

SUMMARY OF THE RESULTS OF TESTS OF CARGO FLOORING FOR AIRCRAFT (A THROUGH U)

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MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

SUMMARY OF THE RESULTS OF TESTS OF CARGO FLOORING FOR AIRCRAFT

(A THROUGH U)¹

By

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Summary

In cooperation with and at the request of the Air Materiel Command, U. S. Air Forces (Wright-Patterson Air Force Base), the Forest Products Laboratory has evaluated the properties of several types of cargo flooring material by means of basic-strength and simulated-service tests.^{2 3 4 5 6 7 8 9} The purpose of this program has been to determine the characteristics of cargo floors either in use or proposed for use as floors for transport aircraft. As a part of this cooperative program, the results of these tests have been summarized to permit simple and rapid comparisons of the

¹This study was made in cooperation with the U. S. Air Force under order No. USAF (33-038) 49-1875E.

²"Methods for Testing and Evaluating Cargo Flooring for Transport Aircraft," Forest Products Laboratory Report No. 1550, April 1945.

³"Tests of Cargo Flooring L for Aircraft," Forest Products Laboratory Report No. 1550-A, October 1946.

⁴"Tests of Cargo Flooring M for Aircraft," Forest Products Laboratory Report No. 1550-B, April 1947.

⁵"Development of a Sandwich-type Cargo Floor for Transport Aircraft," Forest Products Laboratory Report No. 1550-C, September 1947.

⁶"Tests of Cargo Flooring N and P for Aircraft," Forest Products Laboratory Report No. 1550-D, January 1948.

⁷"Tests of Cargo Flooring R and S for Aircraft," Forest Products Laboratory Report No. 1550-E, June 1948.

⁸"Tests of Cargo Flooring Nn and T for Aircraft," Forest Products Laboratory Report No. 1550-F, October 1948.

⁹"Tests of Cargo Flooring Pp and U for Aircraft," Forest Products Laboratory Report No. 1550-G, March 1949.

resistance of the flooring materials to the loads imposed and over-all evaluation of the relative effectiveness of the several types of floorings.

The floors investigated under this program were of three general constructions; plywood, all-aluminum, and sandwich. Sandwich materials having honeycomb cores glued to metal facings were the most satisfactory cargo floorings tested, particularly on the basis of the drop and rolling-load simulated-service tests. Floors of this type faced with aluminum performed better than those faced with magnesium. Generally, the all-aluminum floors were somewhat less acceptable than the sandwich-type floors; however, those having a lower surface formed with small, closely spaced corrugations compared favorably with the floors of sandwich materials. Floors of plywood were the least satisfactory of the types of floors investigated.

Introduction

At the request of and in cooperation with the Air Materiel Command, Army Air Forces (Wright-Patterson Air Force Base), the Forest Products Laboratory has made tests for evaluating several types of cargo aircraft floors. 2 3 4 5 6 7 8 9

To facilitate general comparisons between these various floors, the Air Materiel Command requested the Laboratory to compile this summary report. The data presented in this report were previously obtained from tests that were made in accordance with established methods for evaluation of cargo flooring materials. 2

Material

Plywood Construction

Floor A.--Five-ply Douglas-fir plywood, 1/2 inch thick. Commercial grade; water resistant. Grain of face plies was parallel to long dimension of the panel. Moisture content at time of test was 9.5 percent (based on weight when oven-dry).

Floor B.--Five-ply Douglas-fir plywood, 3/4 inch thick. Commercial grade; water resistant. Grain of face plies was parallel to long dimension of the panel. Moisture content at time of test was 9.5 percent (based on weight when oven-dry).

Floor D.--Five-ply Douglas-fir plywood, 1/2 inch thick, reinforced with two extruded-aluminum skid strips and a 24ST 0.064-inch aluminum-covered treadboard, and equipped with tie-down rings (fig. 1). Face grain of plywood was parallel to long dimension of the panel. Moisture content at time of test was 9.0 percent (based on weight when oven-dry).

Floor F (task force).--Wood floor consisting of panels 27 inches wide, 66 inches long, and 1-1/2 inches thick. Constructed with outside faces of 1/4-inch three-ply Douglas-fir plywood glued to inner yellow-poplar transverse stiffeners 3/4 inch wide spaced at 2-1/4-inch centers along the 66-inch dimension (fig. 2). Outside edges were reinforced by a continuous inserted rail. The wearing surface was roughened by application of a nonskid material. Face grain of plywood was parallel to the 27-inch dimension. This floor was made to be used on floor F on top of the 1/4-inch plywood.

Floor K.--Maple plywood composed of seven cross-laminated plies having a total thickness of approximately 0.54 inch, and weighing 2.17 pounds per square foot. The grain of the face plies was parallel to the long dimension of the panel. Moisture content at time of test was approximately 7 percent (based on weight when oven-dry).

All-aluminum Construction

Floor E.--Flat 0.032-inch aluminum-alloy sheet riveted to a corrugated 0.040-inch aluminum-alloy base (fig. 3). The corrugations were 1-1/4 inches center to center and 3/4 inch deep and extended in the fore and aft direction. A 1/4-inch three-ply Douglas-fir plywood panel with face grain perpendicular to the corrugations was attached to the flat sheet to serve as a replaceable wearing surface.

Floor F.--Flat 0.032-inch aluminum-alloy sheet covering fabricated transverse and longitudinal beams, and all forming an integral part of the airplane. The wearing surface was replaceable 1/4-inch three-ply Douglas-fir plywood attached to the aluminum floor with the grain of the face plies parallel to the fore-and-aft direction. Figure 4 shows a bottom view of floor F.

Floor H.--Flat 0.064-inch aluminum-alloy sheet spot-welded to a corrugated 0.051-inch aluminum-alloy base (fig. 5). The corrugations had flat "heads" 3/4 inch wide, spaced at 3-inch centers, and were 1-1/4 inches deep with webs of the corrugations inclined to the vertical. The wearing surface was provided by the plain flat sheet.

Floor I.--Flat 0.064-inch aluminum-alloy sheet spot-welded to a corrugated 0.040-inch aluminum-alloy base. The corrugations were square, 1-1/2 inches wide and 1-1/2 inches deep, formed on 3-inch centers. The open corrugations were blocked over the floor beams with Sitka spruce fillers. A rough wearing surface was provided on the flat sheet by an application of nonskid material. Figure 6 shows a view of the lower surface of this flooring.

Floor L.--Corrugated aluminum alloy (rounded corrugations), 0.040 inch thick, to the upper side of which were spot-welded, as tread plates, strips of 0.064-inch-thick sheet aluminum alloy. A 6-inch-wide tread plate was along the longitudinal centerline of the

plane, and a 12-inch strip was adjacent to the inner edge of each of two side panels. The rest of the corrugated portion of the floor was without cover. The corrugations were 1-1/4 inches deep and spaced at 3-inch centers. Two spool-shaped aluminum struts standing in the corrugated valleys were riveted to the corrugated sheet and the central tread plate at each point where the tread plate crossed a transverse support. Between these supports aluminum-alloy reinforcing strips 0.040 inch thick and 4 inches wide extended crosswise along the under side of the portion of the side panels not covered by tread plates and were welded to the corrugations. The specimens of floor L consisted of two center and two edge sections. Figure 7 shows a top view of a side section of this flooring.

Floor M.--Floor M consisted of a flat aluminum-alloy sheet, 0.032 inch thick, spot-welded to a dimpled aluminum-alloy sheet of the same thickness. The dimpled sheet had protrusions extending above and below the plane of the sheet about 0.08 inch to form 1/2-inch squares spaced 13/16 inch from center to center. The upper two sheets were spot-welded to a similarly dimpled sheet, of the same thickness and formed to nearly rectangular corrugations with the webs inclined slightly. The corrugations were about 1-1/8 inches deep and spaced at 1-5/8 inches center to center. An end view of this flooring is shown in figure 8.

Floor R.--The 0.047-inch-thick aluminum sheet that formed the wearing surface of this flooring was riveted to the 0.040-inch-thick aluminum corrugated lower sheet by 1/8-inch countersunk rivets. The rivets were spaced approximately 1-1/4 inches on centers both ways, and the corrugations in the lower sheet were also spaced about 1-1/4 inches on centers. Over-all floor thickness was 13/16 inch. Figure 9 shows an edge view of this flooring.

Floor S.--This flooring was identical to flooring R, as shown in figure 9, except that the aluminum used in the corrugated sheet was 0.047 inch thick.

Sandwich Construction

Floor C.--Sandwich construction having 13/32-inch solid bass-wood core with outer faces of parallel-laminated paper plastic arranged with the grain of both the core and the surfacing parallel to the long dimension of the panel. Nominal thickness, 1/2 inch. The wearing surface was roughened in molding to provide resistance to slipping. Moisture content at time of test was 6 percent (based on weight when oven-dry).

Floor G.--Sandwich construction having 13/32-inch seven-ply cross-banded yellow-poplar core with outer faces of cross-laminated paper plastic. Nominal thickness, 1/2 inch. Wearing surface had morocco finish, slightly irregular. Grain of the face ply of the core was parallel to the long dimension of the panel. Moisture content at time of test was 6 percent (based on weight when oven-dry).

Floor J.---Sandwich construction having a three-ply 3/8-inch yellow-poplar cross-banded plywood core placed with the grain of the face plies longitudinal and with the upper surface of 0.025-inch and the lower surface of 0.016-inch 24ST aluminum alloy. Maple skid strips were placed at 10-inch centers and in direct contact with the plywood core. The aluminum covering was made continuous over them. The wearing surface was treated with nonskid material, as shown in figure 10.

