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COMPRESSION TESTS OF SIX CURVED PAPER-BASE PLASTIC PANELS WITH OUTWARD-ACTING NORMAL PRESSURE

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MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

COMPRESSION TESTS OF SIX CURVED PAPER-BASE PLASTIC PANELS WITH OUTWARD-ACTING NORMAL PRESSURE

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SUMMARY

Results are presented of compression tests of six paper-base plastic panels with outward-acting normal pressure. The tests were conducted at the request of the Bureau of Aeronautics, Navy Department.

All panels failed by separation of the skin, either from the rib or from the stiffeners. The average stresses at which the separations occurred were much lower than the ultimate compressive stresses for any of the materials comprising the panels. The addition of clip angles to attach the stiffeners to the rib served to delay separation of the skin from the rib, and thus enabled the panels to carry a higher ultimate load.

The presence of internal pressure caused severe quilting of the skin between ribs and stiffeners.

INTRODUCTION

Plastics and plastic-bonded materials have been extensively used in aircraft for low-stress secondary structural parts, where their adaptability to complicated shapes is advantageous. Recently there has been a trend toward making use of these materials in more highly stressed primary structural parts. Before they can be so used, however, suitable tests are needed to provide design data.

At the request of the Bureau of Aeronautics, Navy Department, compression tests were made of six curved paper-base plastic panels subjected to an outward-acting pressure; the test panels were furnished by the McDonnell Aircraft Corporation, St. Louis, Mo. The results of the tests are presented herein.

TEST PANELS

Figure 1 illustrates the construction of the panels, and table 1 gives dimensions and other pertinent details.

The material used for the skin, ribs, and stiffener cap strips was a paper-base plastic laminate. The spars and stiffeners were Sitka spruce. Compressive stress-strain curves for the spar and stiffener materials are given in figure 2. For panel no. 2, separate coupons were furnished for the wood stiffener and the plastic cap strip. For the other panels, composite wood-and-plastic coupons, cut from the assembled stiffener, were furnished. Because panel no. 5 did not give a satisfactory test, no coupon tests were made for it.

The coupon tests were made simultaneously with the test of the panel from which the coupons were taken. The moisture content of the wood coupons varied from 9.2 percent to 11.8 percent, with an average value of 10.4 percent. The moisture content of the spars in the test panels varied from 9.4 percent to 10.8 percent, with an average value of 10.3 percent. Because of the small variation in moisture content, no corrections were made to the test results to take this factor into account.

METHOD OF TESTING

A panel is shown in place in the testing machine in figure 3. The ends of the panels were ground flat and parallel to insure uniform distribution of load during the tests. A layer of Permatex was applied between the ends of the panels and the loading platens of the testing machine, so that internal air pressure could be maintained. A number of electrical strain gages were distributed over the inner and outer surfaces of each panel but, because of the nature of the failures that occurred, the data obtained from most of these gages were of little value.

The procedure in testing was as follows:

A small initial axial load was applied to insure an air-tight seal at the ends of the panel. An internal air pressure of 1 psi for the specimens with 0.12-inch-thick skin (panels no. 4 and 6) and 2 psi for the specimens with 0.24-inch-thick skin (panels no. 1, 2, and 3) was then applied. The axial load was then increased in steps until failure occurred. After each load increment had been applied, a series of dial-gage readings was taken on one surface of the panel to determine the amount of lateral deflection of the surface, and straight-edge roll tests were made to detect flat spots or depressions in the surface.

RESULTS

Results of the tests are shown in figures 4 to 6 and in table 2. Panel no. 5 failed under the small initial load, as the air pressure was being applied, and consequently no detailed results are given for that panel.

In all the tests, the introduction of air pressure caused a quilting of the skin between ribs and stiffeners, as shown in figure 4, and produced depressions at the stiffeners. The quilting and resultant depressions increased in severity as the axial load was applied and increased.

The quilting effect is evident from the lateral-deflection plots of figure 5. These plots also show clearly the effect of the clip angle between the rib and stiffener in restraining the lateral movement of the stiffener where it crosses the rib (compare panel no. 2 with panels no. 1 and 3).

