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# Sandwich Construction and Core Materials. Part VI

## SECTION I

'Balsolite' Impregnated Paper Cellular Material as an Elastic Stabiliser

*By*

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## SECTION II

Compression Tests on Sandwich Panels with 'Balsolite' Cores

*By*

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of the Royal Aircraft Establishment

## SECTION III

Strength Tests of a Typhoon Type Fuselage of 'Balsolite' Sandwich Construction

*By*

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# Sandwich Construction and Core Materials. Part VI

(In Three Sections)

## SECTION I

## 'Balsolite' Impregnated Paper Cellular Material as an Elastic Stabiliser

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*Summary*.—A range of struts each consisting of 'Balsolite' filler sandwiched between two faces of $\frac{1}{16}$-in. thick birch plywood has been tested in order to assess the efficiency of Balsolite as a stabilizer in sandwich structures.

It is concluded that this material compares favourably with other low density materials when used as a stabilizer. Modification of the material, namely the use of transverse and longitudinal tubes alternately, does not appear to be beneficial.

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*Introduction*.—A wide range of samples of 'Balsolite' material of various constructions was submitted for examination in connection with the research programme on low density stabilizers. From these, one type of construction was chosen for complete investigation and forms the main subject of this report. The type of construction selected for the present tests is shown in Fig. 1. It consisted of sections of tubes of resin impregnated paper approximately $\frac{7}{16}$ in. in diameter by 0·008 to 0·009 in. thick, placed between birch plywood $\frac{1}{16}$ in. thick, the axes of the tubes being perpendicular to the plywood faces and these axes lying in a series of parallel planes, parallel and perpendicular to the length of the strut. The direction of the grain of face veneers was parallel to the length of the strut. The glue used for gluing the tubes together and securing the plywood faces was a synthetic resin glue of the cold-setting type.

Fifteen sandwiches of various lengths were received. The ends of these had been reinforced with wood to a depth of approximately 1·5 in. The weight per square foot of the middle portions of these test pieces varied from 0·67 to 0·74 lb/sq ft. The overall thickness varied from 0·52 to 0·59 in. and the width from 3·16 to 3·23 in.

*Method of Tests*.—The struts were tested using the end fittings shown in Fig. 2. They were held firmly in these fittings by two opposing wedges, arranged so that the centres of the balls would lie on the central axis of the strut.

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## TABLE 1

*Results of Tests on Struts Loaded through a Ball at each End*

| Length (in.) | Balsolite Failing Load (lb) | Specific Weight $\left(\dfrac{\text{Weight (lb/sq ft)}}{\text{Load (lb/in. width)}} \times 10^3\right)$ | $\dfrac{\text{Failing load/ft width}}{\text{Weight/sq ft.}} \times 10^{-4}$ |
|---|---|---|---|
| 6·91 | 2441 | 0·922 | 1·301 |
| 6·95 | 2446 | 0·908 | 1·321 |
| 7·01 | 896 | 2·550 | 0·471 |
| 9·94 | 2009 | 1·130 | 1·062 |
| 9·99 | 2352 | 0·920 | 1·306 |
| 10·03 | 2518 | 0·876 | 1·370 |
| 12·83 | 1453 | 1·470 | 0·816 |
| 12·90 | 1470 | 1·459 | 0·822 |
| 12·95 | 1908 | 1·195 | 1·004 |
| 14·97 | 1355 | 1·630 | 0·736 |
| 15·00 | 1635 | 1·372 | 0·875 |
| 15·04 | 1406 | 1·636 | 0·734 |
| 18·87 | 1561 | 1·491 | 0·805 |
| 18·91 | 1001 | 2·297 | 0·522 |
| 19·07 | 1055 | 2·233 | 0·538 |

The above results have been plotted as shown in Fig. 3 where correction has been made for the variations in width of the test pieces.

The line XY represents the Euler load for a strut as calculated from the flexural rigidity obtained from a bend test on a representative sandwich. The smooth curve EF is derived from the equation

$$\frac{1}{P} = \frac{1}{P_E} + \frac{1}{Ct} \quad \ldots \quad (1)$$

where $P$ actual load per inch width to cause failure,

$P_E$ Euler load/in. width,

$t$ thickness of filler in in.

$C$ Modulus of Rigidity in lb/sq in. of filler.

The value of $C$, namely 2144 lb/sq in. was obtained from a direct shear test on the Balsolite material, as described in Appendix 2. The scatter is rather marked but is probably due mainly to variation in the dimensions of the struts. The line AB represents the limiting strength of this type of strut as determined by tests on very short struts between flat platens. This corresponds to a limiting strength of plywood of 7220 lb/sq in.

A study of the types of failure, shows that in nearly every case the failure was due to a definite quasi Euler buckle. In the shorter struts a tendency to shear failure in the stabilizer was noted, but the incidence of glue failure was not at all marked.

Fig. 4 shows the results of the tests, plotted so that a correction is made for the weight of each strut. The lines drawn here enable a figure of merit, weight/sq ft per load/in. width to be given for a wide range of $P/L$ values. The line CD represents a limit for the normal Balsolite as determined from tests on very short struts between flat platens. Comparison of this curve with that given in say R. & M. 2125[3] will show that for values of $P/L$ between 10 and 100 this particular arrangement of Balsolite is as efficient as the stringer boards described therein, in fact the two curves are coincident within this range.

*Conclusions.*—1. For values of $P/L$ betow 100 the particular arrangement of Balsolite tested is as efficient as alternative constructions.

2. There is considerable variation in strength from one strut to another, probably as a result of variations in dimensions. It may be expected that, as experience is obtained in handling this material, such variations will be minimised.

3. The equivalent modulus of rigidity of the material is high in relation to its density. Experimental results appear to agree with the strength calculated using this value but the scatter is wide.

4. The adhesion between the plywood and the filler material of the sandwich struts, appeared to be of adequate strength and, as the filler material itself is readily bent, there should be no difficulty in handling the material in production.

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## APPENDIX I

*Tests on Component Materials.*—Samples of both the filler and the skin material were obtained at the same time as the sandwich struts and the following subsidiary tests were made.

1. *Filler Materials.*—Samples of filler material of the type shown in Fig. 1 were tested for modulus of rigidity.

Four rectangular slabs of the material Balsolite were glued to four steel plates. These plates had been prepared for gluing by facing them with thin veneer, secured by means of a resin film glue. The arrangement of the test is shown in Fig. 5.

The two plates in the centre were pulled in a tensile testing machine, thereby placing the four slabs of cellular material in shear. A Marten's extensometer was used to measure the relative movement of these centre plates so that the shear strain of the test slabs could be estimated.

This method of test, however, is liable to error, due to the unstressed end surfaces of the test pieces, but this error was minimised by making the pieces long in relation to their thickness.

Compression tests were also carried out on the filler material. The properties of the filler material are shown in Table 2.

### TABLE 2

*Properties of the Filler Material*

| | |
|---|---|
| Equivalent Density (gm/cc) .. .. .. | 0·064 |
| Modulus of Rigidity (lb/sq in.) .. .. | 2144 for a stress range of 0·6 to 11·5 lb/sq in. |
| Specific Modulus of Rigidity (Km) .. .. | 23·7 |
| Modulus of Elasticity in Compression (lb/sq in.) | 4530 for a stress range of 6 to 18 lb/sq in. |
| Specific Compression Modulus (Km) .. .. | 49·8 |
| Crushing Strength (lb/sq in.) .. .. .. | 191 |
| Specific Crushing Strengtn (Km) .. .. | 2·12 |

2. *Plywood*.—Test pieces, cut from the same sheet of plywood as was used in the struts, were tested. The value of Young's modulus in tension obtained by using a Lindley extensometer on a 2-in gauge length was $1 \cdot 72 \times 10^6$ lb/sq in. The tensile strength was 13,800 lb/sq in. The flexural rigidity of the plywood as determined by a simple four point loading bend test was 45 lb/sq in.

