AIRSHIPS INTERNATIONAL, INC.

THE PRESENT STATE OF METALCLAD AIRSHIP TECHNOLOGY

Metalclad airships have a long historical background, commencing with intuitive concepts in the middle of the last century. During the last decade David Schwarz designed the world's first rigid airship constructed completely of metal.

All-metal technology was then still not understood in principle and for a long time was not suitable for practical use. This was probably the main reason why Count Zeppelin decided to develop an airship with a rigid skeleton covered with fabric instead of making it completely of metal. His work grew out of the principles of Schwarz, which Zeppelin bought from Schwarz' widow.

Twenty-five years later, Ralph H. Upson clearly and precisely defined and developed the ultimate Metalclad hull theory with the understanding and inventiveness necessary for designing and constructing Metalclad airships. The first Metalclad airship, the ZMC-2, was based on his principles and used them with complete success. It remained in service from 1929 until 1941, when it was decommissioned, still in perfect condition.

Metalclad principles are now a classic of structural simplicity. A perfected concept, Metalclad hulls of high overall and local strength lend themselves to easy and rapid fabrication.

In the third decade of this century, after four catastrophic mishaps involving large, skeletal, fabric-covered airships, it appeared assured that Metalclad airship construction would continue. This prospect did not materialize, however, partly due to political attitudes and partly because of the general abandonment of further airship construction forty years ago.

Metalclad airships were a new, never-before-used concept of an extremely light and elastic metal shell supported by a light structure. Both the shell and the structure could not be erected independently of one another because each would collapse from its own weight; but assembled together, they form a rigid structure capable of considerable strength—despite local elastic buckling of the thin shell of metal when not inflated by internal pressure.

When internal hull pressure is raised even slightly, elastic buckles disappear and the skin becomes taut. It acquires a high degree of rigidity and local as well as overall strength, never before attained by any other means, with lightness of weight out of proportion to the loads the hull lifts and the abuses it tolerates. These hulls are also precise bodies, even under the forces of high speed flight.

The impact of Metalclad technology has not yet been felt on earth-bound structures, although the Apollo Project probably would not have been possible without the internal pressure of its fuel tanks. All modern, high-speed transport aircraft use internal pressure; but it is unlikely that passengers inside a wide-body airplane are aware, at 35,000 ft. altitude, that the internal pressure has made the aircraft body much stronger than it was at take-off.

In the fifty years since the first Metalclad airship, all technologies have progressed so much that considerable input from them will also serve in the design and construction of airships. The catalog of these available contributions is long; among them are strong and light metals, carbon-epoxy laminates, synthetic membranes for hull cells and techniques of joining by bonding and welding by means undreamed of before. Computer technology will be a powerful instrument in airship design and also in logistic planning of construction. Among the most significant assets not available to airships in the past and now highly developed are turbo-machinery power and the sophisticated state of development of electronics. Light, efficient and dependable, turbo-machinery power promises to have a profoundly positive influence on the economic viability of airship operations. And without today's electronics for navigation, control, stress-sensing, etc., airships would be limited in service and less safe.

Several basic technological advancements in the design, construction and operation of Metalclad airships were originated within a group now known as Airships International, Inc., and represent the most significant progress in design concept and engineering relative to Metalclad airship technology to occur since the second decade of this century. Among these singular modern advancements, nine stand out as the most important:

1. The perfection of Upson's hull shell/structure combination, attaining simplicity of structure, increased redundancy, and higher strength with exceptionally low cost and rapid construction of Metalclad hulls.

2. The concept of assembly of Metalclad hulls on cushioned belts, rotating the whole hull as the construction task progresses, always at floor level and under the best and safest working conditions, resulting in rapid and inexpensive erection of highly precise hulls.

3. The development of dynamic thrusters for control of airships without need of fins and movable surfaces, at all speeds from zero to maximum, in all weather, with dependability and rapid response. The use of thrusters larger than the units used for control for augmenting lift when heavy and during icing episodes, temperature inversions or down drafts. Control thrusters and lift thrusters also eliminate the need for weight ballast and ground crew.

4. The design of membrane cells in hull sub-volumes of minimum possible surface area for containment of lifting gas and control of volumetric changes, for inflation without trapped air to maintain high initial purity of lifting gas, and for transfer of gas from any location within the hull to any other location with simplicity of operation—costing almost no additional weight for rapid trim control at any time during flight. The membrane cells will make inflation with gas a routine operation.