In every test failure occurred by separation of the skin, either from the rib or from the stiffeners. These separations are shown in figure 6, and the loads and corresponding average stresses at which they occurred are listed in table 2. Because the failure was a separation rather than a failure of the material, the average stresses listed in table 2 are much lower than the maximum compressive stresses for any of the materials comprising the panels. For example, panel no. 3, which carried the highest average stress, developed about 69 percent of the maximum compressive stress for the wood spar material and about 26 percent of the maximum compressive stress for the plastic.

Separation from the rib occurred in only one specimen where the clip angles were used to attach the stiffeners to the rib (panel no. 1), and in this case separation from the stiffeners also occurred. Panels no. 2 and 5 did not have clip angles, and both these panels failed by separation of the skin from the rib, with no accompanying separation of skin and stiffeners. An examination of these two panels indicated that the failure was the result of a tearing action, which presumably began at the point where the rib is interrupted by the stiffener. In the other panels, the clip angle evidently served to tie the two skins together and thus inhibited this tearing action and delayed the separation of the skin from the rib, resulting in a higher ultimate load.

A slight inward buckle occurred in the upper middle bay of panel no. 6 just before the maximum load was reached. No inward buckling was evident in any of the other panels.

CONCLUSIONS

All panels failed by separation of the skin, either from the rib or from the stiffeners. The average stresses at which the separations occurred were much lower than the maximum compressive stresses for any of the materials comprising the panels.

The addition of clip angles to attach the stiffeners to the rib served to delay separation of the skin from the rib, and thus enabled the panels to carry a higher ultimate load.

The presence of internal pressure caused severe quilting of the skin between ribs and stiffeners.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, September 19, 1944

TABLE I

DETAILS OF TEST PANELS

[Symbols are shown in fig. 1. Dimensions are given in inches.]

Panel no.	t	Part A	Part B	Part C	Part D	Part E	R	W	Remarks
1	0.242	0.77 × 0.92	0.29 × 0.92	1.98 × 2.38 × 2.39	0.08	$1 \times 1 \times \frac{1}{8}$	219	38.8	$0.80 \times 1.43 \times \frac{3}{32}$ dural clip angles used to attach stiffener to rib. Sheet tack riveted to rib on both sides.
2	0.244	0.79 × 0.91	0.26 × 0.91	2.01 × 2.38 × 2.38	0.08	$1 \times 1 \times \frac{1}{8}$	239	38.8	No clip angles. Sheet tack riveted to rib on one side, fully riveted on other side.
3	0.243	0.77 × 0.92	0.27 × 0.92	1.99 × 2.38 × 2.38	0.08	$1 \times 1 \times \frac{1}{8}$	226	38.8	$0.80 \times 1.43 \times \frac{3}{32}$ dural clip angles used to attach stiffener to rib. Sheet fully riveted to rib on both sides.
4	0.123	0.78 × 0.52	0.23 × 0.52	1.83 × 2.06 × 1.99	0.04	$\frac{3}{4} \times \frac{3}{4} \times \frac{1}{16}$	290	38.0	Same as panel no. 1.
5	0.102	0.76 × 0.52	0.24 × 0.52	1.84 × 2.07 × 2.00	0.04	$\frac{3}{4} \times \frac{3}{4} \times \frac{1}{16}$	306	38.0	Same as panel no. 2.
6	0.127	0.78 × 0.51	0.24 × 0.51	1.80 × 2.05 × 1.98	0.04	$\frac{3}{4} \times \frac{3}{4} \times \frac{1}{16}$	284	37.9	Same as panel no. 3.