Floor X-15.---Sandwich-type floor with a 0.032-inch 75ST-aluminum sheet glued to five-ply 5/32-inch maple plywood (grain direction of face ply oriented in the transverse direction), which in turn was glued to a 0.625-inch paper honeycomb core. The lower face was 0.016-inch 75ST aluminum.

Floor X-16.---Sandwich-type floor with a 0.032-inch 75ST-aluminum sheet glued to seven-ply 7/32-inch maple plywood (grain direction of face ply oriented in the transverse direction), which in turn was glued to a 0.625-inch paper honeycomb core. The lower face was 0.016-inch 75ST aluminum. Figure 11 shows an edge view of this flooring.

Floor N.---The sandwich-type flooring material of floor N had an upper facing or wearing surface of 0.064-inch-thick 24ST alclad aluminum; a 3/4-inch-thick honeycomb core of resin-impregnated cotton duck having hexagonal cells approximately 3/8 inch across the flats and weighing 0.60 pound per square foot, including face-to-core adhesive; and a lower facing of 0.025-inch 24ST alclad aluminum.

Floor Nn.---Floor Nn was identical to floor N. An edge view of this flooring is shown in figure 12.

Floor P.---Floor P was similar in construction to floor N, except for replacement of the 24ST alclad aluminum with FS-1H magnesium alloy. The top facing for this floor was 0.090 inch thick and the lower facing 0.032 inch thick.

Floor Pp.---Floor Pp was identical to floor P except that the top facing was FS-1A magnesium alloy. Figure 13 shows an edge view of this flooring.

Floor T.---Floor T was identical to floors Nn and N, as shown in figure 12, except that the top wearing surface was 0.051-inch 24ST alclad aluminum.

Floor U.---Floor U was identical to floor Pp, as shown in figure 13, except that the top wearing surface was 0.081-inch FS-1A magnesium alloy.

Methods of Tests

The panels were trimmed, weighed, and measured, and were then prepared, as required, for use as specimens. The following tests were made in accordance with methods specified for evaluation of this material and described in an earlier report.²

Static bending: Over an 8- and over a 16-inch span.

Strip loading: Under a 1-1/4- by 9-inch steel bar, as illustrated in figure 14.

Concentrated loading: Applied by a 1-inch-diameter steel cylinder and by a 2-1/2-inch-wide maple block shaped to a 4-inch radius. Figures 15 and 16 illustrate the loading procedures used.

Impact loading: Under the drop of a 200-pound softwood-box corner. Figure 17 shows the equipment in place before dropping the weighted box corner.

Rolling load: Applied by an engine-cradle wheel (fig. 18).

In some instances it was not possible, because of the type or amount of flooring material furnished, to make all of the tests outlined above or to make some of the simulated-service tests in sufficient number to insure reasonable accuracy of results obtained. This scarcity and resultant lack of data are noted in table 1. In the evaluation studies made on cargo-aircraft flooring materials A through J, some additional tests were made that were, upon analysis of the results, considered unnecessary because they added no needed information to that obtained from the above series of tests and that were, therefore, eliminated from subsequent studies.

The corrugations of the all-aluminum floors were parallel to the length of all test specimens except the strip-load specimens. The sandwich-type floors made with a treated cotton-duck core were so oriented that the direction in which the cotton duck was continuous was parallel to the length of all specimens except the strip-load specimens.

Analysis of Data

A summary of the results of tests made on all flooring materials tested is presented in table 1. The tabulated values are averages of the results of two or more tests except in the case of rolling load, where generally only one specimen was used for each loading condition. Three general types of floors were tested. One type was of plywood construction, with and without reinforcing, which included flooring materials A, B, D, F (task force), and K. A second type was all

aluminum in construction, either in the form of flat or of corrugated sheets, or of such sheets in combination, and included floors E, F, H, I, L, M, R, and S. The third type was of sandwich-type construction, for which both metal and paper plastic were used as wearing surfaces and for which the cores were of wood, paper honeycomb, and cotton-duck honeycomb. The floors in this group were C, G, J, X-15, X-16, N, Nn, P, Pp, T, and U.

Weight

The lightest complete flooring material tested was plywood floor A, weighing 1.42 pounds per square foot, but in all other cases the plywood floors weighed in excess of the 2.00 pounds per square foot assumed as the upper limit for cargo-aircraft flooring. The all-aluminum floors ranged in weight from 1.67 to 3.40 pounds per square foot, with the lowest being that of floor R, which had small, closely spaced corrugations. The weight of the heaviest floor, F, may be accounted for by the fact that it is an integral part of the airplane in which it is used. Sandwich flooring materials vary in weight from 1.52 pounds per square foot for the wood core, paper-laminate facing material of floor C to the 2.19 pounds per square foot of experimental floor X-16. The aluminum- or magnesium-faced, honeycomb-core sandwich floors have a weight range of 1.62 to 1.89 pounds per square foot.

Static Bending

The aluminum floors generally exhibit a higher strength when tested over a short span, where the load reflects the shear strength of the material, than do the other flooring materials. Failure does occur, however, by shearing of the rivets or of the spot welds in these panels, but the specimens still carry considerable load after failure occurs because of the strength of the corrugated lower surface. Sandwich-type materials, particularly those having metal facings and honeycomb cores, while less strong than all-aluminum flooring panels, exhibit strengths that are entirely satisfactory and that are higher than those obtained with plywood specimens. Failure occurs in shear of the glue line between the core and the facing material, and, once failure has occurred, the strength is decreased abruptly to a very small load. On longer spans, where the bending strength of the panel governs, the aluminum- and metal-faced, honeycomb-core, sandwich panels are equally satisfactory and are superior to plywood. The all-aluminum panels do not fail so suddenly, however, as do the sandwich specimens that fail normally in tension of the lower facing, which failure is accompanied by an abrupt decrease in load.

Largely because of the characteristic mode of failure, sudden or gradual for sandwich or for aluminum flooring materials, respectively, the aluminum panels exhibit a much higher shock resistance as measured by work to maximum load in bending tests made over short spans. As the span is increased, this difference in energy-absorption capacity

decreases; and in tests made over a 16-inch span, only flooring R, an aluminum floor having small corrugations, exhibited any definite superiority over the other sandwich and aluminum floorings. Plywood floorings are least satisfactory in shock resistance of the three types tested.

Strip Load

The results of the strip-load tests, simulating the action of a floor beam against the lower surface of the floor, illustrated in figure 14, proved the sandwich-type floors to be much more resistant to the crushing, caused by this test, than any of the floors of the other two constructions. The sandwich floors made with a core of paper honeycomb or yellow-poplar were stronger than those made with treated cotton-duck honeycomb cores. On the average, plywood flooring materials were more able to resist the crushing action in this test than were the aluminum floors. The excellent performance of floors R and S, however, shows the advantage of using small, closely spaced corrugations in contrast to the larger corrugations of the other aluminum floorings.

Concentrated Loading

The tests to determine the resistance of cargo-aircraft flooring materials to concentrated loads applied by means of a 1-inch-diameter bar gave results that indicate that aluminum floorings and metal-faced, honeycomb-core floorings generally may be considered equally satisfactory in puncture resistance. Sandwich-type floorings N and Nn showed the greatest resistance to damage under this type of loading, and the aluminum-faced sandwich materials gave higher results than did those faced with magnesium. Plywood generally was least satisfactory.

Loading with a 2-inch-wide maple block rounded to a 4-inch radius simulates the concentrated-load effect due to an engine-cradle wheel. Comparisons are made between loads at ultimate and loads at 0.5-inch deformation. This latter comparison is included because the sandwich materials in general fail in shear in the glue line between core and facings, and since this property is measured by the short-span bending test, it was believed that a better criterion of performance for these materials was the load at a fixed deformation. When ultimate load is used as the measure of quality, the all-aluminum floors generally give better performance than any of the other types, although when loaded at an interior position floor N of sandwich material gives the highest strength obtained in this type of test. Plywood floorings are, on the whole, weaker than sandwich-type materials. Where the load at 0.5-inch deformation is taken to indicate suitability, there is little difference in performance of metal-faced, honeycomb-core, sandwich materials and all-aluminum floorings, with the sandwich materials exhibiting more uniform results and with floor I of aluminum having the highest strength of any flooring tested.

Impact Loading

In resistance to the impact load of a 200-pound softwood-box corner, there was little difference between the better floors of the all-aluminum and of the sandwich constructions. The majority of the floors of these two constructions easily withstood drops at a height of 15 inches without serious damage to the floor. The sandwich-type floors with wood cores did not respond to this test as well as did the floors with a cotton-duck or paper core and heavier aluminum or magnesium facings. The advantage of using an annealed magnesium alloy rather than the alloy in the cold-rolled state is shown by the difference in the results of this test on floors Pp and P. Results of the impact tests on the floors constructed of plywood showed that they would not be considered satisfactory under impact loading.

Rolling Load

The data on rolling-load tests presented in table 1 were taken from fatigue curves (load plotted against number of repetitions of load to failure) obtained for the various types of floors where a sufficient number of tests were made to permit drawing such a curve. Figure 19 shows the fatigue curve for type-T cargo flooring and illustrates the method used in determining the values presented in table 1. Because of limited data in some instances, the results must not be considered as other than approximate values. Test results indicate an over-all superiority of the sandwich-type floorings when compared to those of aluminum or plywood. The aluminum floorings having small, closely spaced corrugations, however, are materially excelled in quality, as measured by this test, only by floorings N and Nn. The maple plywood floor K, and floor D, of Douglas-fir plywood reinforced with aluminum skid strips, also performed satisfactorily under rolling-load tests.

