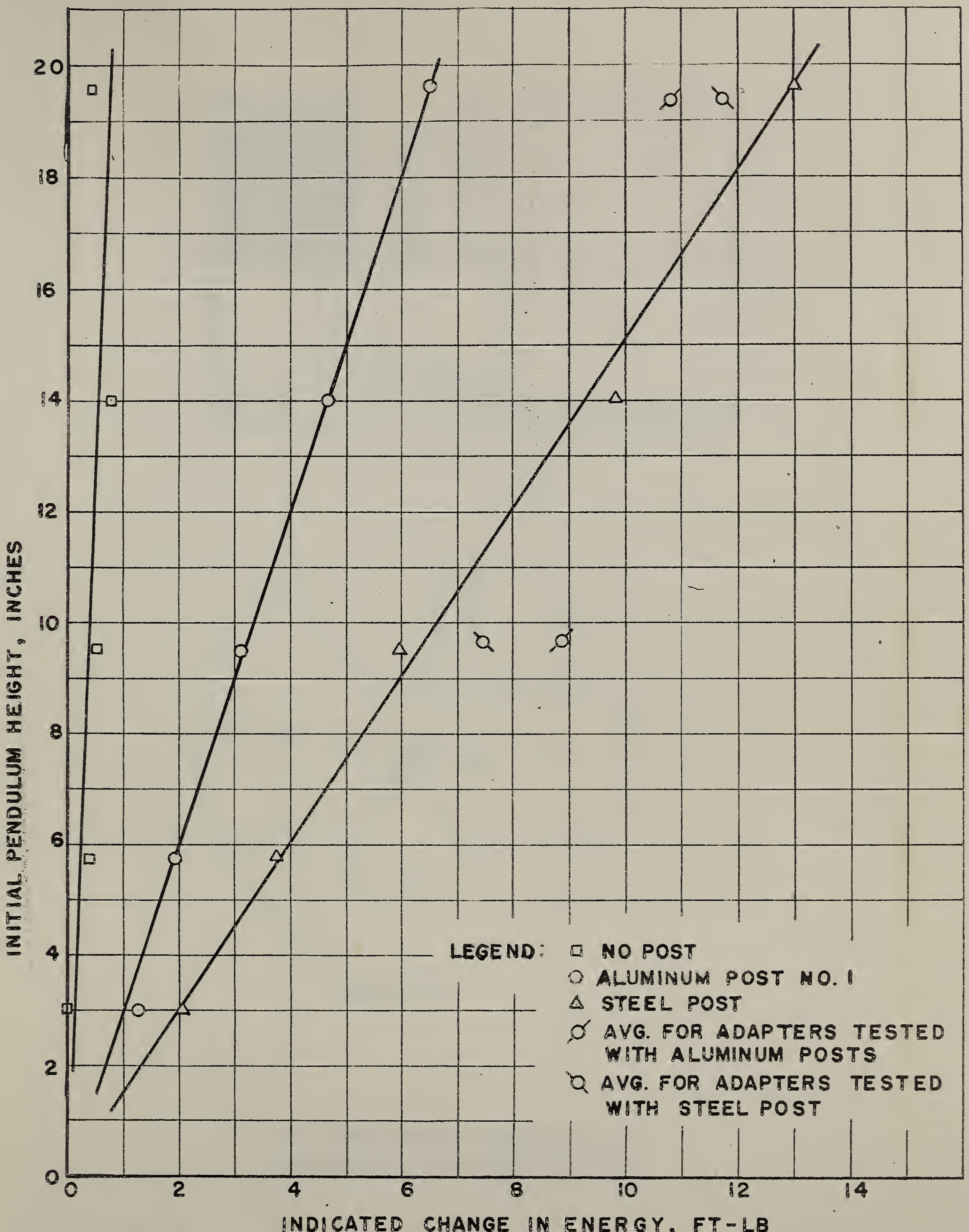
Sample C-1 After Impact Test

6.4/295-3

Figure 6



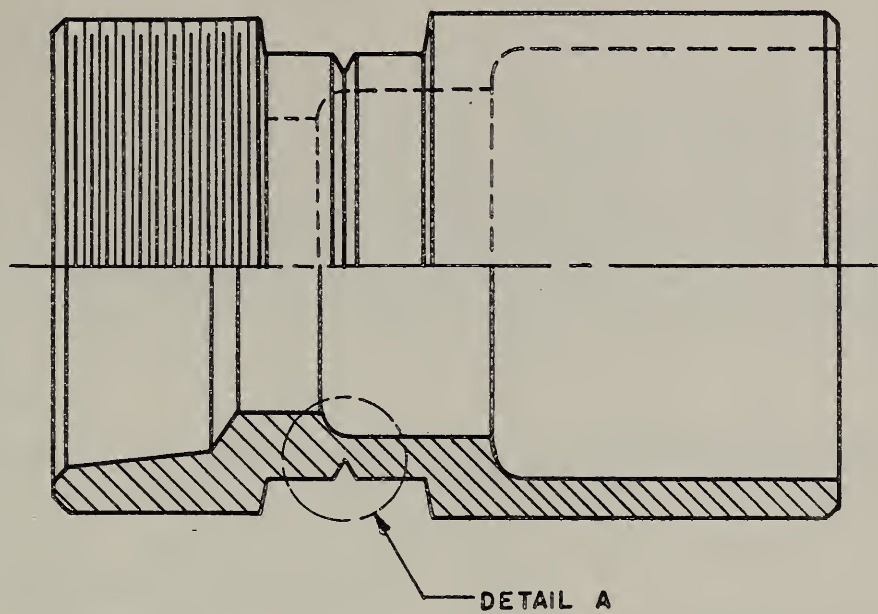
TYPICAL SAMPLES OF TWO INCH FRANGIBLE ADAPTERS AFTER IMPACT TESTS
6.4/295-3 FIGURE 7

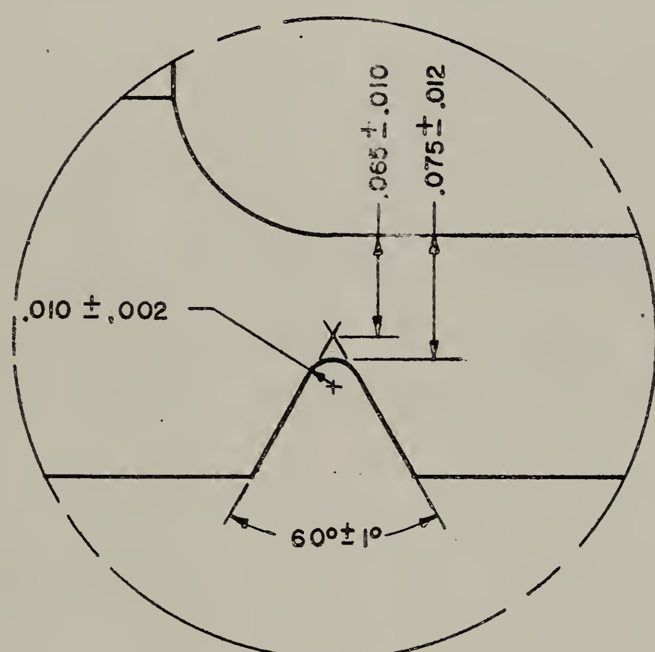


PENDULUM ENERGY LOSS UNDER VARIOUS CONDITIONS

6.4/ 295-3

FIGURE 8





DETAIL A

RECOMMENDED DETAILS OF
FRANGIBLE ADAPTER NOTCH

FIGURE 9

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

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Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

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- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

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Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

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