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TABLE 2

RESULTS OF PANEL TESTS

Panel no.	Internal pressure (psi)	Maximum load (kips)	Average stress at max. load (ksi)	Remarks
1	2	160	4.83	Separation of skin from rib and stiffeners
2	2	120	3.61	Separation of skin from rib
3	2	170	5.13	Separation of skin from stiffeners
4	1	45	2.34	Separation of skin from stiffeners
5	$\frac{1}{2}$	5	----	Separation of skin from rib at initial load of 5 kips while introducing internal air pressure
6	1	55	2.84	Separation of skin from stiffeners. Slight inward buckle in upper middle bay just prior to failure

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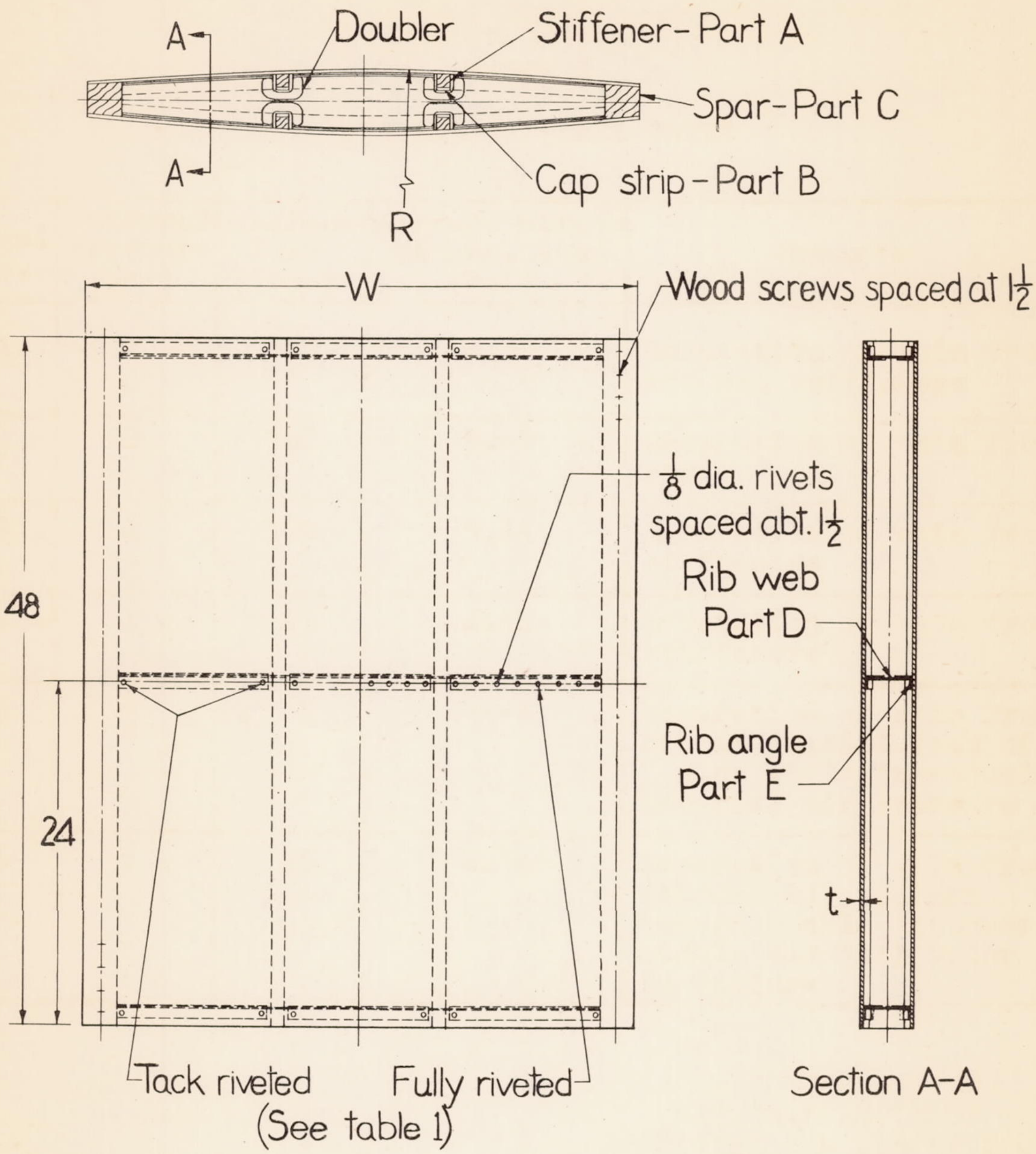

Figure 1.- Test panel.