The value of Young's modulus is in agreement with that calculated from a test on a complete sandwich tested in pure bending.

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## APPENDIX II

*Tests on Struts with Fillers of Modified Form*.—Twelve struts of varying length, in which the stabilizing Balsolite had been modified as shown in Fig. 6. The density of this filler material was 0·089 gm/cc as compared with 0·064 gm/cc for Balsolite. The results of the tests are given in Table 3 and plotted on Figs. 3 and 4.

### TABLE 3

*Results of Tests on Struts Loaded through a Ball at Each End*

| Length (in.) | Modified Balsolite Failing Load (lb) | Specific Weight $\left(\frac{\text{Weight (lb/sq ft)}}{\text{Load (lb/in. width)}} \times 10^3\right)$ | $\frac{\text{Failing load/ft width}}{\text{Weight/sq ft}} \times 10^{-4}$ |
|---|---|---|---|
| 6·81 | 2105 | 1·021 | 1·175 |
| 6·88 | 2446 | 0·908 | 1·320 |
| 6·93 | 2103 | 1·031 | 1·164 |
| 9·86 | 1837 | 1·133 | 1·059 |
| 9·88 | 1505 | 1·448 | 0·829 |
| 10·05 | 1591 | 1·351 | 0·888 |
| 12·90 | 1557 | 1·384 | 0·890 |
| 12·93 | 1411 | 1·530 | 0·784 |
| 12·96 | 1822 | 1·164 | 1·031 |
| 14·84 | 1255 | 1·778 | 0·675 |
| 14·87 | 1436 | 1·510 | 0·795 |
| 14·91 | 994·4 | 2·049 | 0·586 |

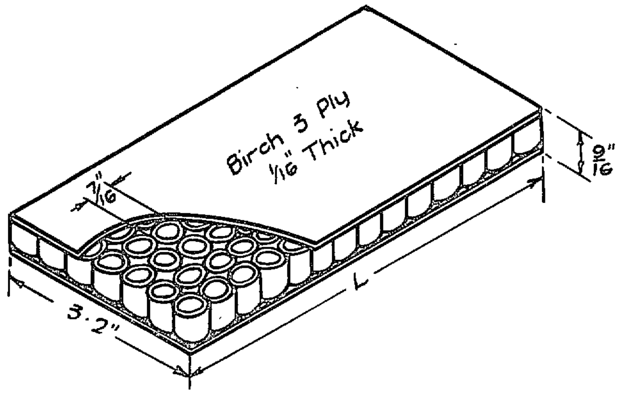


FIG. 1. Arrangement of Balsolite struts.

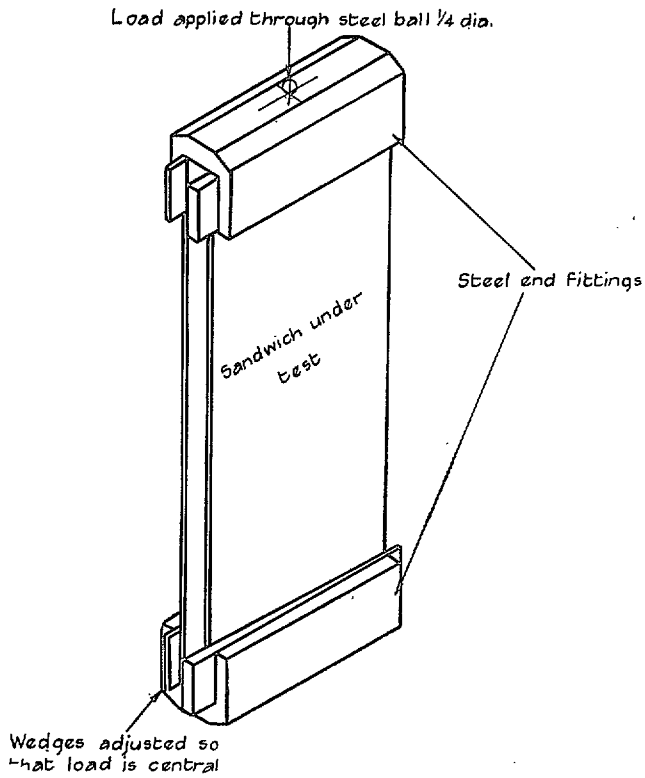


FIG. 2. Method of applying load to sandwich struts.

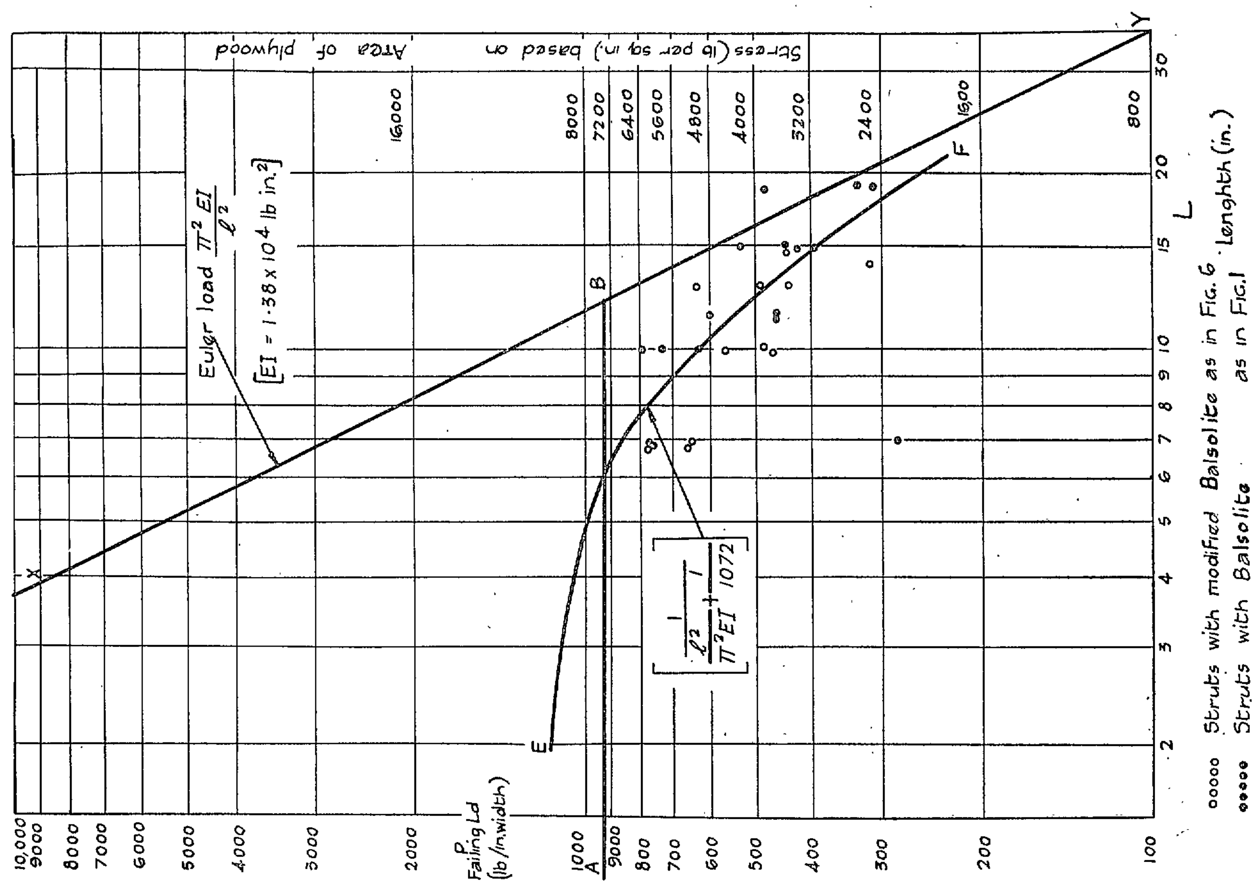
Stress (lb per sq in.) based on Area of plywood
Euler load $\frac{\pi^2 EI}{\ell^2}$
$[EI = 1{\cdot}38 \times 10^4$ lb in.$^2]$
$\left[\frac{1}{\frac{\ell^2}{\pi^2 EI} + \frac{1}{1072}}\right]$
P Failing Ld (lb/in. width)
L Length (in.)
ooooo Struts with modified Balsolite as in Fig. 6
●●●●● Struts with Balsolite as in Fig. 1

FIG. 3.