Failures in the aluminum floors generally start by failure of the spot welds or rivets in shear or pulling out of the rivets, which means the flooring no longer acts as a unit. Crushing of the corrugations over the supports with resultant failure of the aluminum or fractures of the wearing surface along the wheel path subsequently occur and determine the ultimate resistance of the panel. Sandwich panels fail initially by crushing of the core material over the supports. After this occurs the load must be carried almost entirely by the wearing surface, and failure occurs by fracture along the edges of the wheel path. Plywood panels show considerable wear along the wheel path, which causes a weakening of the panel and ultimate failure by complete rupture under the loading wheel.

Comparative Ratings

Two methods of rating the flooring materials tested under this program have been established upon the basis of best performance of panels tested early in the program with respect to weight and behavior

under the simulated-service drop and rolling-load tests. Since the original drop test permitted a maximum height of drop of 15 inches and this was used in rating other floors, the same value will be used to rate floors tested after the equipment was modified to permit increased height of drop, even though these floors may take greater impacts without damage. A floor will be given a rating of 100 in impact if no serious damage results from a drop test from heights of 15 or more inches. The methods used in rating the flooring materials tested are outlined below.

Tentative Method A

<u>Criteria</u>	<u>Rating</u>
Weight = 1.42 pounds per square foot	$\frac{1.42}{\text{weight of test floor}} = x \text{ percent}$
Rolling load for 500 trips = 1,450 pounds	$\frac{\text{Load on test floor}}{1,450} = y \text{ percent}$
Impact height of drop = 15 inches	$\frac{\text{Drop on test floor}}{15} = z \text{ percent}$
	Rating = $\frac{x + y + z}{3}$

Tentative Method B

Weight = 1.42 pounds per square foot	$\frac{1.42}{\text{weight of test floor}} = a \text{ percent}$
Rolling load for 1,000 trips = 1,300 pounds	$\frac{\text{Load on test floor}}{1,300} = b \text{ percent}$
Impact height of drop = 15 inches	$\frac{\text{Drop on test floor}}{15} = c \text{ percent}$
	Rating = $\frac{a + b + c}{3}$

Conclusions

On an over-all basis, and especially if performance in the drop and rolling-load simulated-service tests is considered, the sandwich-type materials having metal facings and honeycomb cores are the most satisfactory cargo-aircraft floorings tested in this program. This conclusion is substantiated by the ratings using tentative methods A and B, which also show that flooring Nn is the most satisfactory of the

sandwich-type floors. The results also indicate that these materials, when faced with aluminum, give a better performance than when magnesium is the facing material; and that if magnesium is used, a better flooring will result if it is used in the annealed instead of in the hard-rolled condition.

The aluminum floorings are somewhat less satisfactory than the sandwich materials unless the corrugated lower surface has small, closely spaced corrugations, as in floors R and S. These two floorings compare very well with the sandwich-type floors, probably because the imposed loads are distributed over more than one corrugation.

Plywood floors are the least satisfactory of the three types investigated, and of this type the best results were obtained with the maple plywood construction.

Table 1.--Summary of results of tests of cargo-aircraft flooring materials¹

Floor No.	Weight per inch of width: load per inch of width	Bending strength: Work to ultimate			Strip load at 0.05-inch deformation	Concentrated load			Drop test	Engine-criadle Wheel at:			Rating					
		8-inch span	16-inch span	16-inch span		1-inch-diameter bar -- Ultimate load	2-inch maple block -- Ultimate load	2-inch maple block: Load at 0.5-inch deformation		500 trips	1,000 trips	3,000 trips						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
	lb. per sq. ft.	lb.	lb.	in.-lb.	in.-lb.	P.S.I.	lb.	lb.	lb.	lb.	lb.	lb.	in.	lb.	lb.	lb.	Percent	Percent
Plywood construction																		
A	1.42	190	90	20	40	1,100	1,250	900	1,360	1,260				500	450	300	47	47
B	2.20	310	180	40	50	1,060	1,750	1,670	3,020	1,900	2,520	1,820	1	750	600	375	52	50
D	2.55	200	150	20	20	1,100	1,250	900	3,140	1,340			2	1,300	1,100	775	53	51
F (task force)	2.17					530	1,150		5,720	5,160			7	1,250	1,125	1,050	66	66
All-aluminum construction																		
E	2.17	720	330	340	260	760	3,200	3,520	8,400	8,400	3,150	3,100	15	975	625	125	78	71
F	1.40						2,130		3,940				17	1,250	1,050	750	58	56
H	1.93	800	410	290	170	410	4,000	2,500	10,250	6,470	5,280	3,490	15	975	750	450	80	77
I	2.12	700	420	260	200	150	4,500	4,350	11,200	8,280	6,670	4,370	15	1,125	900	600	81	78
L (center section)	1.90												215	2,000	1,850	1,650	93	80
L (side panel)	1.86	430	260		80	350	2,500	2,260	4,340	3,160	2,700	2,250	8	1,250	1,100	800	93	92
R	1.67	790	330	600	550	970	42,500	42,100					15	21,300			892	87
S	1.86	1,020	350	1,060	440	1,350	44,390	43,200					15	21,450			892	87
Sandwich construction																		
G	1.52	360	180	80	120	1,380	1,725	1,630	2,470	2,610		2,320	3	500	375	150	49	47
J	1.77	350	180	60	100	1,980	2,160	1,900	2,540	2,530		2,970	11	500	375	150	49	48
N	1.87	500	360	140	440	21,440	5,440	5,260	11,320	5,820	4,620	4,100	11	51,400	1,275	1,050	82	82
N	1.88	510	360	100	380	21,430	5,430	4,300	4,300	4,300	4,790	3,930	821	51,600	1,575	1,250	101	98
P	1.78	520	350	130	280	21,430	3,040	3,020	7,670	5,900	4,700	4,200	821	51,300	1,200	1,025	91	92
P	1.71	460	300	60	250	21,360	3,680	3,450			4,470	3,540	821	1,425	1,200	1,025	95	95
P	1.66	470	340	70	240	21,530	4,150	3,960			4,780	3,620	821	1,425	1,100	900	91	91
X-15	1.62	460	310	60	270	21,390	3,300	2,940			4,400	3,460	821	1,225	1,075	800	86	85
X-16	2.19	610	340			1,630	3,040	2,540	4,100	3,240	3,040	2,540	15	1,400	1,250	1,000	87	87

¹Omissions in data are due to lack of or unsuitability of flooring material for test specimens.

²Criteria for ratings according to tentative methods A and B are given under Analysis of Data.

³On tread strips only. Values for the uncovered portion of the floor would be appreciably lower.

⁴Average load directly over or between crests of corrugations, not at exterior or interior positions.

⁵Approximate value because of limited amount of data.

⁶Based on approximate value for rolling-load test.

⁷Ultimate load occurred at about 0.03-inch deformation.

⁸Test equipment modified to permit drops up to 21 inches. In all other tests maximum height of drop was 15 inches.

Figure 1.--Tested panel of cargo flooring D showing
the extruded-aluminum skid strips,
treadboard, and tie-down rings.