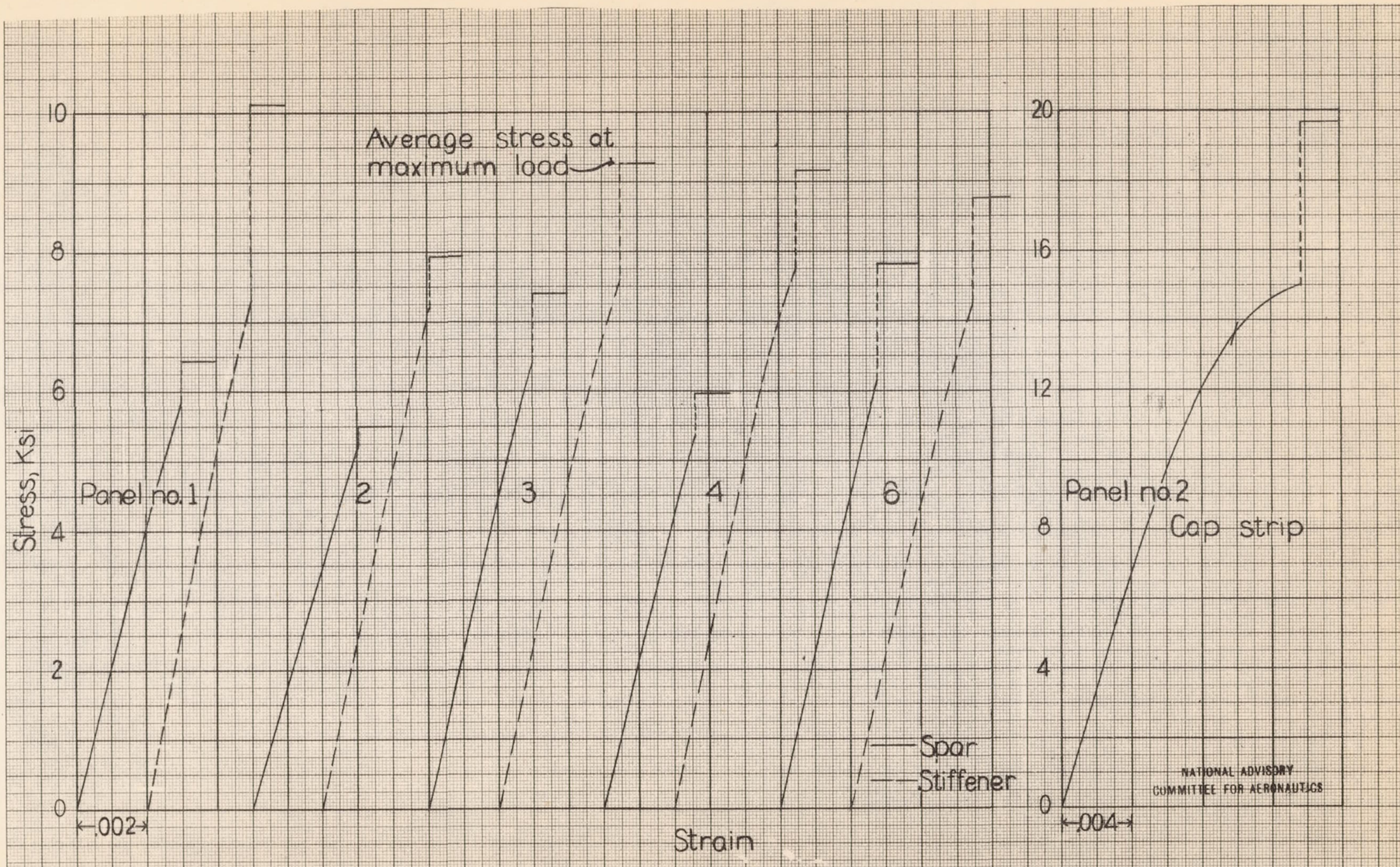

Figure 2.- Average compressive stress-strain curves for component parts of test panels. Curves for stiffeners of panels no. 1, 3, 4, and 6 include cap strip.

