MARTIN COMPANY

The *M-130* was built to a contract granted in 1932 to both Sikorsky and Martin. The *Sikorsky S-42* was the first result, delivered in 1934. The construction of the Martin airplane was subject to long delays but the airplane outperformed the Sikorsky in the end. Once again the aviation community was amazed by a daring creation, this time by a company that had been leading a relatively sleepy existence, well-known for its large bombers and patrol planes in the past, but not by any entries in the field of commercial aviation. The Martin company had been known as a supplier of Navy sea planes and patrol boats and had indeed edged Consolidated out of a production contract in this category in 1930. Few however suspected that this same firm would turn out an airliner that would beat every other airplane in its class. The *Martin M-130* flying boat appeared in 1935 and soon became the public's favourite *Clipper.* The all-metal (stressed-skin) *M-130* had an exceptional range and passenger capacity and was indeed the aircraft that Pan American Airways had been waiting for. Its weights were remarkable: empty 11100kg, while its starting weight was 23130kg. Its lightness was most surprising: 0.48.

Its fuel capacity was much larger than needed for passenger service allowing extremely long exploratory flights with crew only. (Check this and the resulting ranges.) It also meant that in favourable circumstances starts with over-loads could be made.

The following figures from two contemporary sources apply to the extreme range configuration:

PW TwWasp S1A4G (Ency: R-1830; 532kg)

GM-130: 40m/7.4 - 23130kg - 4 x 830hp 209km/h @ m >5150km @ load: 5%??

(1935) wingload 107 - powerload 7.0 - own weight 48% - (engine 9%) - fuel weight47%

fuel: 15140ltr x 0.72 = 10900 kg = 47% x 0.9 = 42%; (van STEENDEREN)

load = 5% = 1157kg; olie: 818ltr = 600 kg

5150 = L/D x 270 x 0.85 / 0.24 x 0.42/(1 - 0.21);

------956-------- -----.532------ ; L/D= 5150 / (956 x .532)=5150/508= 10.1

wingarea=23130/110=210; AR=1600/210=7.6

@60% hp

GM-130: 40m/ - 23130kg - 4 x 800hp 262km/h @ 1980m 6440km @ load:8%?

(1935) wingload 114 - powerload 7.2 - own weight 45% - (engine 9%)- fuel weight47%

incl sponsoons? (SPIT, OYENS)

fuel: 8100+ 2 x 3500 = 15100 x 0.72 = 10870 kg= 47% x 0.9 = 42%

load = crew + oil + mail = 450 + 600 + 700 = 1750 kg = 8%

6440 = L/D x 270 x 0.85 / 0.24 x 0.42/(1 - 0.21);

------956-------- -----.532------ ; L/D= 6440 / (956 x .532)=6440/508= 12.7

(The English author Stroud gives same weights as the Dutch sources quoted.)

During actual regular service only 9 to 12 passengers were carried on the run San Francisco - Honolulu

The most striking aspect of the construction of the Martin-130 flying boat was its lightness of construction, allowing for fuel loads during regular service in the order of 35 to 40%.

In the following quote Spit and Oyens give some of the highlights of this successful design in which the stressed skin principle is being exploited to the fullest extent:

"...The all-metal airplane is of the semi-cantilever type [a very lightweight type of construction, GJS]... ...The four engines are positioned before the nose of the centre segment of the three-part wing. This segment is braced by supports to the sea-wings on either side of the hull; the two outer segments of the wing are free cantilevers (vrijdragend). The internal wing structure is simple: there are two spars, with the upper webs joined together by a wide corrugated metal strip, the corrugations running in

the length-direction of the wing. On topof this strip the smooth outer skin of the wing is fastened, reaching from the leading edge to the rearward spar. Aft of this spar the wing is covered with fabric.
Because the corrugated sheet absorbs a large part of the compression load during flight, the upper flange-areas of the spars can be very small. The bottom flanges have been dimensioned in such a way that they can bear the compression forces that occur during landing and inverted flight. The tension forces that occur during normal flight in the lower part of the wing are mainly absorbed by the skin. The webs of the spars are of metal sheet, reinforced by rivited U-profiles. The ribs are built as trusses, with tubular vertical members and U-shaped diagonals...”

“...All stressed parts of the structure are made of Alclad. The wing profile is approximately Göttingen 398.
The steeltubing engine mounts are bolted to the front spar of the center segment. Immediately behind each engine, and in front of the spar, an oil tank is located, with a capacity of 230 liter.
The stressed-skin fuselage has a great number of rings (four of which are watertight bulkheads) with the skin consisting largely of corrugated sheet. Thanks to this construction method the hull compartment below the cabin floor can be employed as a *fuel tank*. Bottom and sides of this tank, which has a capacity of 8100 liter, are thus an *integral* part of the hull construction. Two additional tanks of 3500 liter each are placed in the sea-wings. The planing bottom of the hull has two steps. The empannage has a skeleton of light metal, with fabric covering, except for the lower part of the vertical fin, which forms part of the fuselage. The upper part of the fin, with the stabilizer is bolted to the lower part and braced with streamlined wires..”'

According to this description it would seem that the lower hold of the hull served as an integral fuel tank. As may be expected the sponsoons ('sea wings') provide a certain amount of lift during flight. (According to Spit this may amount to 50% of a normal wing with the same dimensions. We estimate that in this way the sponsoons augment the total lifting area of the airplane by 10%.) The additional lift has the effect of lowering the loading due to bending of the main wing, allowing for a lighter construction. Note on the other hand that for stability on the water the principal fuel stores are kept low in the hull and sponsoons, not in the wings. This actually causes an unfavorable bending moment of the wing during flight, being at a maximum immediately after take-off with tanks full. (Note that in normal practice, when the fuel tanks are situated *inside* of the wing, the maximum bending loads occurs at the end of the flight, when the tanks are near empty.)