ZM 58247 F

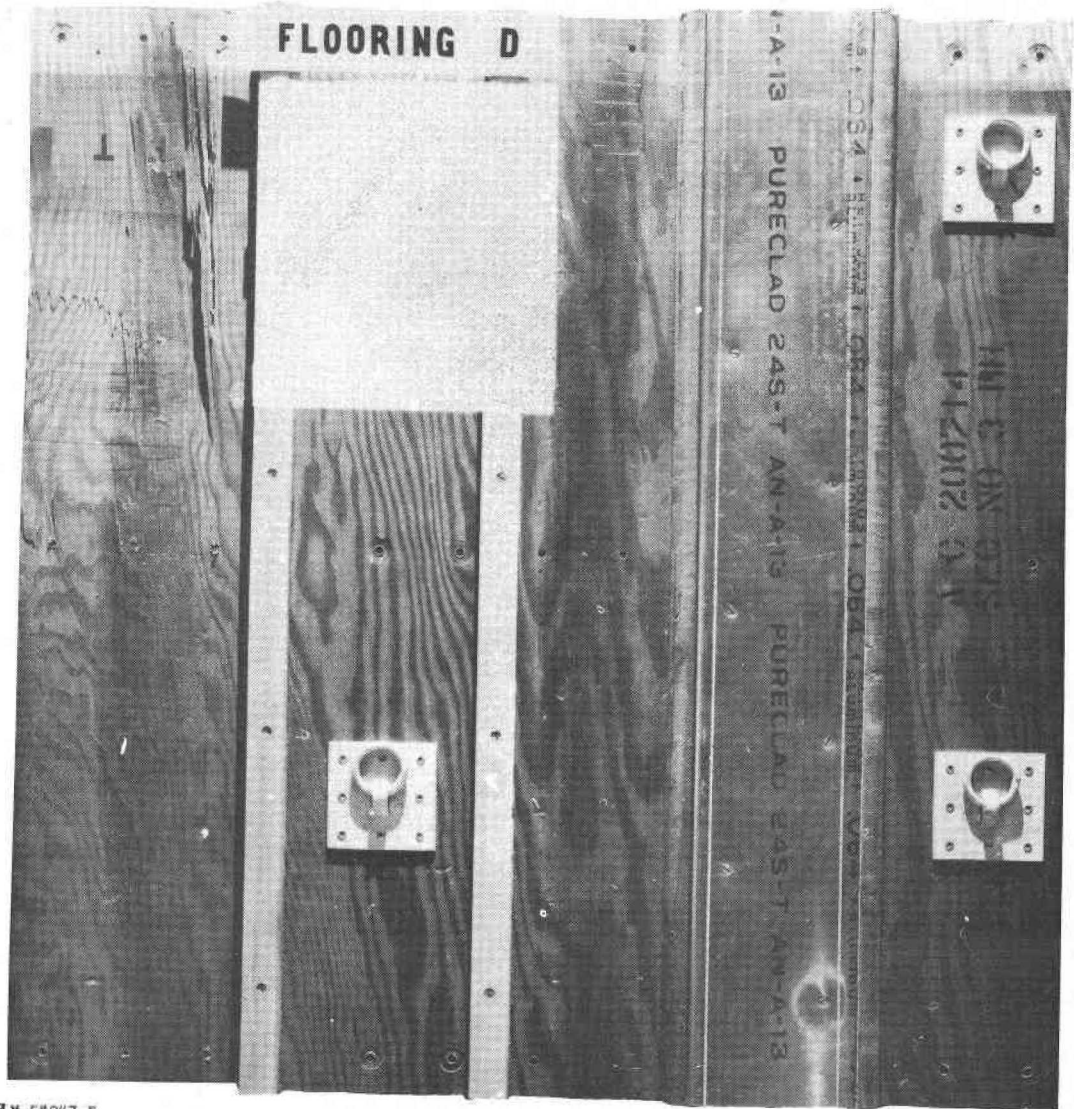


Figure 2--A specimen of cargo flooring F (task force) showing the outer faces glued to the yellow-poplar stiffeners. This floor was made to be used on floor F (fig. 4) on top of the 1/4-inch plywood.

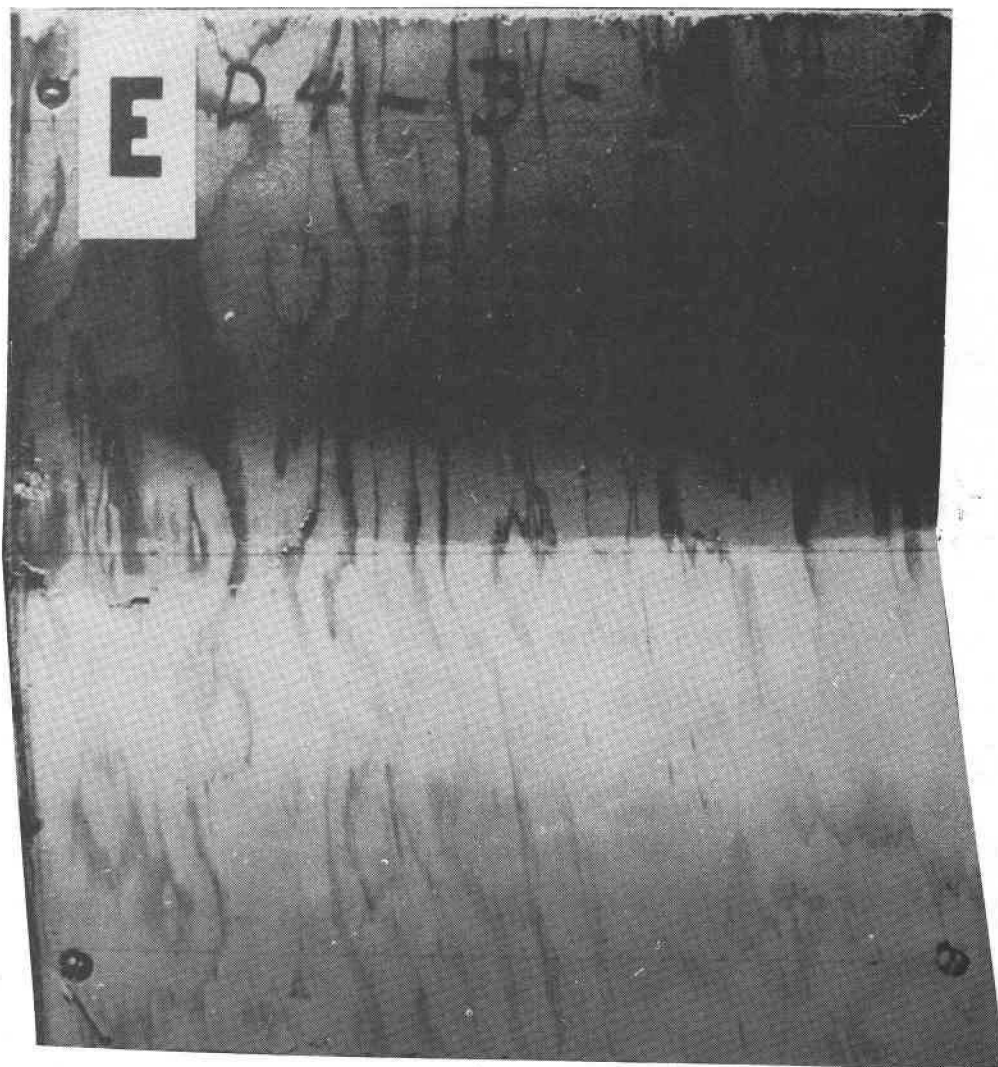
ZM 81084 F

F

74 61084 F

Figure 3.--Tested specimen of cargo flooring E.
The wearing surface was 1/4-inch
Douglas-fir plywood attached to the
all-aluminum subfloor.

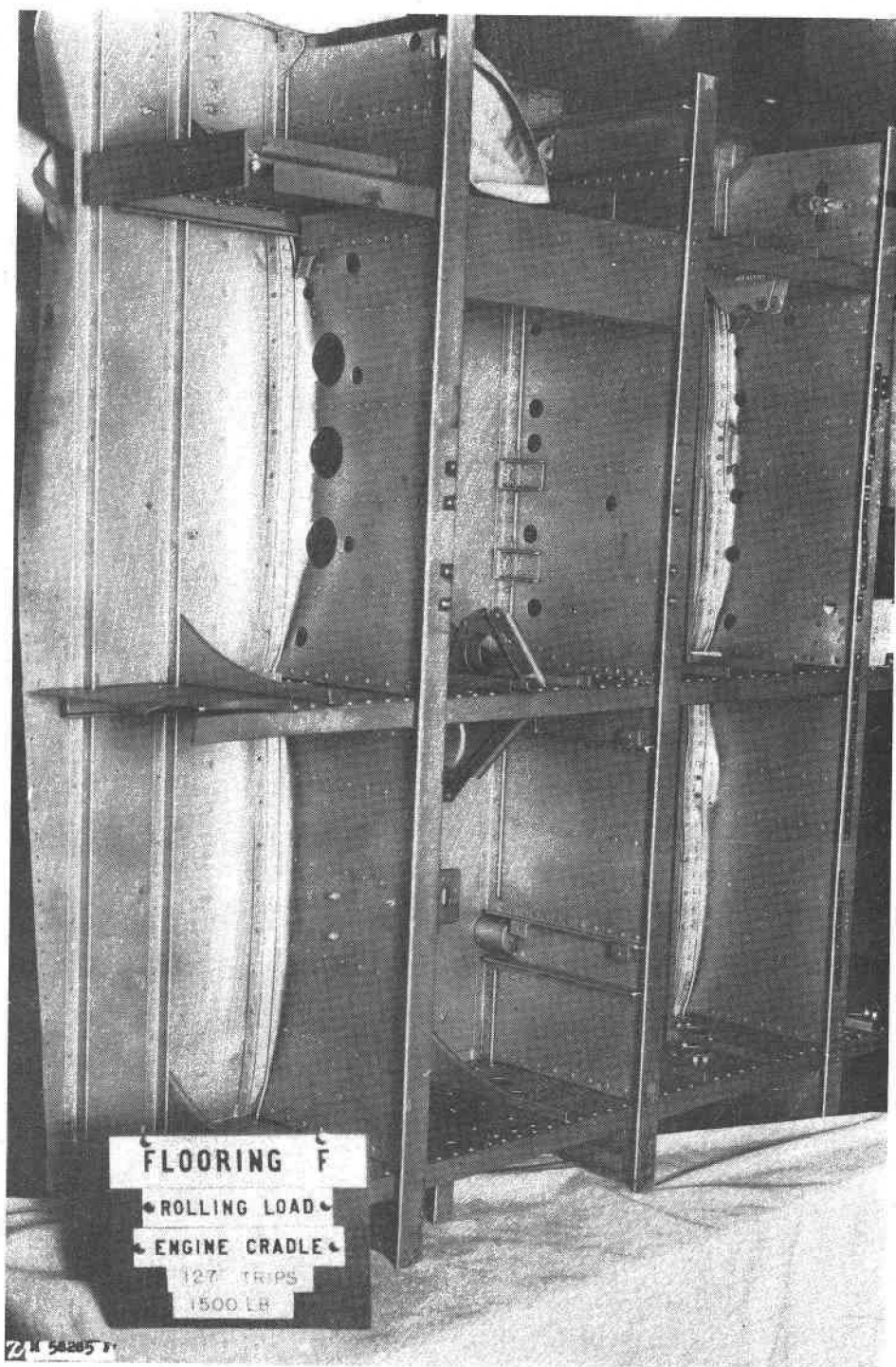
ZM 81083 F



14-00000-1

Figure 4.--The bottom view of a failed portion of cargo flooring F. This floor was an integral part of the airplane and was covered with a wearing surface of 1/4-inch Douglas-fir plywood.