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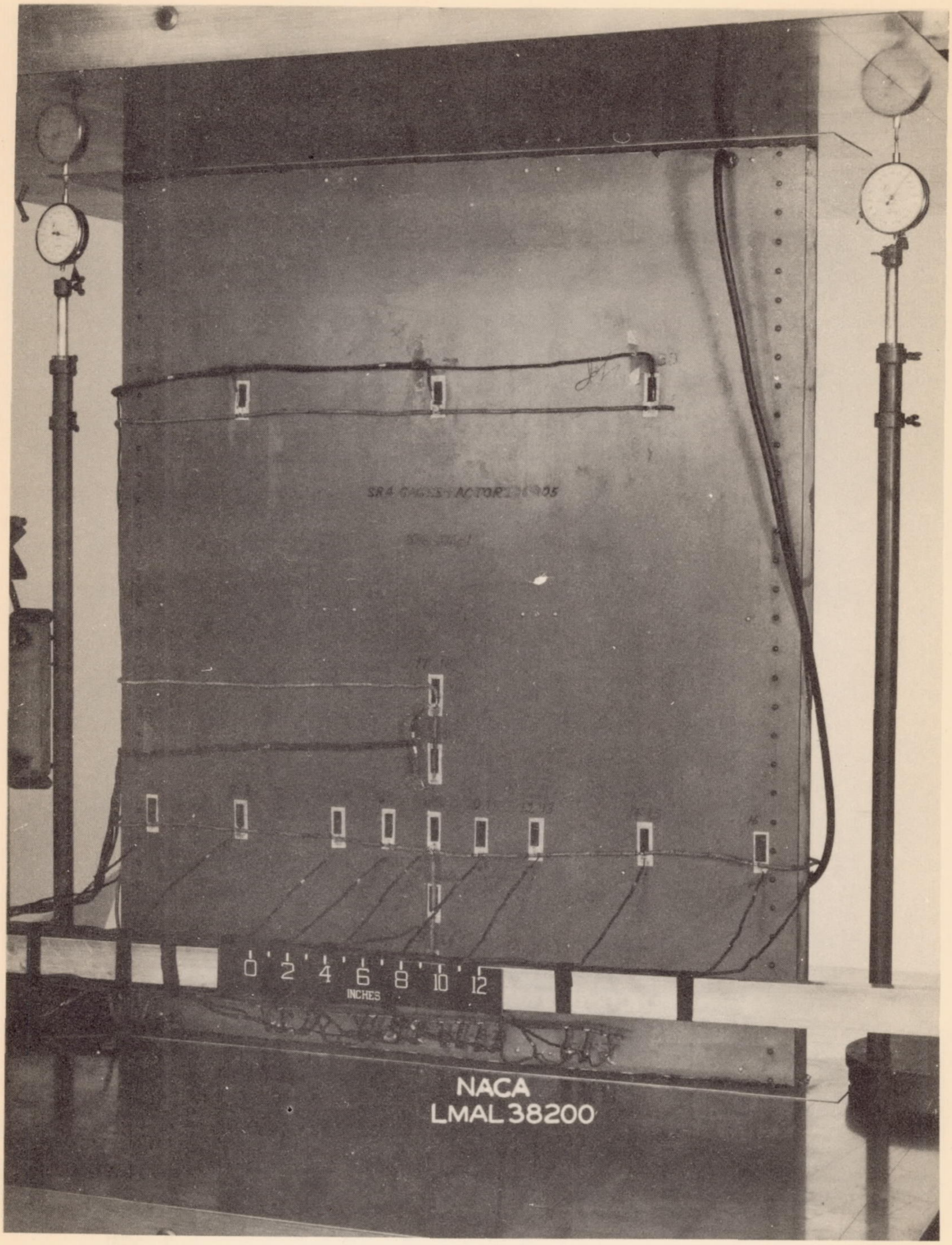

Figure 3.- Panel in testing machine.