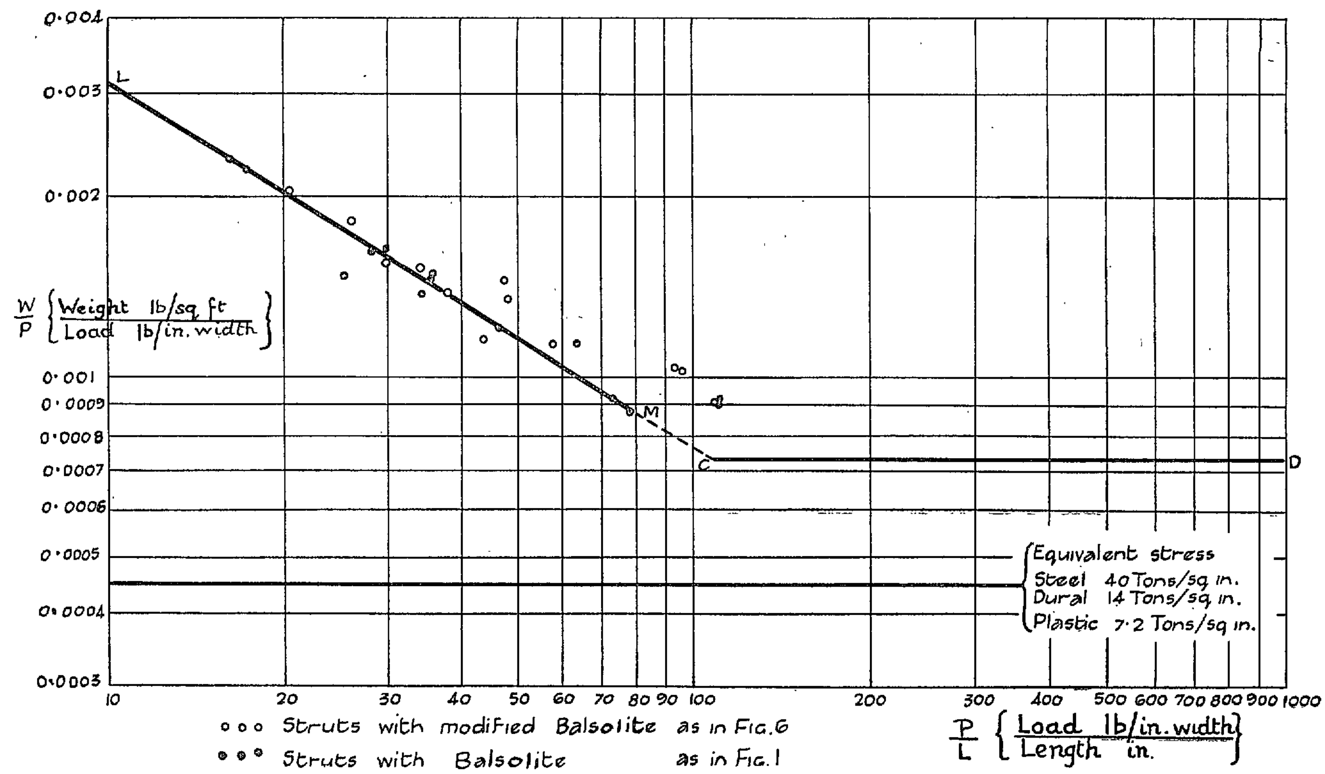
$\frac{W}{P}$ {Weight lb/sq ft / Load lb/in. width}
Equivalent stress
Steel 40 Tons/sq in.
Dural 14 Tons/sq in.
Plastic 7·2 Tons/sq in.
○○○ Struts with modified Balsolite as in Fig. 6
●●● Struts with Balsolite as in Fig. 1
$\frac{P}{L}$ {Load lb/in. width / Length in.}

FIG. 4.

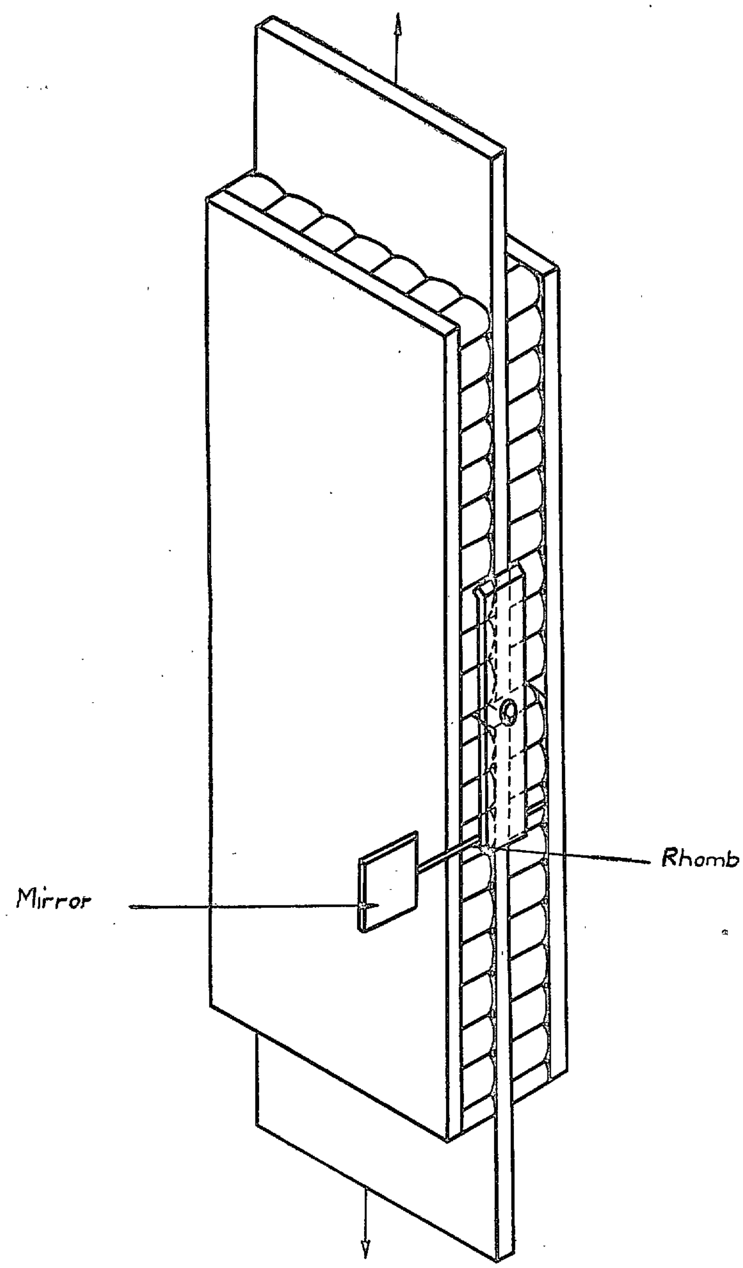


FIG. 5. Arrangement of direct shear test on Balsolite.