ZM 58285 F



FLOORING F

ROLLING LOAD

ENGINE CRADLE

127 TRIPS

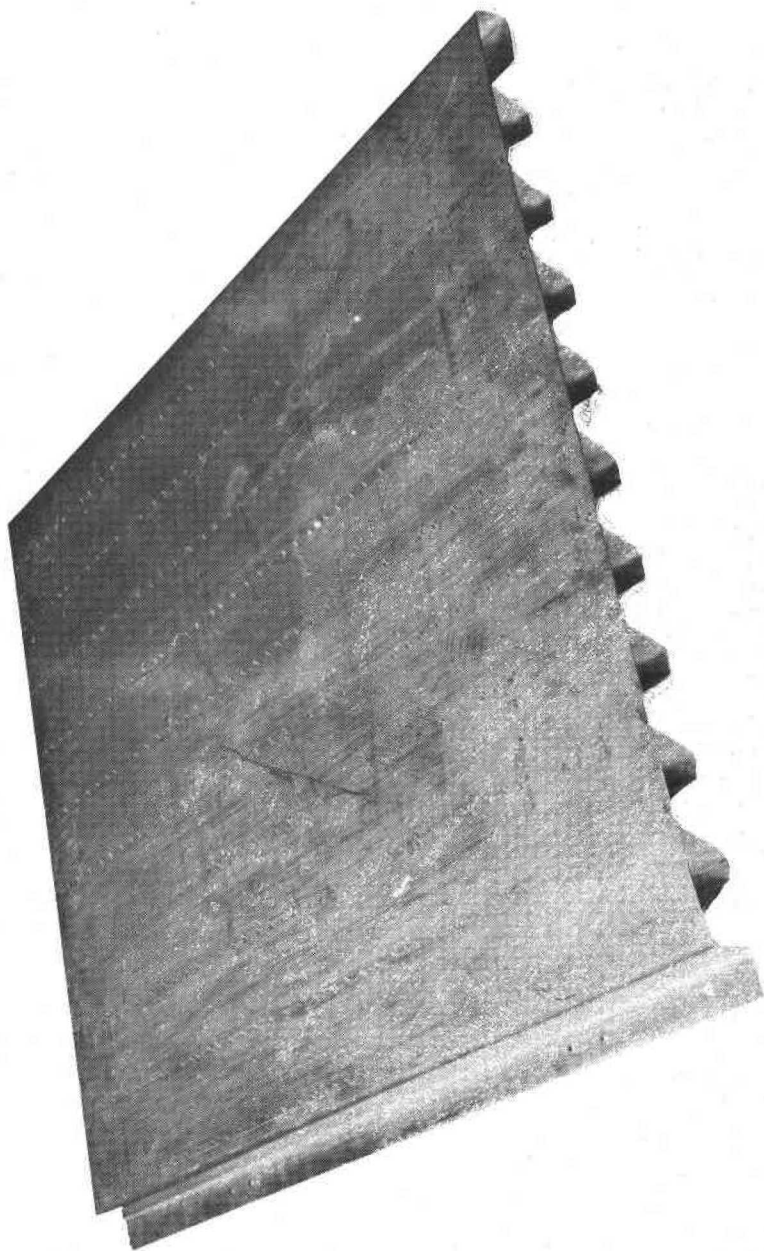
1500 LB

2 56205

Figure 5.--Cargo flooring H. The aluminum-alloy corrugations were spot-welded to the aluminum alloy sheet. The flat aluminum-alloy sheet was used as the wearing surface.

ZM 58870 F

Report No. 1550-H



68870 7

Figure 6.--View of the lower surface of a tested panel of cargo flooring I showing the corrugated aluminum portion of the floor with the Sitka spruce filler blocks where the floor was supported on the floor beams. The corrugated portion of the floor was spot-welded to an aluminum sheet. The flat sheet was treated with nonskid material and used as the wearing surface.

ZM 59578 F

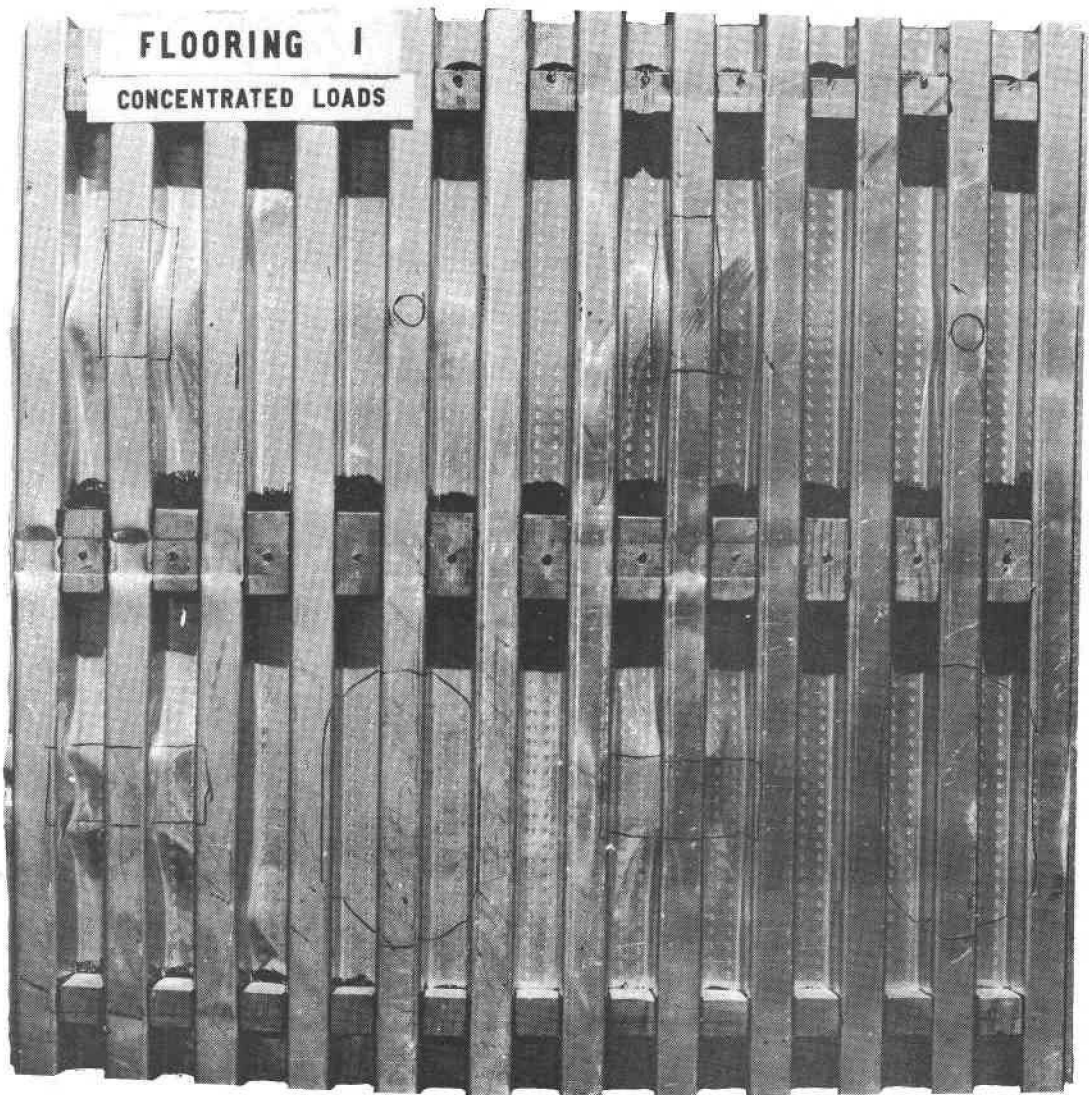
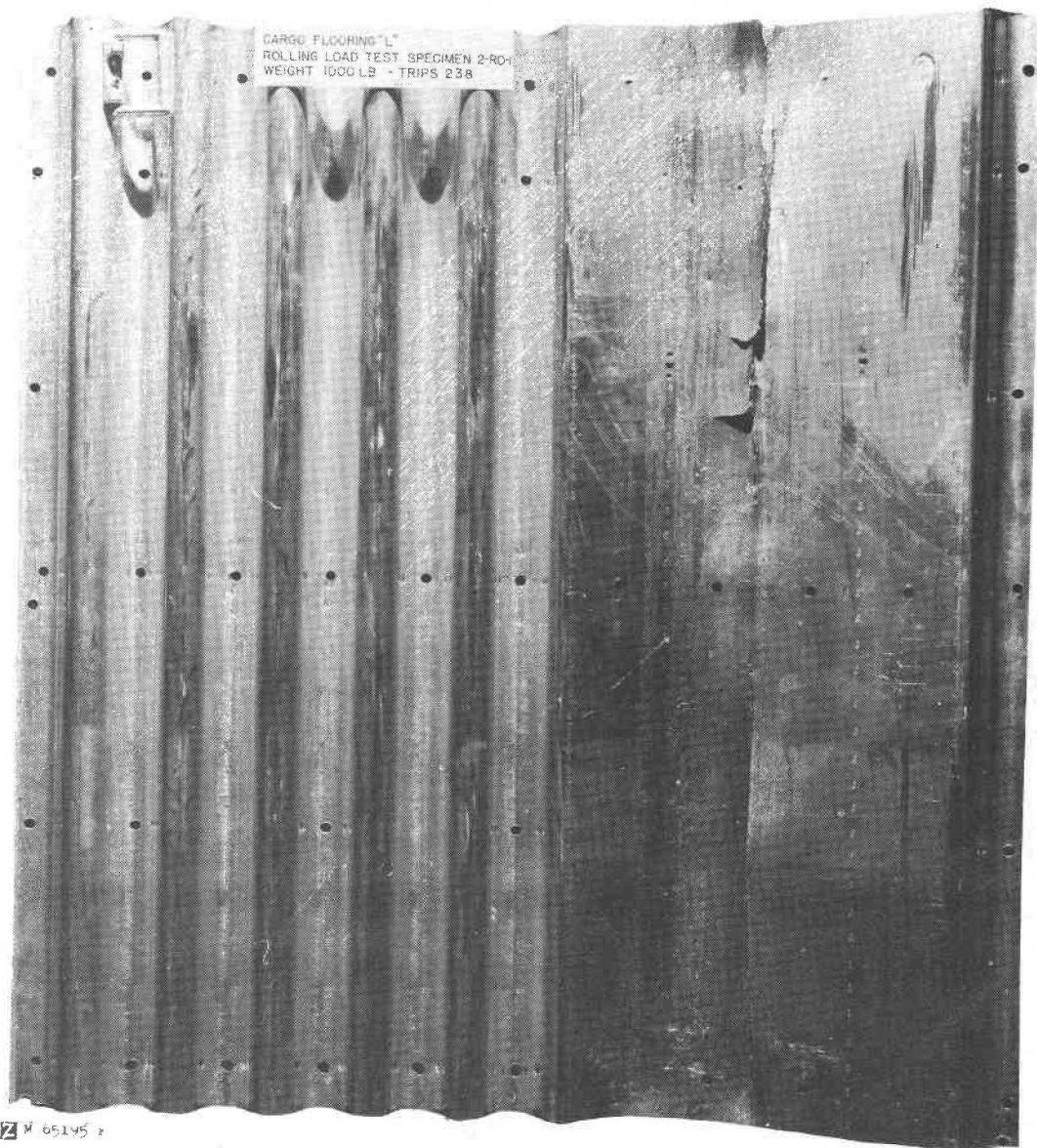