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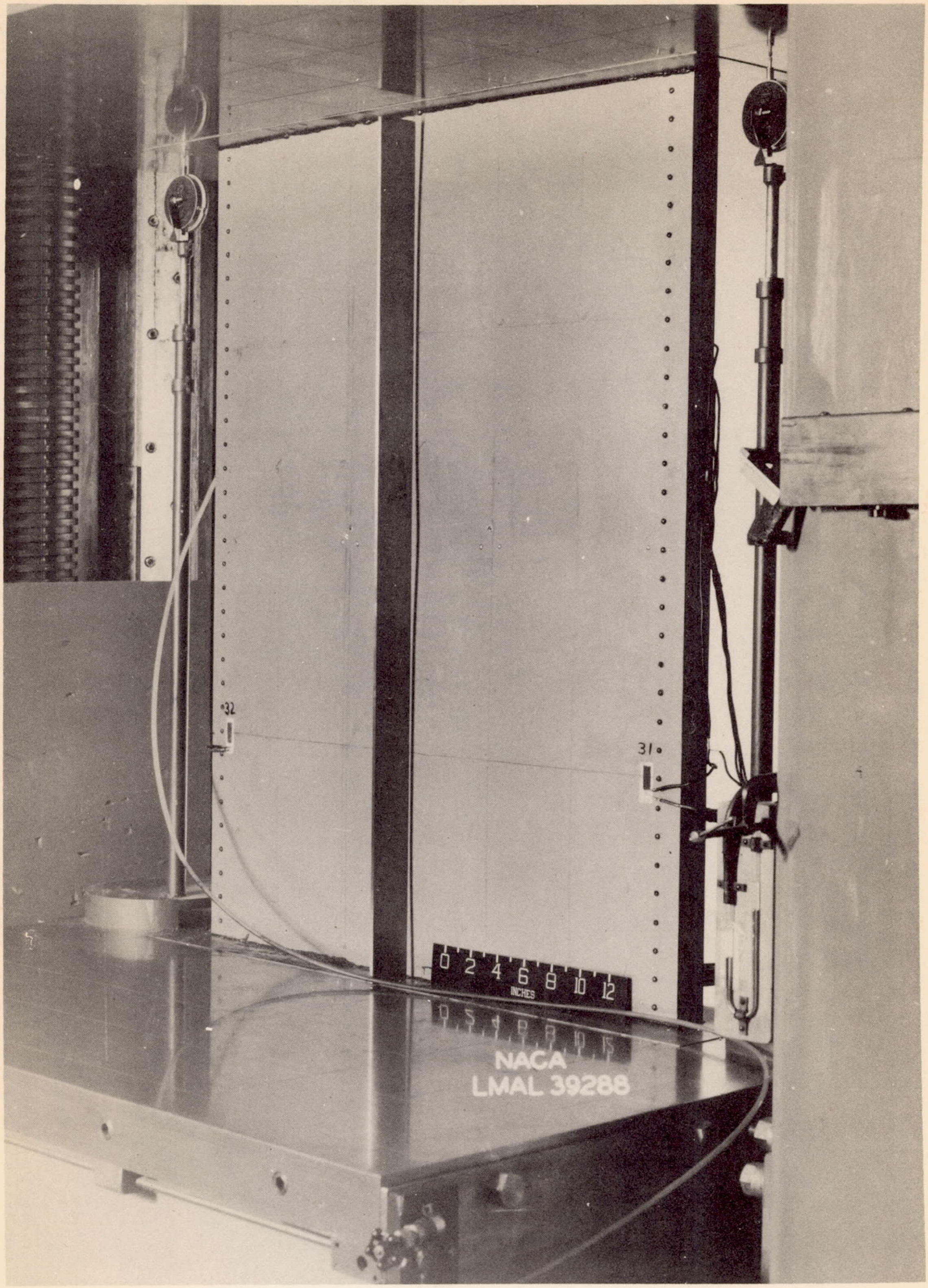

Figure 4.- Test panel under load, showing typical quilting of skin between ribs. Note shadow of straight edge.