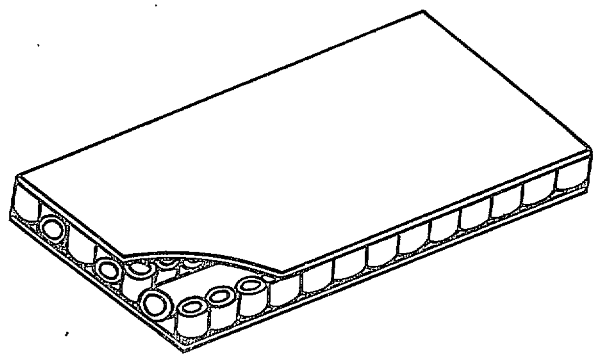

FIG. 6. Arrangement of Balsolite struts (modified form).

# SECTION II*

## Compression Tests on Sandwich Penals with 'Balsolite' Cores

*By*

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*Summary.*—This note gives the results of tests on ten sandwich panels having 'Balsolite' filling and either birch plywood or laminated-paper faces. It is concluded that for taking compressive end load, ply-Balsolite is at present a more efficient sandwich than laminated-paper-Balsolite, and that for use in a lightly loaded structure Balsolite shows considerable promise as a filling material.

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1. *Introduction.*—The need for wing and fuselage structures that give a smooth and wave-free surface under conditions of normal flight has promoted interest in various kinds of sandwich, for the inherent stability of this type of construction makes it specially well fitted to provide a smooth and unbuckled surface. An extensive theoretical[1, 2, 3] and experimental[4] investigation has already been undertaken with respect to dural-balsa sandwich panels, and the object of this note is to describe the results of a series of tests on panels having Balsolite filling and either birch plywood or laminated-paper faces. Of the ten panels tested, six had laminated-paper faces and four birch 3-ply faces with the grain of the outside veneers parallel to the direction of loading. The panels were in duplicate pairs, although in the case of the paper-faced panels two different methods were used to produce the faces. The Balsolite filling was the same for all ten panels, and consisted of paper cylinders, $\frac{1}{2}$ in. long and $\frac{1}{2}$ in. in diameter, which were glued to each other and to the faces of the panel. The cylinders had wall thicknesses of about 0·01 in. and were arranged with their axes normal to the panel surface (*see* Fig. 1). The panels were 18 in. long, 6 in. wide, and are described in Table 1.

2. *Method of Test.*—During the tests on the dural-balsa sandwich panels referred to in Section 1, it was found desirable to reinforce the ends to prevent local crushing, and the same procedure was adopted here (*see* Fig. 1). Pieces of plywood, $\frac{1}{4}$ in. thick and 2 in. wide, were glued to the ply or paper faces at each end of the panel, and in general these proved satisfactory. As the panels were being tested as struts it was felt that there was no point in fixing side supports and these were omitted. After attaching the plywood supports, the ends were planed square and parallel, and the specimens weighed and measured. The panels were then placed between the flat and parallel platens of a testing machine and loaded in compression. During each test the movement between the loaded edges was measured by means of two dial gauges, recording in thousands of an inch, and these were read up to the time of failure (*see* Fig. 2). At the same time a close watch was kept for any local or overall bowing. After examining the types of failure that had occurred, the faces were stripped off the Balsolite filling, and measurements made of the face thicknesses and weight of the plywood end supports.

3. *Description of Results.*—The results of the tests are summarised in Table 1, and it will be noted that if failing load per feet width divided by weight per square feet is taken as the measure of a panel's efficiency, the plywood-faced panels are considerably more efficient than the paper-faced panels.

The stress in the faces at failure was worked out on the assumption that the end load taken by the balsolite filling was negligible. For the plywood-faced panels the values thus obtained show that the faces developed a very high proportion of their ultimate strength in compression.

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* R.A.E. Tech. Note S.M.E. 268, received 16th January, 1947.

In panels 1 and 2, where the faces pulled away from the filling the stress is somewhat lower than in panel 3 where no such pulling away occurred, and the type of failure suggests faulty adhesion between faces and filling. As no reliable figures for the compressive strength of the laminated paper faces are available, the proportion of the ultimate stress developed is uncertain, but with the exception of panels 7 and 10 it seems likely that the proportion is high. In panels 7 and 10 where pulling away of the faces occurred, the stress developed is somewhat lower, and here again faulty adhesion is indicated.

The results of tension tests, made on specimens representative of the various types of paper face used in the panels, are shown in Table 2.

Curvature readings showed that the panel surface remained plane up to at least 80 per cent of the failing load. At higher loads some of the panels began to bow slightly, but failure, which occurred suddenly, took place before bowing became very pronounced. Typical failures for both the plywood and paper-faced panels are shown in Figs. 3 and 4.

A study of the panel efficiencies as given in Table 1 shows up the following points:

(i) The plywood-faced panels are more efficient than the paper-faced panels and have an average efficiency of $1 \cdot 39 \times 10^4$ ft.

(ii) There is little to choose between the two types of paper-faced panel, the average efficiency of panels with ordinary laminated-paper faces being $0 \cdot 93 \times 10^4$ ft and of paper faces made by the Iromould process $0 \cdot 90 \times 10^4$ ft.

(iii) The average weight of the Balsolite filling, including gluing, is only $0 \cdot 1$ lb/sq ft, so that on a weight basis balsolite (2 to 3 lb/cu ft) compares favourably with balsa (8 to 16 lb/cu ft), Onazote (5 to 10 lb/cu ft), or Celuboard (8 to 16 lb/cu ft).

(iv) In spite of its light weight, the Balsolite filling enables the plywood and laminated-paper faces to exploit their full compressive yield strength.

4. *Conclusions.*—For taking compressive end load it is concluded that plywood-Balsolite is at present a more efficient sandwich than laminated-paper-Balsolite, and that for use in a lightly loaded structure Balsolite shows considerable promise as a filling material.

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| 3 | D. M. A. Leggett and H. G. Hopkins .. | Sandwich Panels and Cylinders under Compressive End Loads. R. & M. 2262. August, 1942. |
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## APPENDIX

| *Panel number* | *Method of Failure* |
|---|---|
| | *Panels with Plywood Faces* |
| 1 | Simple buckling of the panel occurred, and as the failing load was reached, the plywood face pulled away from the filling in one region adjacent to the plywood end supports. |
| 2 | The manner of failure was the same as for panel 1. |
| 3 | As the failing load was reached the panel cracked across its whole breadth in two places about 3 in. apart, but in opposite directions. |
| 4 | As the load increased, lateral waves, extending across the whole breadth of the panel, developed in the faces. The wavelength was 1 in., corresponding to the distance between centres of adjacent paper cylinders. The amplitude of the waves increased until local failure of the skin occurred (*see* Fig. 3); general failure followed immediately. |
| | *Panels with Faces of* 18 *mils Laminated Paper—Pressed* |
| 5 (2 laminations) | Simple buckling occurred and at the point of failure the concave face cracked across the whole width of the panel. |
| 6 (3 laminations) | As the load increased the top two laminations on the concave face separated at one edge in two places forming local bulges. The amplitude of the bulges steadily increased until the two joined. Failure of the panel followed immediately (*see* Fig. 4), the skin cracking across the whole width of the panel. |
| 7 (4 laminations) | As the load increased, the top two laminations separated in two places at opposite ends of the panel forming local bulges, adjacent to the plywood end supports. As failure occurred the whole face pulled away from the filler at a third place on the concave side, also adjacent to the plywood end supports. |
| | *Panels with* 18 *mils Paper Laminated by Iromould Process* |
| 8 (2 laminations) | Simple buckling of the panel occurred and at the point of failure the concave face cracked across the whole width of the panel. |
| 9 (3 laminations) | The manner of failure was similar to that of panel 8. |
| 10 (4 laminations) | With this panel, too much pressure during manufacture seems to have been applied to the plywood end supports, causing at one end slight squashing of the paper filler. At this point, early on in the loading, bulges developed in the faces, on both sides of the panel, causing failure at a lower load than otherwise might have been expected. |

