# SANDWICH CONSTRUCTION IN GLIDERS


*By*

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*Introduction*

Since the disclosure last summer of the structural details of the British mystery bomber plane, the DeHaviland "Mosquito," interest in the sandwich construction has increased to such an extent that there are few airplane companies left in this country that have not made some experiments with this promising new combination of materials. For this reason the authors are glad to present some data on sandwich construction, and a survey of its applicability to gliders.

*Properties of Sandwich Construction*

Sandwich construction is characterized by the use of a comparatively thick multilayer skin the thin faces of which are of some high strength material between which a thick core of ultra-lightweight material is sandwiched. Materials suitable for the faces are plywood, laminated paper plastic (papreg), fiberglass, and metals; for the core cork, balsa wood, and synthetic materials such as cellulose acetate.

Multilayer construction may have been used long ago for industrial purposes. It is even possible to uncover isolated applications of it to early aircraft. Mr. C. J. McCarthy, Vice President of United Aircraft Corporation, disclosed in a letter to the authors that the Sundstedt airplane, built in this country in 1919, had pontoons constructed according to the sandwich principle. A German patent granted in 1924 to von Kármán and Stock (Ref. 1) indicates that the gliding society of the Polytechnic Institute of Aachen must have planned, if not built a fuselage having a sandwich skin. The more recent development began in the early thirties when S. E. Mautner carried out experiments for the airplane plants of the Schneider-Creusot concern in France, and deBruyne initiated in England the work which later culminated in the successful Mosquito. It is believed that in the United States the first sandwich type aileron was built in 1939 by Skydyne, Inc., the holders of Mautner's patents. A recently built aileron of the same type has now been flying for over a year on a military plane, and is giving satisfactory service.


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The advantage of the sandwich skin is its great rigidity in bending, obtained through the wide spacing of the faces. Because of this rigidity the sandwich skin does not buckle, develop waves or folds, when compressive or shear stresses are acting upon it. On the other hand, such rigidity in bending is lacking in the thin aluminum alloy sheet covering of the current metal airplane, and thus in the latter recourse must be taken to a great number of longitudinal and transverse reinforcing elements in order to retain the aerodynamic shape of the structure and to prevent premature structural failure. The elimination of these reinforcing elements is the fundamental achievement of the sandwich system. It makes possible a simpler and consequently cheaper construction.

The strength of 24ST alclad sheet will now be compared to that of one type of sandwich skin. The faces of this sandwich are made of laminated paper plastic which weighs 86 lb. per cu. ft. and has a tensile ultimate strength of 28,000 lb. per sq. in., a compressive ultimate strength of 20,000 lb. per sq. in., an ultimate shearing strength of 15,000 lb. per sq. in., and a modulus of elasticity of 2,200,000 lb. per sq. in. For the core cellulose acetate weighing 3 lb. per cu. ft. is chosen. In the calculation the strength of the core will be neglected.

The weight of alclad is 174 lb. per cu. ft., its ultimate tensile strength 56,000 lb. per sq. in., ultimate shear strength 34,000 lb. per sq. in., and the modulus of elasticity 9,500,000 lb. per sq. in.

A typical panel of sheet in an aluminum alloy monocoque wing may have a thickness of 0.025 in. Its counterpart built according to the sandwich principle may have an outer face of 0.010 in., a core of ½ in., and an inner face of 0.010 in. The weight of the construction is proportional to the product of the thickness and the weight of the material per cubic foot. With the alclad sheet the product is $0.025 \times 174 = 4.35$. With the sandwich skin the calculation gives $(0.01 + 0.01) \times 86 + 0.5 \times 3 = 3.22$.

The tensile strength of a strip one inch wide is 1,400 lb. in the case of alclad, 560 lb. in the case of the sandwich. The figures corresponding to compression are similar, those to shear 850 lb., and 300 lb., respectively. However, the compressive and shearing strength of the alclad sheet could be fully realized only if it were reinforced with a prohibitive number of closely spaced stiffeners which would add to the cost of production as well as the weight. Without these stiffeners the sheet buckles under comparatively small loads.