Figure 7.--Panel from a side section of cargo flooring L after test. The flooring was of corrugated aluminum having a 6-inch-wide aluminum strip spot-welded to the corrugations along the longitudinal centerline of the airplane and having, as shown, 12-inch aluminum strips attached at the edge of each side section.

ZM 65195 F



Z M 05145 x

Figure 8.--End view of cargo flooring M showing the upper flat and dimpled aluminum-alloy sheets that were spot-welded to a dimpled, corrugated, aluminum-alloy lower surface.

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CARGO FLOORING M

14 M 70153 E

Figure 9.--An edge view of cargo flooring R and S. The corrugated sheet was riveted to the flat aluminum sheet that formed the wearing surface for these floors. The two floors differed in that 0.040-inch-thick aluminum was used for the corrugated sheet for floor R and 0.047-inch-thick aluminum for floor S.

ZM 77658 F

Report No. 1550-H



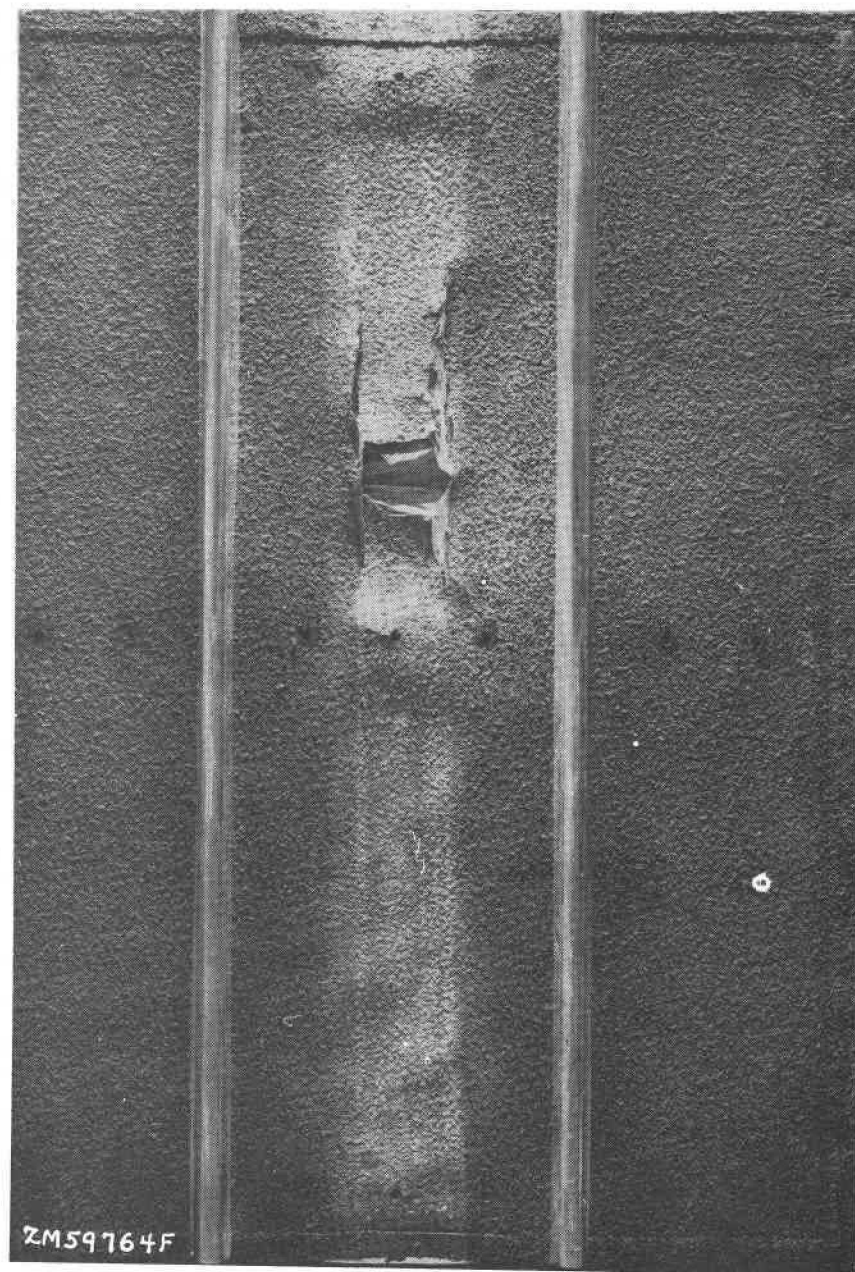
CARGO FLOORING S



CARGO FLOORING R

Figure 10.--View of the wearing surface of a failed specimen of cargo flooring J showing the treated aluminum upper face, skid strips, and a part of the plywood core.

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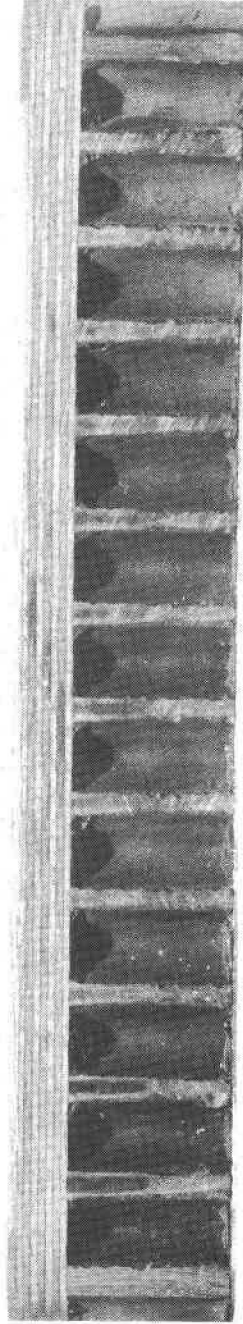


ZM59764F

Figure 11.--An edge view of cargo flooring X-16 showing the aluminum-covered 7/32-inch maple plywood wearing surface, the paper honeycomb core, and the aluminum lower face.

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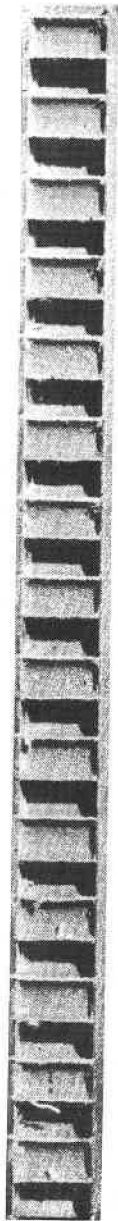


Z H 80859 P

Figure 12.--An edge view of cargo flooring Nn and T showing the aluminum faces and the cotton-duck honeycomb core. These floors differed in that the upper facing, or wearing surface, was 0.064-inch-thick 24ST alclad aluminum for floor Nn and was 0.051-inch-thick 24ST alclad aluminum for floor T.

ZM 78393 F

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CARGO FLOORING N_n



CARGO FLOORING T

Figure 13.--An edge view of cargo flooring Pp and U showing the magnesium-alloy facings and the cotton-duck honeycomb core. These floors differed in that the upper facing, or wearing surface, of floor Pp was 0.090-inch-thick and that of floor U was 0.081-inch thick FS-1A magnesium alloy.