## TABLE 1

*Summary of Results*

| Panel number | Particulars of Panel: Material of faces | Thickness of each face (in.) | Total Thickness (in.) | Total weight per sq ft (lb) | Failing load (lb) | Failing load/ft width / wt./sq ft (ft × $10^4$) | Mean stress in faces at failure (lb/sq in.) |
|---|---|---|---|---|---|---|---|
| 1 | Birch plywood .. .. | 0·065 | 0·643 | 0·720 | 4,800 | 1·33 | 6,150 |
| 2 | Birch plywood .. .. | 0·067 | 0·658 | 0·733 | 5,400 | 1·47 | 6,710 |
| 3 | Birch plywood .. .. | 0·035 | 0·582 | 0·466 | 3,500 | 1·50 | 8,330 |
| 4 | Birch plywood .. .. | 0·035 | 0·573 | 0·466 | 2,900 | 1·25 | 6,900 |
| 5 | 2 Laminations 18 mils Paper pressed | 0·024 | 0·567 | 0·427 | 1,800 | 0·844 | 6,250 |
| 6 | 3 Laminations 18 mils Paper pressed | 0·036 | 0·557 | 0·506 | 2,600 | 1·03 | 6,010 |
| 7 | 4 Laminations 18 mils Paper pressed | 0·069 | 0·604 | 0·640 | 2,900 | 0·905 | 3,500 |
| 8 | 2 Laminations 18 mils Paper laminated by Iromould process | 0·033 | 0·572 | 0·466 | 2,100 | 0·90 | 5,300 |
| 9 | 3 Laminations 18 mils Paper laminated by Iromould process | 0·053 | 0·613 | 0·600 | 2,900 | 0·966 | 4,560 |
| 10 | 4 Laminations 18 mils Paper laminated by Iromould process | 0·072 | 0·647 | 0·760 | 3,200 | 0·840 | 3,710 |

## TABLE 2

*Properties of Paper Faces*

| Description of specimen | Test Piece no. | Density (lb/ft³) | Young's Modulus (lb/sq in.) | Limit of proportionality (lb/sq in.) | 0·1 per cent proof stress (lb/sq in.) | Failing stress (lb/sq in.) |
|---|---|---|---|---|---|---|
| 2 Laminations paper pressed .. | 1 | 58·9 | $0·71 \times 10^6$ | 2.240 | 3,200 | 7,160 |
| | 2 | | $0·79 \times 10^6$ | 2,530 | 3,610 | 8,710 |
| 3 Laminations paper pressed .. | 1 | 65·7 | $0·81 \times 10^6$ | 2,550 | 3,920 | 6,970 |
| | 2 | | $0·90 \times 10^6$ | 3,250 | 4,640 | 8,180 |
| 4 Laminations paper pressed .. | 1 | 63·5 | $1·15 \times 10^6$ | 3,060 | 4,930 | 12,210 |
| | 2 | | $1·06 \times 10^6$ | 2,730 | 4,270 | 12,400 |
| 2 Laminations Iromould process | 1 | 50·9 | $0·49 \times 10^6$ | 2,250 | 2,750 | 6,820 |
| | 2 | | $0·52 \times 10^6$ | 1,990 | 2,620 | 6,320 |
| 3 Laminations Iromould process | 1 | 52·1 | $0·54 \times 10^6$ | 1,660 | 2,420 | 6,360 |
| | 2 | | $0·57 \times 10^6$ | 2,150 | 2,850 | 6,230 |
| 4 Laminations Iromould process | 1 | 52·4 | $0·39 \times 10^6$ | 1,540 | 2,040 | 5,420 |
| | 2 | | $0·40 \times 10^6$ | 1,530 | 2,030 | 5,110 |

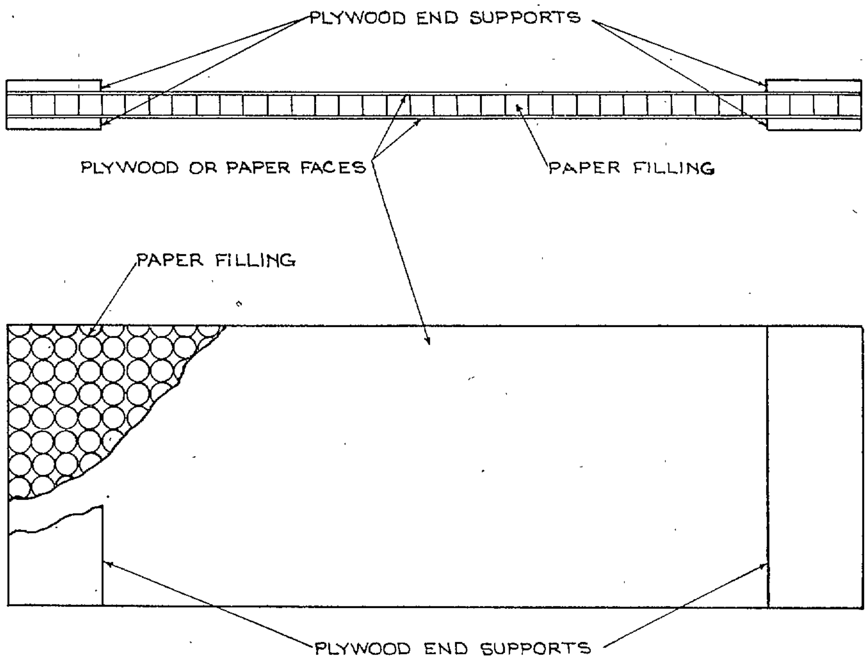


FIG. 1. The method of construction of a typical panel.

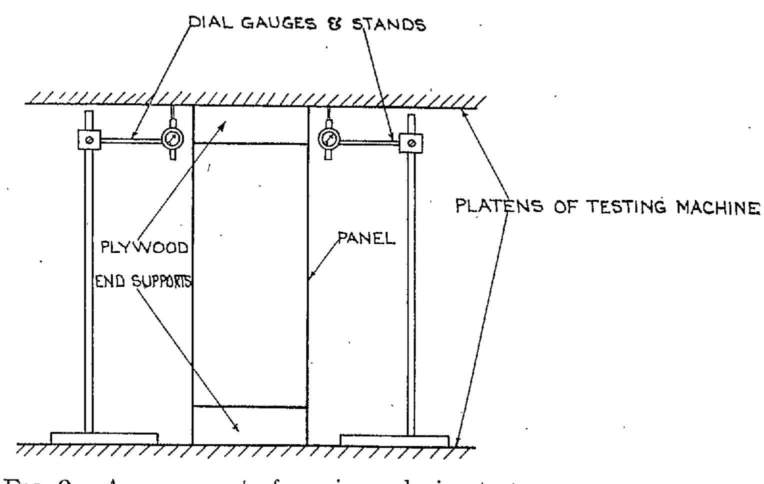


FIG. 2. Arrangement of specimen during test.