5. The means for heating the lifting gas with rapid circulation by blowers (used also in item 4) during rain or snow and particularly during icing. Metalclad airships possess a high degree of security not feasible before.

6. The use of composite liquid-gaseous fuel. The fuel gas is contained in separate cells located inside the helium cells, completely secure and safe, for the purpose of maintaining exact lift-load equilibrium at all times during flight.

7. The solution of the problem of carrying heavy loads by airships as freighters. This had not been solved before, and in the past there was little incentive to develop a heavy load-lifting capability by fragile, skeletal-rigid airships. Airships International has developed means for converting an express airship into a freighter airship, within a short time period, by attachment of a freighter rig with its own lifting thrusters for augmenting the static lift of the airship by additional dynamic lift of the freight rig thrusters. The freight rig has its own fuel system controlled from the bridge. Typically, for a long distance trip of up to 10 hours, the static lift can be increased by approximately 40%; for shorter trips, the static lift can be doubled by the dynamic lift of the thrusters. This method of load carrying permits a variety of utilization of airships for freight carrying; without the freight rig, the airship again is a long-range express vehicle.

8. The propulsion of airships by internally-located power plants, drawing the air mass of the hull boundary layer into perimetral slot ducts by driving propellers, and accelerating this air mass to an elevated velocity at high propulsive efficiency for the cold air jets emerging from the stern of the hull. Reversing of the power plants for backward motion will eject sheets of air at high momentum from the boundary layer slots.

9. The system of mooring airships on the ground by attaching to a telescoping mooring tower, which will lower the airship from its elevated position at the time of attachment to the tower to ground level for loading while being held steady by the stern control thrusters. In gusty winds, the airship hull will be supported on a cushioned cradle on a ground vehicle, moving on a circular rail track, with the tower at its center.

Metalclad airship principles have now been effectively enlarged and broadened by the nine items recited above into a completely integrated airship technology for all purposes. These airships will, by a considerable margin, carry a useful load greater than their empty weight—a quality which will make them economically desirable transport vehicles.

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SUMMARY OF COMPARISONS

ITEM	METALCLAD	SKELETAL FABRIC
SAFETY	HIGH	LIMITED
HEAVY LIFT	HIGH	LIMITED
HIGH SPEED	HIGH	LOW
LONGEVITY	VERY GOOD	LIMITED
FLIGHT IN TURBULENT WEATHER	DEPENDABLE	RISKY
DRAG	VERY LOW	HIGH
FIRE RESISTANCE	HIGH	POOR
RELIABILITY	HIGH	MEDIUM
MAINTENANCE COSTS	LOW	HIGH
WEIGHT/LIFT	EXCELLENT	LOW
EASE OF FAB AND ASSY	HIGH	SLOW
LIFE-CYCLE COST	FAVORABLE	UNFAVORABLE
STRENGTH	HIGH	LOW
RIGIDITY	HIGH	POOR
PURITY OF INFLATION	EXCELLENT	INFERIOR
RESISTANCE TO RADIATION SUPERHEAT	POOR	VERY GOOD
REFLECTION OF RADIATION	HIGH	POOR
ICING/SNOW RESISTANCE	GOOD	POOR
RAIN ABSORPTION	ZERO	HIGH
SAFETY OF CREW IN HULL STRUCTURE	EXCELLENT	POOR
DURABILITY (LIFE TIME)	HIGH	POOR
HEAVY LIFT LOADING/UNLOADING	FAVORABLE	UNFAVORABLE
RESPONSE TO CONTROLS	RAPID	SLOW
UTILIZATION OF STRUCTURE	EXCELLENT (TENSION-SHEAR)	POOR (COMPRESSION-BENDING)
NONLIFTING VOLUME IN HULL	SMALL	HIGH
STRUCTURAL REDUNDANCY	VERY HIGH	LOW
RESISTANCE TO WEATHER DETERIORATION	HIGH	LOW
PRECISION OF HULL FORM AT ALL SPEEDS	HIGH	LOW
DURABILITY OF CELL MEMBRANES	GOOD	NOT GOOD
SHEAR STRENGTH AND RIGIDITY	HIGH	LIMITED
LOCAL STRENGTH OF HULL	HIGH	POOR
RESISTANCE TO ADIABATIC SUPERHEAT	VERY GOOD	POOR