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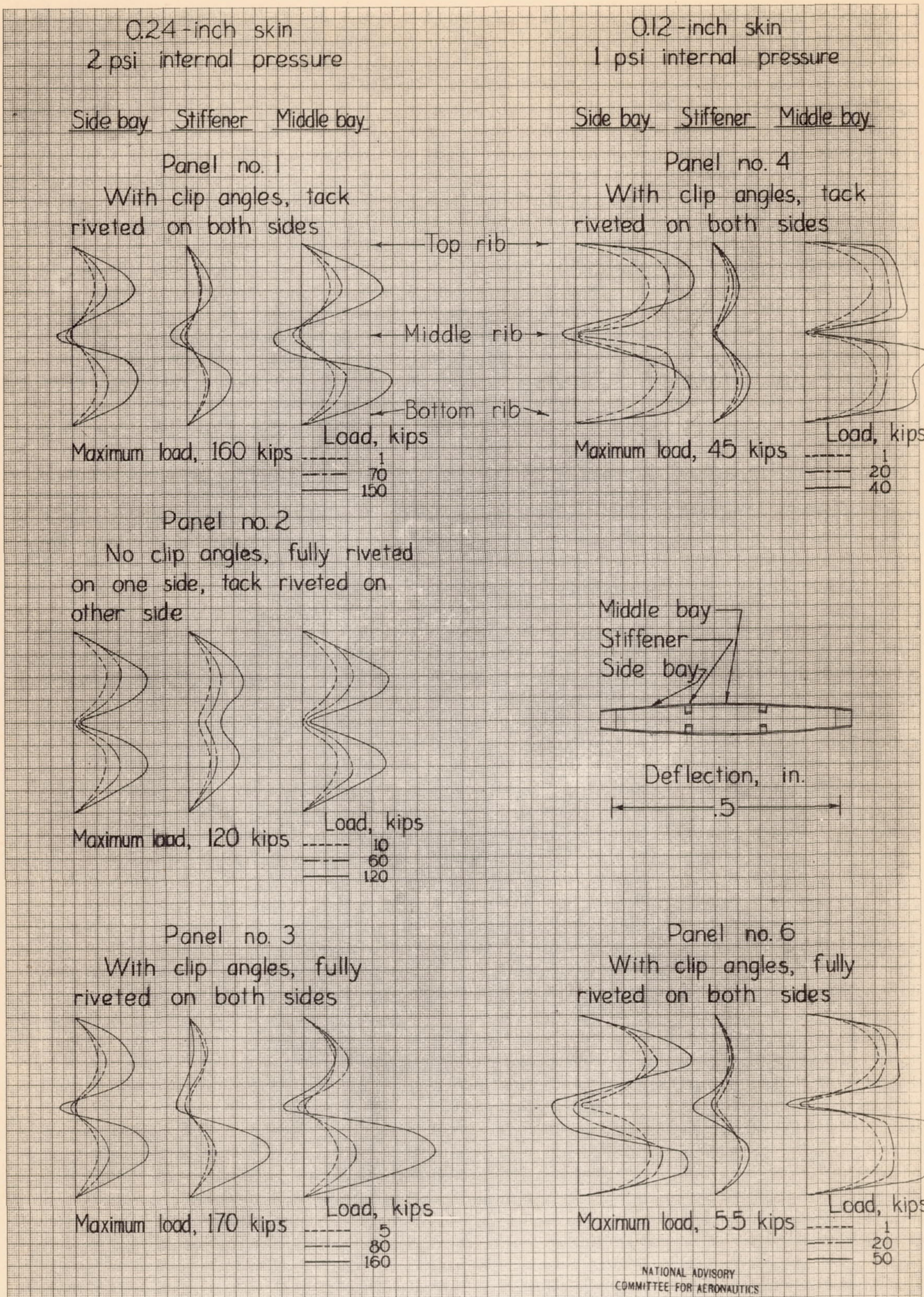

Figure 5.- Lateral-deflection plots for test panels.