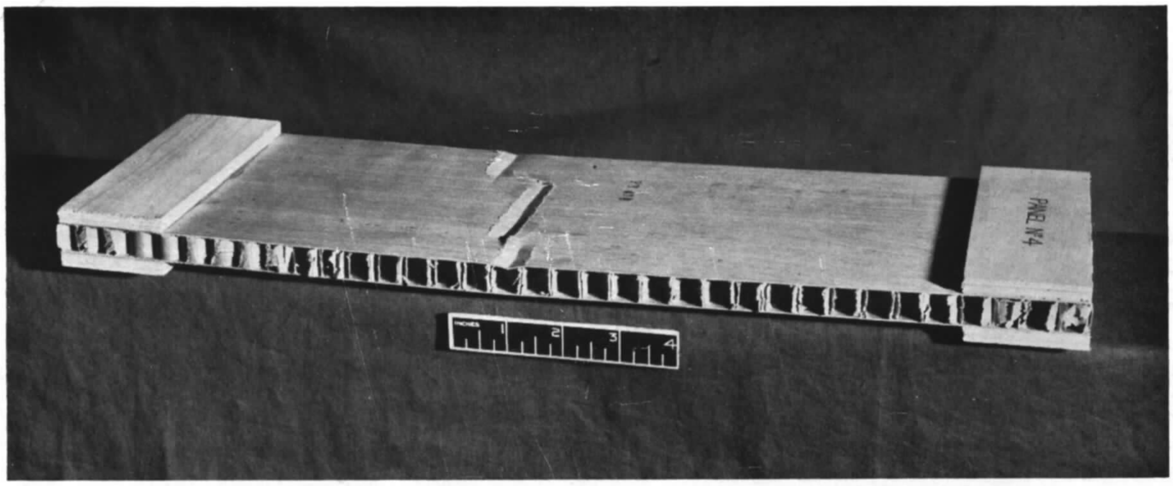


FIG. 3.

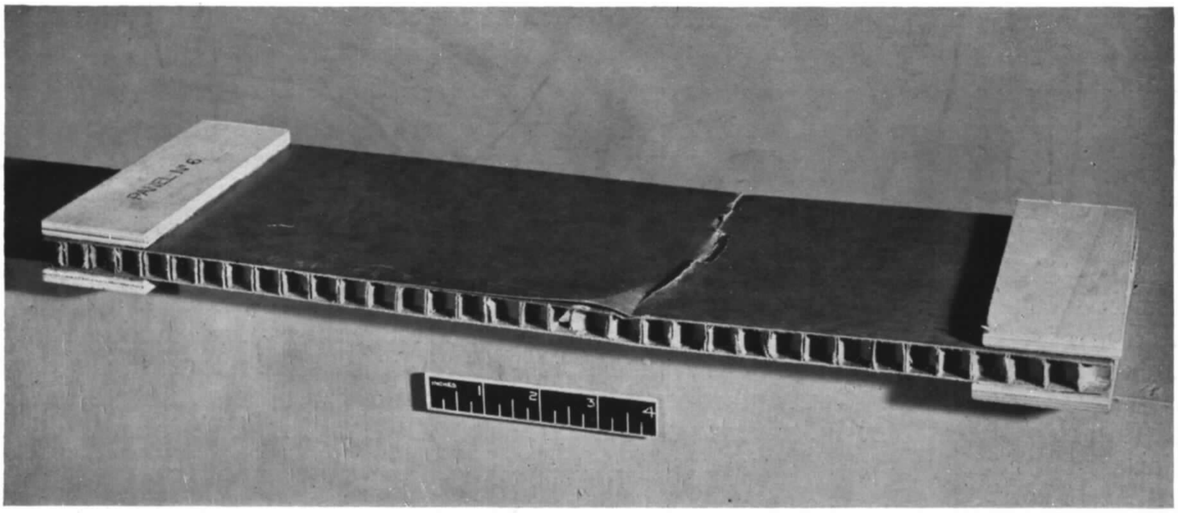


FIG. 4.

# SECTION III*

## Strength Tests of a Typhoon Type Fuselage of 'Balsolite' Sandwich Construction

*By*

J. K. Oaks

of the Royal Aircraft Establishment

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1. *Introduction.*—The object of the tests was to determine the strength and stiffness of a *Typhoon*-type fuselage of Balsolite construction, for comparison with corresponding values obtained for similar fuselages of other constructions.

2. *Description of Specimen.*—The fuselage is shown in Fig. 1. It was a pure monocoque and in shape it was a frustrum of a cone of elliptical cross-section. The ends of the specimen were reinforced with plywood over a length of 9 in., and there was a plywood butt strap 4 in. wide along each side on the ends of the minor axis.

There was one circumferential lap joint and several longitudinal lap joints. They were all flush finished and those in the outer skin were staggered relatively to those in the inner skin. Steel rings which fitted both inside and out, were bolted to the reinforced ends for picking up on the test frame and the loading rig. The shell construction was a sandwich, consisting of outer and inner skins of $\frac{3}{32}$ in. birch 3-ply, and a filler of impregnated paper cylinders $\frac{1}{2}$ in. long and 0·01 in. thick, with axes normal to the skins. The ply skins had outer veneers with the grain parallel to the longitudinal axis of the fuselage and inner veneers with the grain at right-angles. The weight of the fuselage was 135 lb and the weight/sq ft of surface area was 0·94 lb.

3. *Range of Investigation.*—The forward end of the fuselage was bolted to the test frame and the loading rig was bolted to the tail end. Strain-gauges arranged to measure direct strain and deflection measuring instruments were fitted at the positions shown in Fig. 1. The strain-gauges were read during the tests on a Tinsley hand set. Two tests were made (1) a side-load test to 2700 lb and (2) an up-load test to failure. The positions of the loading points are shown in Fig. 1.

Load deflection graphs were plotted and the stresses were calculated and compared with the strain-gauge readings. After the test, 11 panels 12 in. long $\times$ 6 in. wide were cut from the fuselage and tested in compression.

4. *Results.*—Failure occurred under an up-load at the tail of 7680 lb. The failure was by compression in the top half of the fuselage 11 to 16 in. from the forward end. The failure is illustrated in Fig. 2. The calculated maximum stress in the plywood at the failing load and in the plane of the failure was 4,300 lb/sq in. The strain-gauges were 22 in. nearer the loading point than the position of failure. Gauge number 1, which was on the top of the fuselage, indicated a stress at failure of 4,100 lb/sq in. assuming an $E$ of $1 \cdot 5 \times 10^6$ lb/sq in. The calculated stress at this point was 4,250 lb/sq in. This is a rough check of the calculated stress in the plane of the failure 4,300 lb/sq in.

For the side-load test deflections are plotted in Fig. 3 and the strain-gauge readings in Fig. 5 for the up-load test deflection are plotted in Fig. 4 and strain-gauge readings in Fig. 6.

There was only very slight buckling of the skin right up to the failing load.

---

* R.A.E. Test Note No. 122.