Van Steenderen does give a good impression of the boxlike construction of the wing and the original way of employing corrugated sheet instead of longerons. A lighter wing may have been the result.
In yet another way the wing of the M-130 proves the skill of Martin's structural engineers. The spars are designed as continuous beams, supported in the middle by the central pylon on top of the hull and by two diagonal struts on either side of the hull. *The maximum bending moments occur above the wing struts and here the wing is thickest. The wing depth actually diminishes towards the main axis of the hull and also towards the wing tips. In this way the depth of the spars (and at the same time the length of the chords) varies proportionally to the external loading of the wing. The resulting construction is one of minimal weight.* At the same time a most unusual planform is created (for the wing) that is rather pleasing to the eye. It must have taken a great number of (re)calculations and wind tunnel tests to arrive at this particular shape. Was this one of the reasons why it took so long to build the M-130?
There are more design elements which point to weight saving. Van Steenderen mentions the use of fabric and external bracing of the empannage. The engineers chose for lightness even at the penalty of extra drag. They also omitted to equip the airplane with wing flaps (like the *Sikorsky S-42* had) in order to save the weight of operating mechanisms and hydraulics. Here again the wish for lightness prevailed even at the cost of higher landing speed and longer take-off runs.

Altough the construction of the M-130 is extremely light, the resulting airframe is also extremely strong as testified by van Masland:

"...Captain Musick eased the China Clipper down to two thousand feet. Earlier experience in the massive cumulonimbus clouds that tower over the deltas of the Orinoco and the Amazon had shown that while there was no easy way through so lusty a mass of clouds, the lower you flew, the lower the violence. Glenn Martin built three of these Clippers for us.
Though they were very light for their size, they seemed to be strong. But the ships were still new. Nobody really knew how strong they were, and no one wished to be the first to find out. As the Clipper entered the turbulent mass, Captain Musick kicked off the automatic pilot and took a firm grip on the control wheel in front of him. This would be man's work - no chore for a weak and indifferent mechanism. He was right. As they entered the leading edge of the front, a blast of wind from the south picked up the ship as though it were no more than a dry autumn leaf and flung it down to the sea. In his written report, filed later, Musick said that the ship had gone 'up on a wing tip'.
"Wing tip?" screamed Freddie Ralph, the first officer, in telling me about it later. "Wing tip? We were on our back. It took all the muscle of both of us to get that ship level and pull it out of the dive before we went in. At that we scooped seawater with the starboard wing when it finally came up level..."

"...The Clipper spent three days in overhaul at Manila instead of the usual two. The engineers found the paint all gone from the leading edges of wing and tail surfaces. Some parts of the interior, especially the dining saloon and the navigation compartment, badly needed a generous application of soap and water. But there had been no structural damage, no cracked spars, no started rivets. What a ship!
These Martin Clippers carried VG recorders, devices that recorded the accelerations to which the ships had been subjected. They were designed to record up to 3.5 g. the maximum to which a ship must be designed under the rules and regulations of the U.S. government. When the China Clipper penetrated the typhoon, the scribing needle of the recorder moved well off the recording tape, as far as 4.5 g. the engineers concluded, which means that if the ship at that moment weighed twenty-five tons, it had thrown a load of wel over one hundred tons on its wings. The Martin company built well..."

(Uit: Prologue, "Through the back doors of the World in a Ship that had Wings", William M.Masland, 1984, Vantage Press.)

NB1 Vincenti mentions the heavy steering forces. Pilots were dead tired after 8 hrs flying

NB2 The thickness of the skin of the boat hull was 1.3mm in places subject to bumps and butts. In less vulnerable places (near the tail): 0.65mm (AE).
Cohen: the main structure of the wing was of the box spar type, with tension field beams acting as side plates. the boat hull had no longerons and relied on the deck for strength

Glenn Martin B-10 bomber

Where had the Martin design team, headed by engineer/test pilot Ken Ebel, gained their experience? As for flying boat hulls the Martin firm had of course a long standing tradition. On the point of all-metal wings, a possible predecessor may have been the land-based bomber *B-10*, an equally exceptional aircraft as the *M-130*, developed between 1929 and 1932 (as the *Martin Model 123)* in close cooperation with the US Army Air Corps. It is not unlikely that this machine was inspired by the Northrop *Alpha* of the same period, the Army having obtained three of these aircraft for evaluation. [see also article about the B-10/12 by Hazewinkel in Luchtvaartkennis, Jan. 2002.]

Jean Roeder ("Bombenflugzeuge und Aufklärer") describes the B-10 as follows:
Die B-10 ist ein freitragender Mitteldecker mit Einziehfahrwerk. Der dreiteilige Ganz-metall-Schalenrumpf hat ovalen Querschnitt. Rumpfoberseite und Rumpfunterseite sind mit *Wellblech*, die Rumpfsetenwände mit *Glattblech* beplankt. Der dreiteilige, zweiholmige Flügel hat eine tragende innere *Wellblechhaut*, mit äuszerem *Glattblechbezug*. Die Flügeloberseite ist ab Hinterholm mit Stoff bespannt. Als Landehilfe dienen Spreizklappen an der inneren Flügelhinterkante. Höhen- und Seotenleitwerk sind freitragende Metaalgerüste, die Flossen sind mit Glattblech beplankt, die Ruder mit Stoff bespannt. Alle Ruder haben Trimmklappen. usw.
[gjs:Apparently the use of corrugated sheet in fuselage and wing was similar on the B-10 and the M-130.]

This *B-10/12* design was a big succes and saved the Martin factory from great financial difficulties (see Biddle). Many orders were obtained, both from the American Army and foreign nations, among which the Dutch East Indies.