ZM 80506 F

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CARGO FLOORING P_P

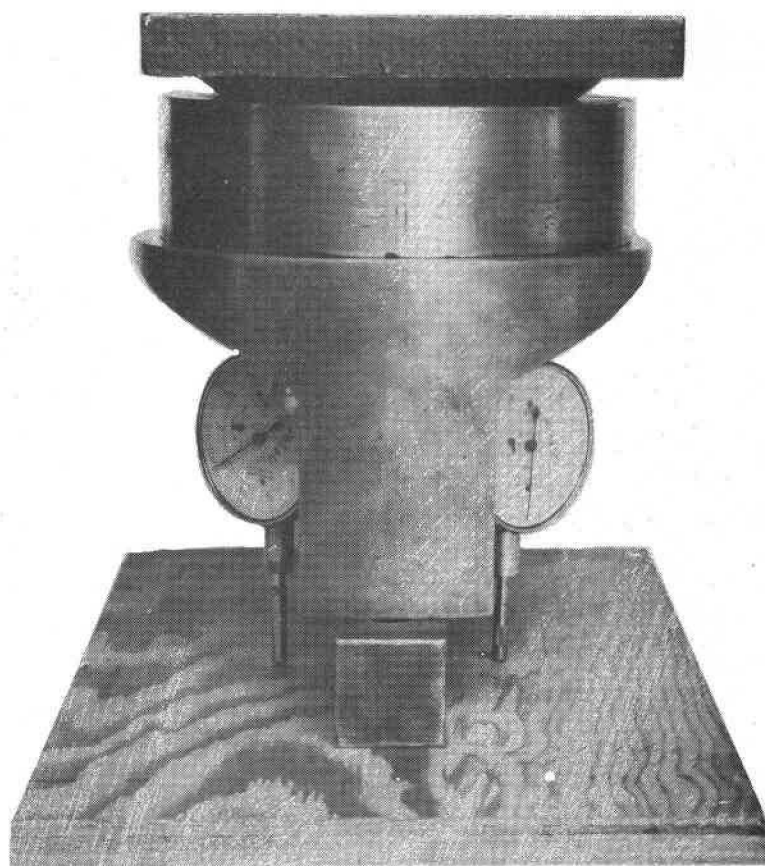


CARGO FLOORING U

ZM 80506 R

Figure 14.--Test set-up for the strip-loading test.
The load was applied to the 1-1/4- by
9-inch steel bar through the spherical
head. The average penetration of the
bar representing deformation of the
floor was determined from the two dial
indicators.

ZM 59569 F

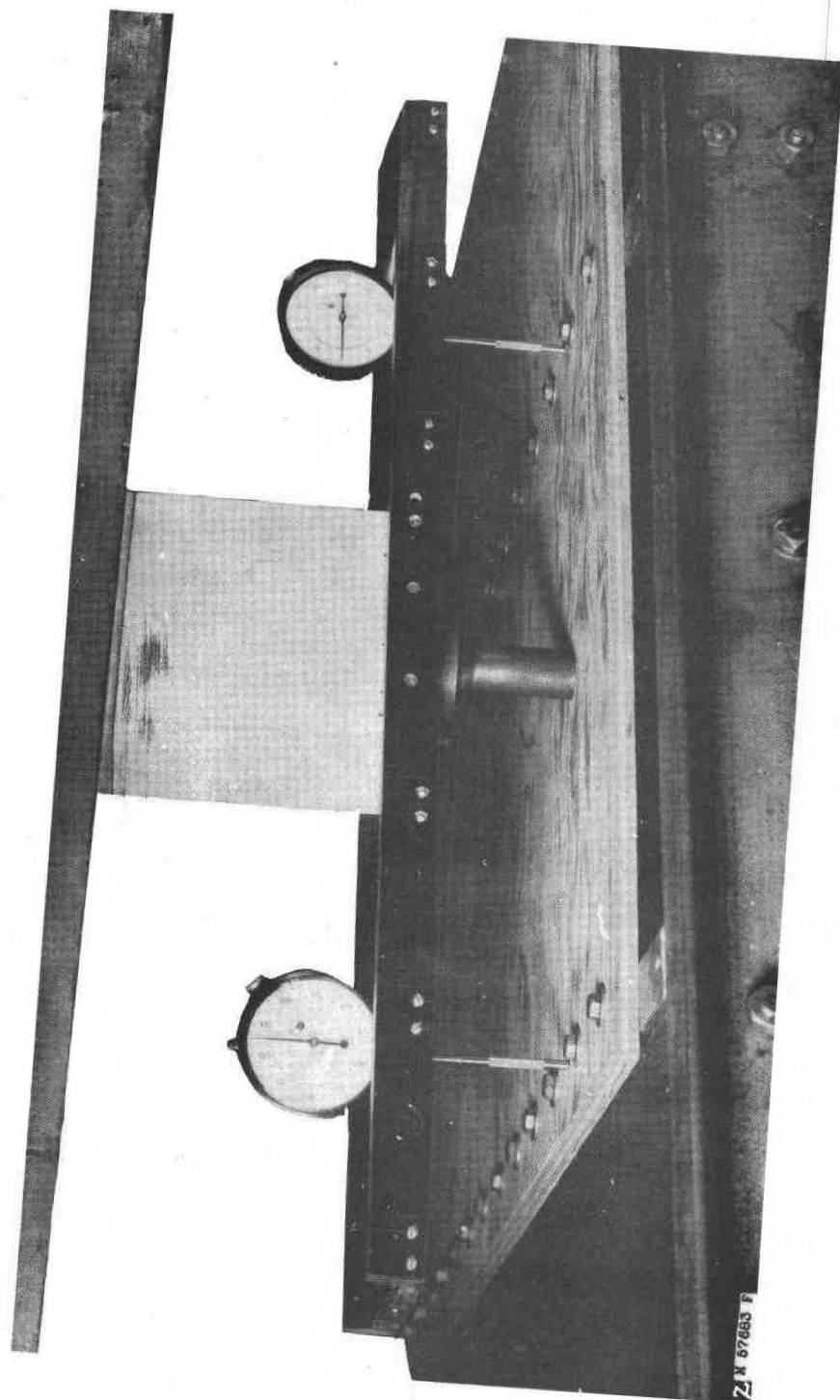


ZM 59569 F

Figure 15.--Test set-up for the concentrated-loading
tests using the 1-inch-diameter steel
cylinder.

ZM 57683 F

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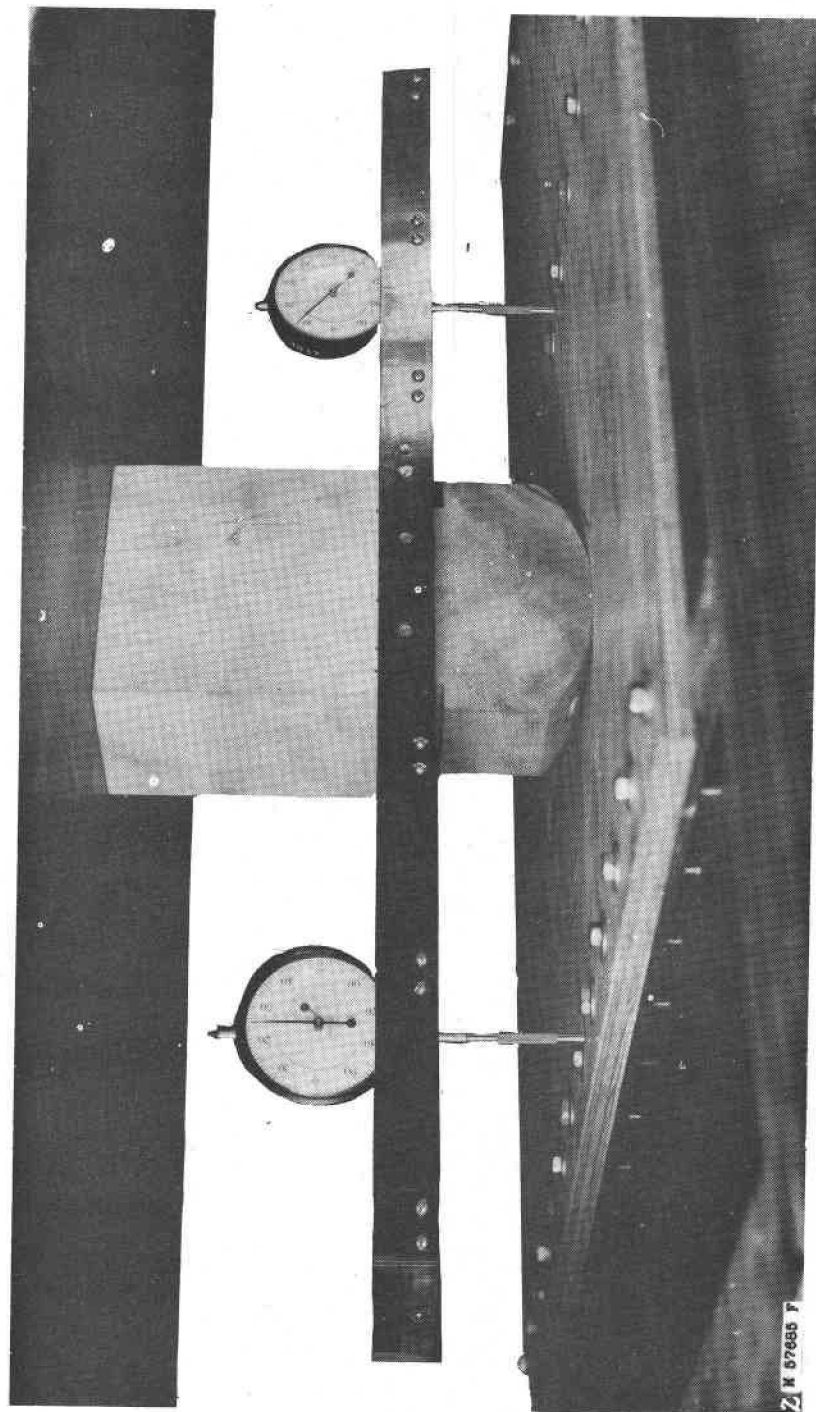


Z N 57653 F

Figure 16.--Test set-up for the concentrated-load tests using a
2-1/2-inch-wide maple block shaped to a 4-inch radius
and simulating an engine-cradle wheel.