5. *Panel Tests.*—The results of the panel tests are given in Table below. Failure was by buckling, accompanied, except in specimens 3, 6 and 10, by failure in the glue. The stresses are loads divided by the area of the plywood skins only.

| No. | Radius (in.) | Max. load (lb) | Max. stress (lb/sq in.) | Remarks |
|---|---|---|---|---|
| 1 | 36 | 5,820 | 5,180 | |
| 2 | 29 | 4,170 | 3,700 | |
| 3 | 26 | 3,700 | 3,290 | Specimen initially slightly bent. |
| 4 | 26 | 3,720 | 3,300 | |
| 5 | 26 | 4,660 | 4,140 | |
| 6 | 24 | 6,950 | 6,180 | Slight tearing of filler at failure. |
| 7 | 24 | 5,600 | 4,980 | Failure at one end in glue and filler. |
| 8 | 24 | 6,140 | 5,450 | |
| 9 | 24 | 5,700 | 5,060 | |
| 10 | 22 | 6,140 | 5,450 | Specimen initially slightly bent. Slight tearing of filler at failure. |
| 11 | 20 | 3,250 | 2,890 | |

Only the best of these panels No. 6 reached a stress comparable with those of Section II of this report. The Balsolite panels tested previously were 18 in. long 6 in. wide and were flat, but the plywood skin was 0·035 to 0·067 in. thick compared with 0·094 in. thick in the fuselage panels. It is probable that the skin in the fuselage panels is above the optimum thickness that can be stabilised by the strength of the glue joint.

The average stress in the panels at failure is 4,500 lb/sq in. which is of the same order as the failing stress in the fuselage 4,300 lb/sq in.

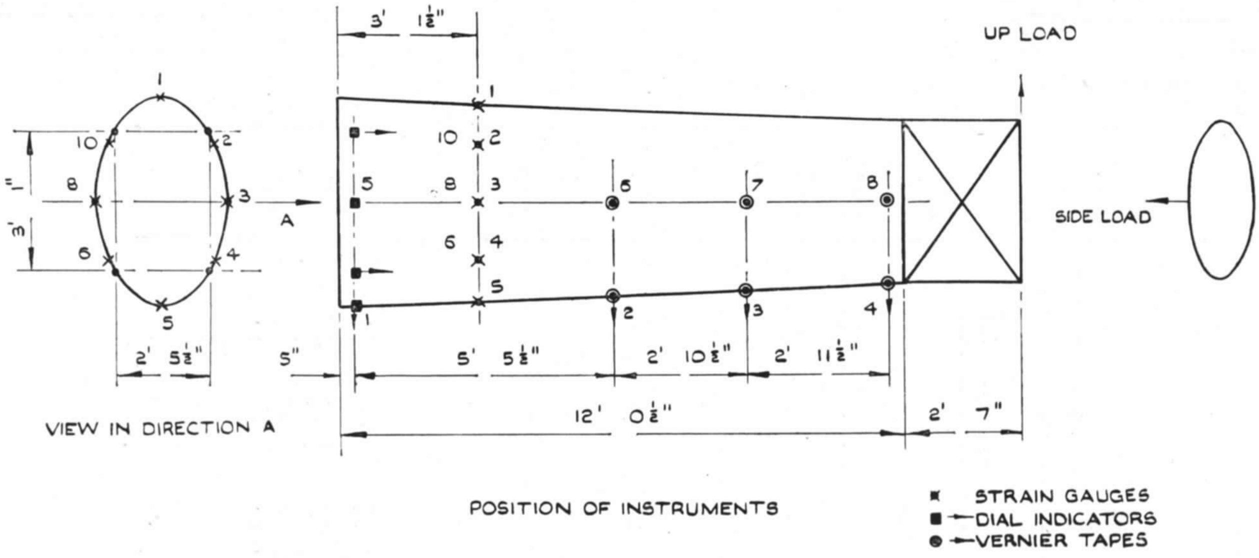


FIG. 1. *Typhoon*-type Balsolite fuselage.

FIG. 2.