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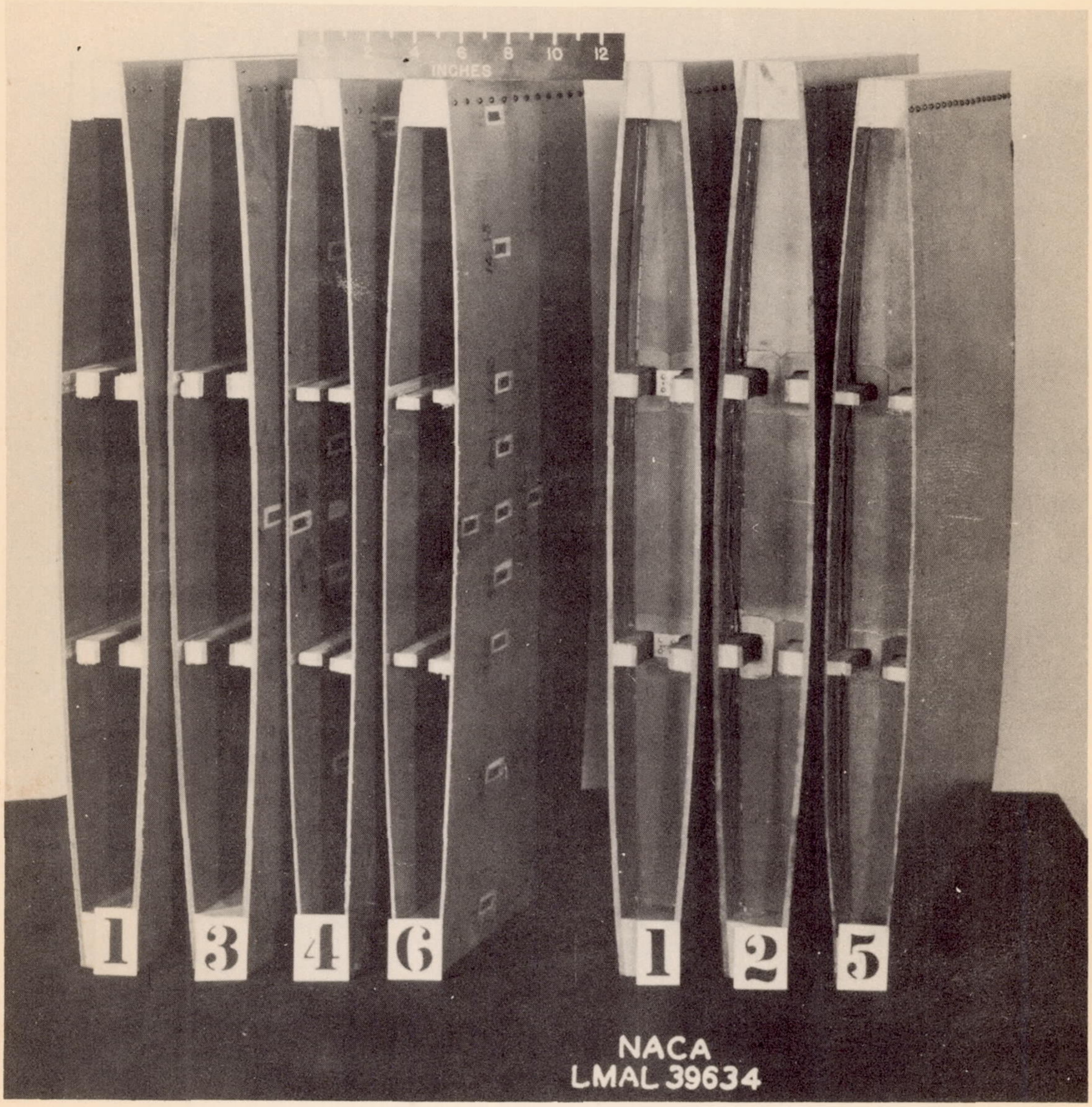

Figure 6.- Sections of test panels after failure, showing separation of skin from stiffeners and rib. (See table 2.)