ZM 57685 F

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Z N 57055 F

Figure 17.--Procedure used in making the impact-loading tests. The softwood-box corner was attached to the steel box, which was loaded to a total weight of 200 pounds.

ZM 57690 F

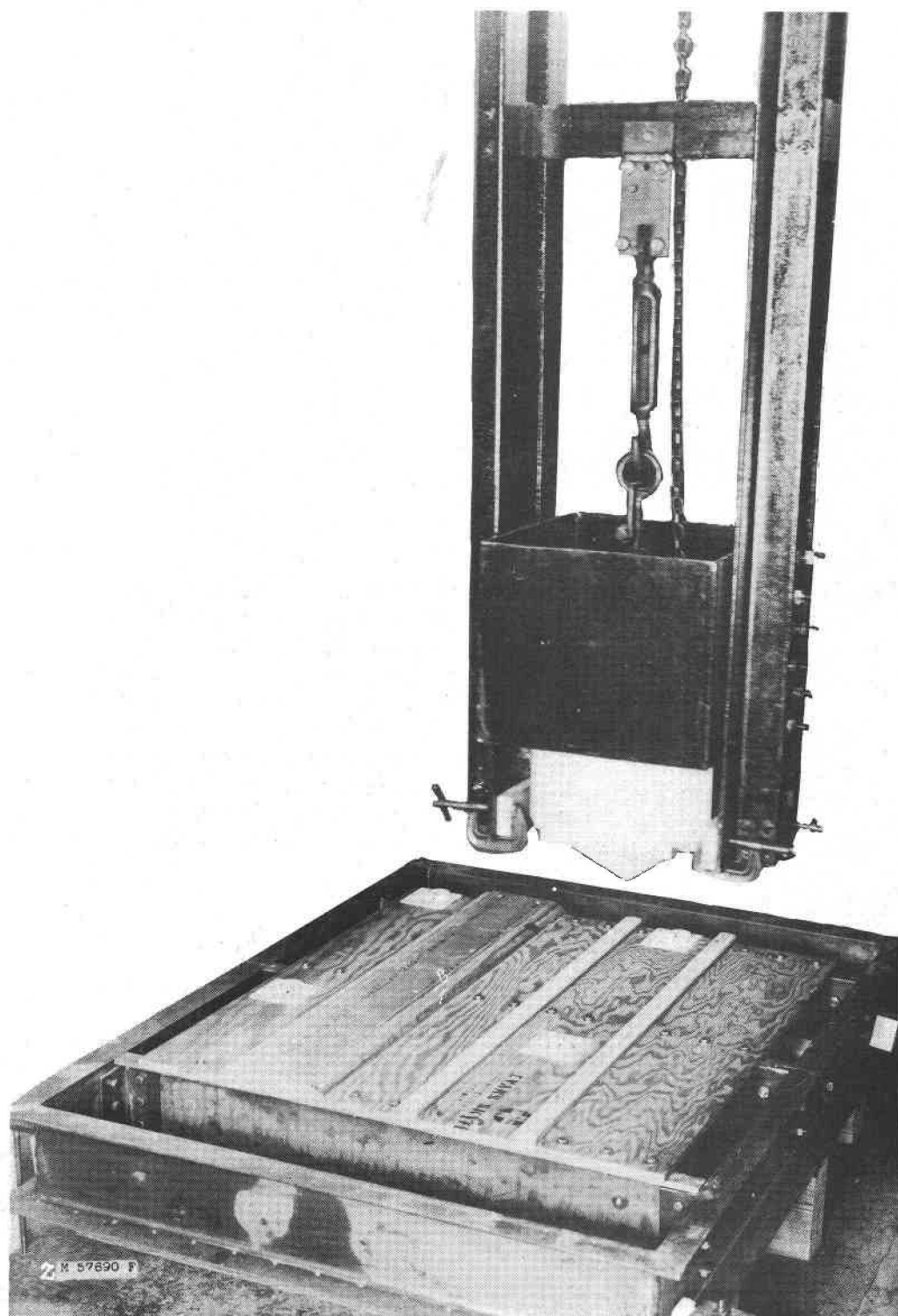


Figure 18.--Rolling-load-test procedure to simulate the loading effect of an engine-cradle wheel. The center wheel, loaded to the desired amount by adding weights to the box mounted on the frame, applied the load to the test panel as the assembly was repeatedly moved forward and backward over the length of the panel. Blocks on each side of the loading wheel prevented it from falling completely through the panel when failure occurred.

ZM 58235 F

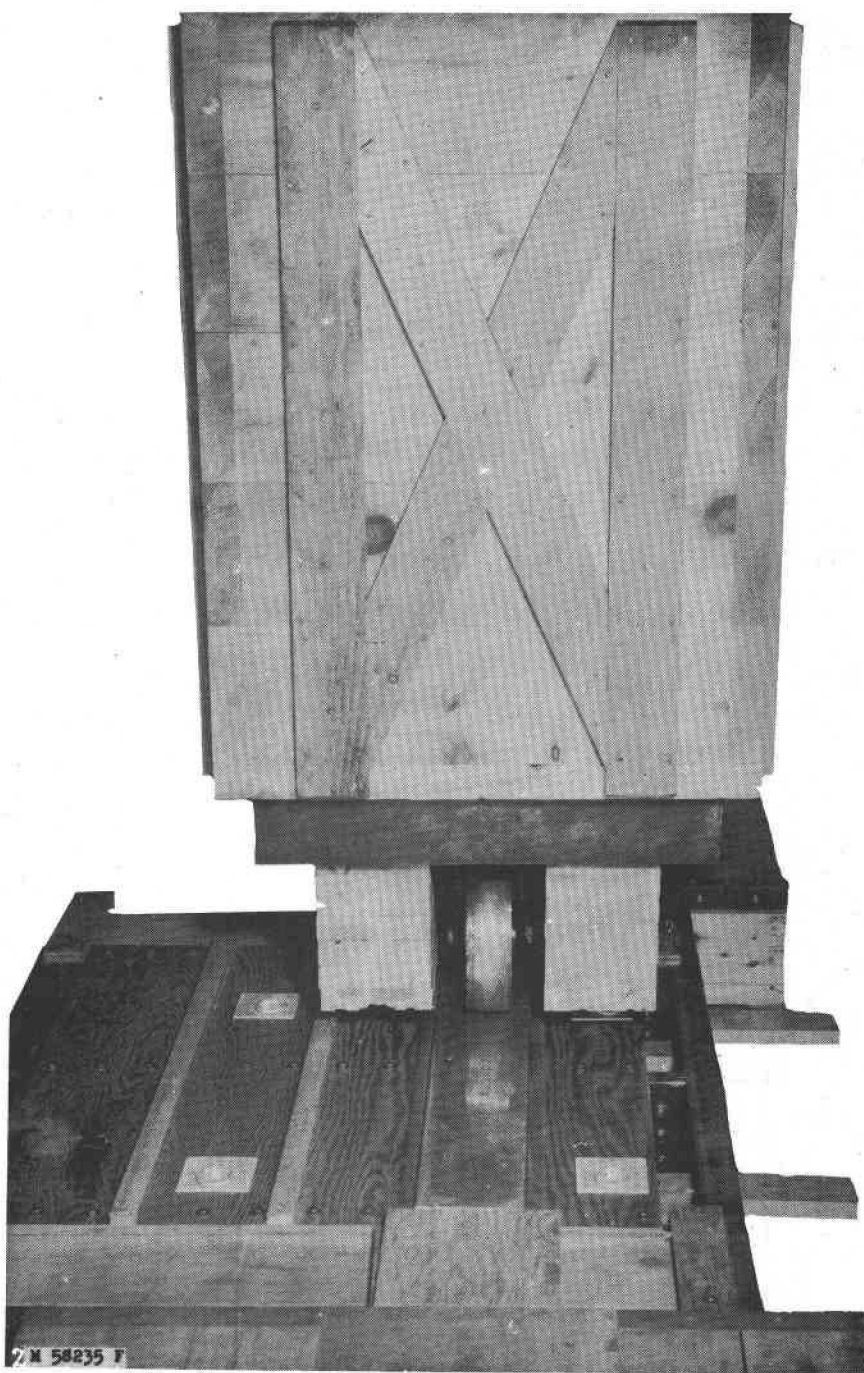


Figure 19.--The fatigue-curve load plotted against number of repetitions of load to failure for type-T cargo flooring, illustrating the method used to determine the engine-cradle-wheel load at 500, 1,000, and 3,000 trips for the various floorings listed in table 1.

ZM 81354 F

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