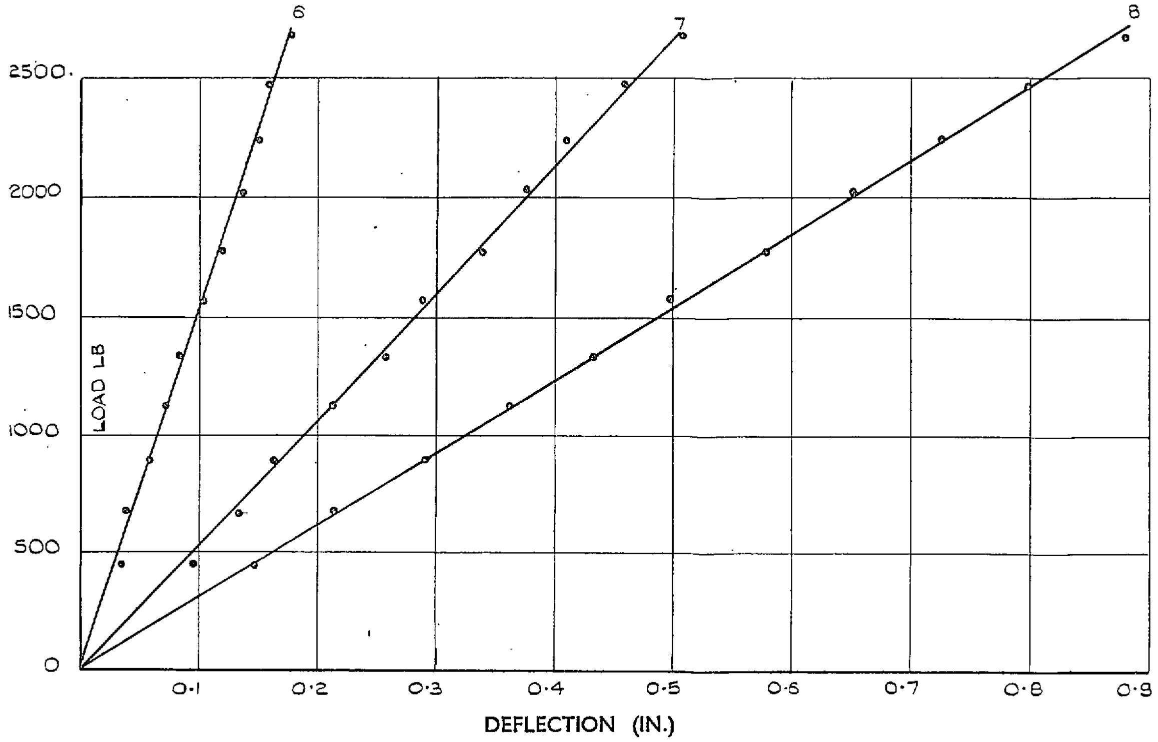


**Fig. 3.** *Typhoon*-type Balsolite fuselage. Side load.

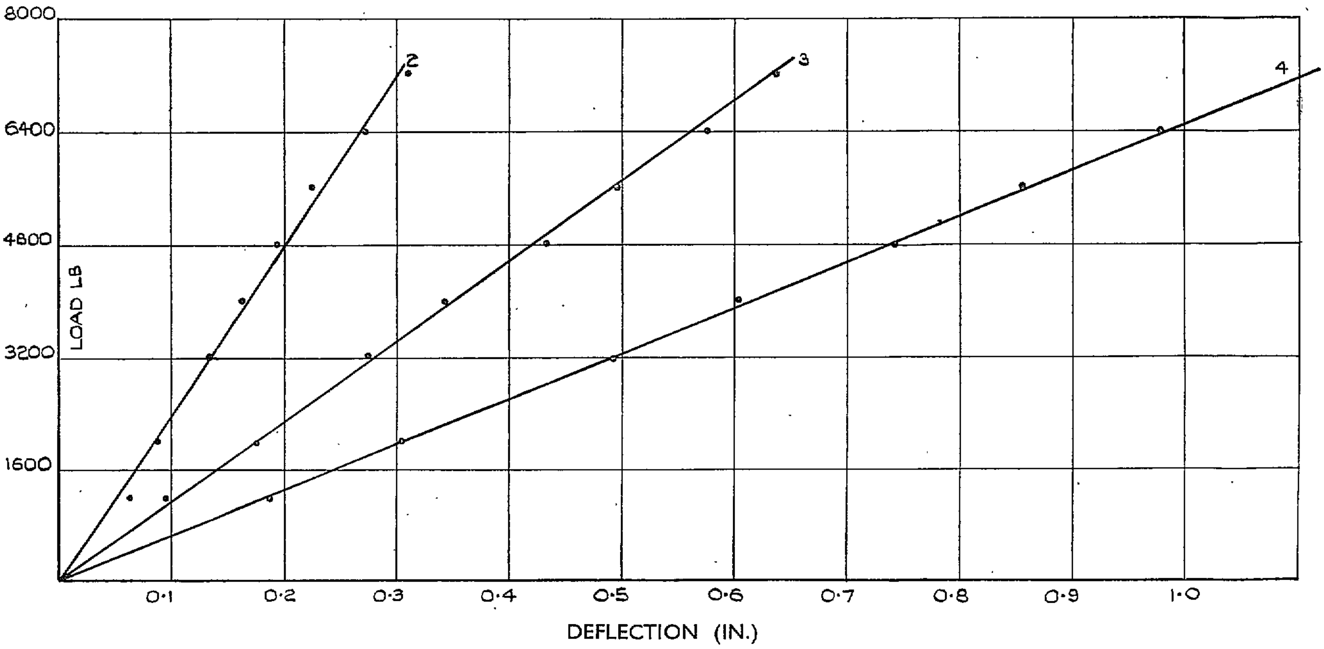


**Fig. 4.** *Typhoon*-type Balsolite fuselage. Up load.

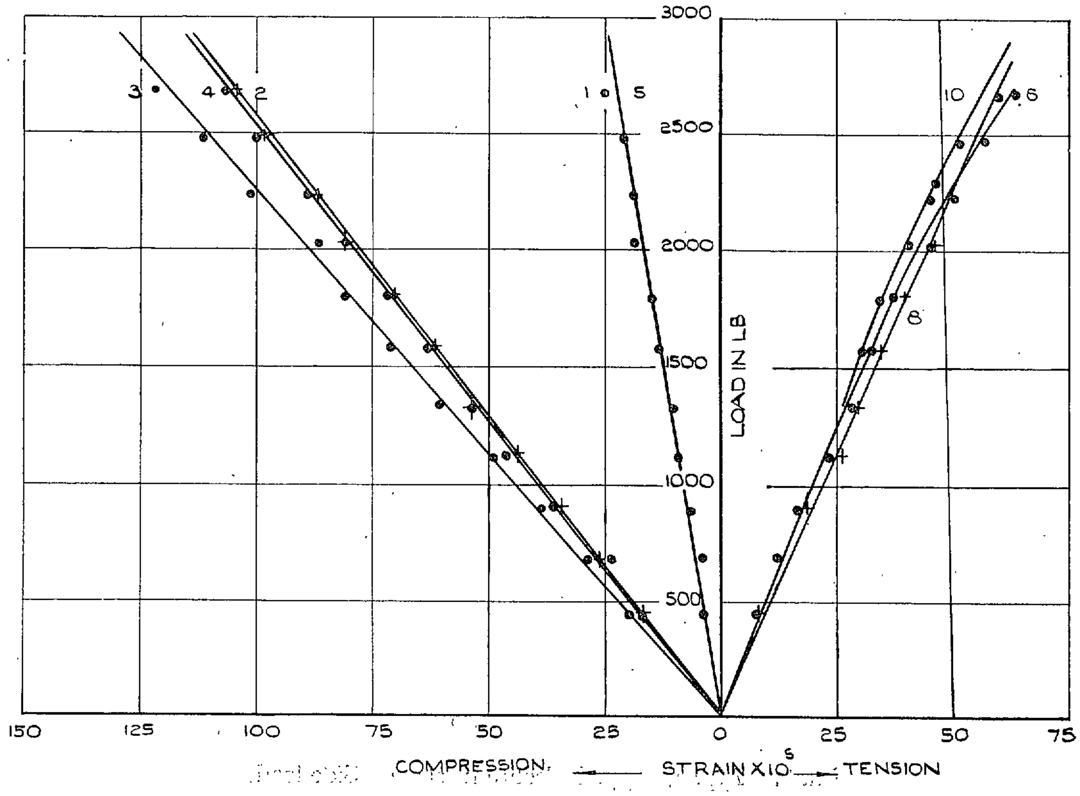


FIG. 5. *Typhoon*-type Balsolite fuselage. Side load.

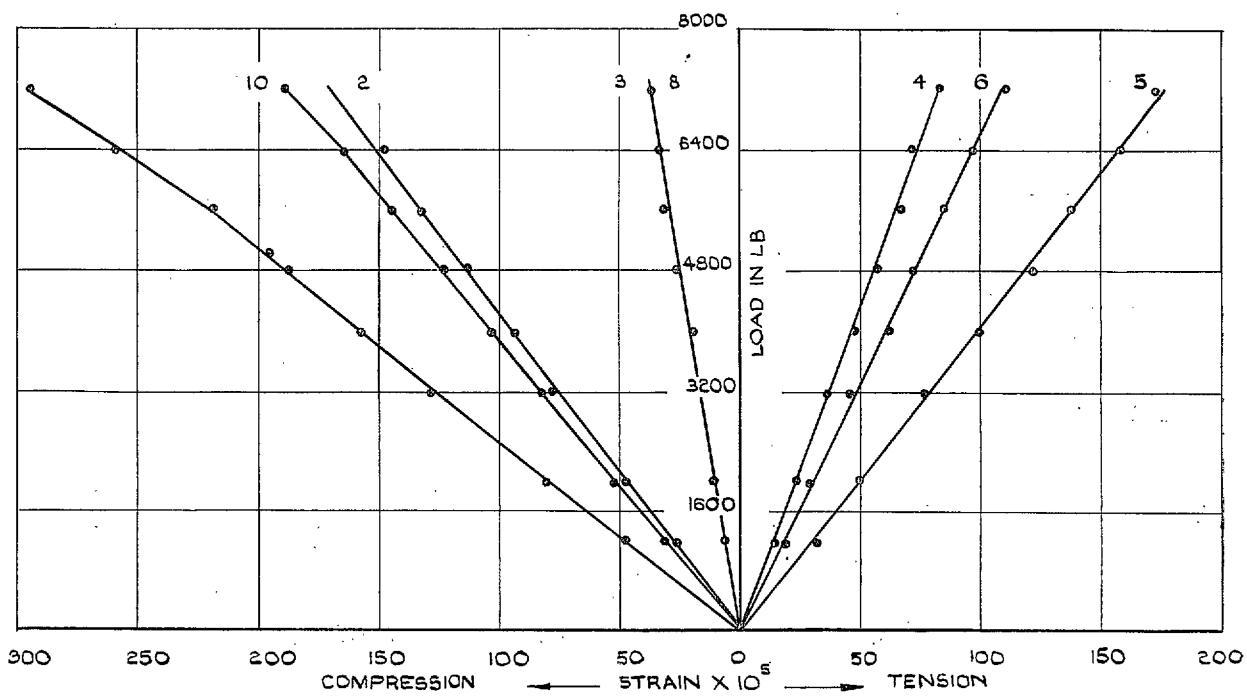


FIG. 6. *Typhoon*-type Balsolite fuselage. Up load.



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