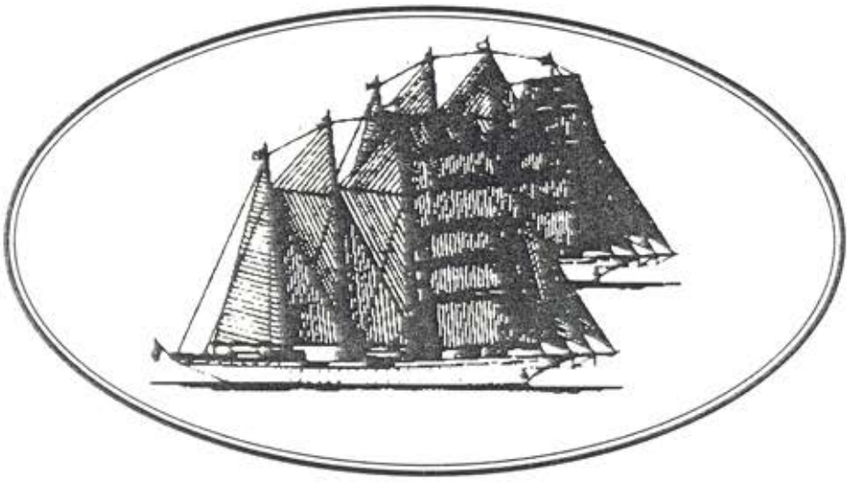
THE STAR CLIPPERS LOG

By Michael Bidnell



Published By
The Bloomsbury Partnership Ltd., London.

Masting And Rigging

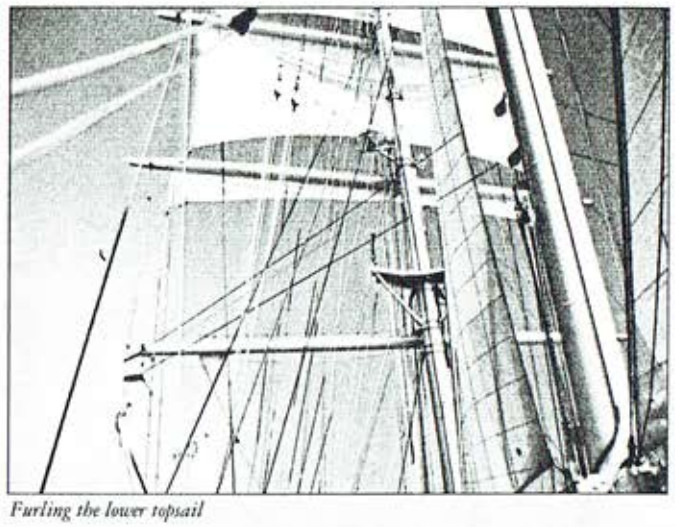
Historically, a series of three curved sections of steel plate, each with a longitudinal stiffener, if more than 15" diameter, would be riveted together to form a cylinder, the length of which would be limited by the size of equipment available to bend the steel plates. Each sleeve would be linked to the next with the vertical seams stepped out of line to form the mast.

It was a very labour intensive operation, each rivet being hammered home by men working both inside and outside the hollow tube. When completed the mast was lifted and literally slipped through a hole in the deck, resting directly onto the keel and supported by a ring of wooden wedges at deck level.

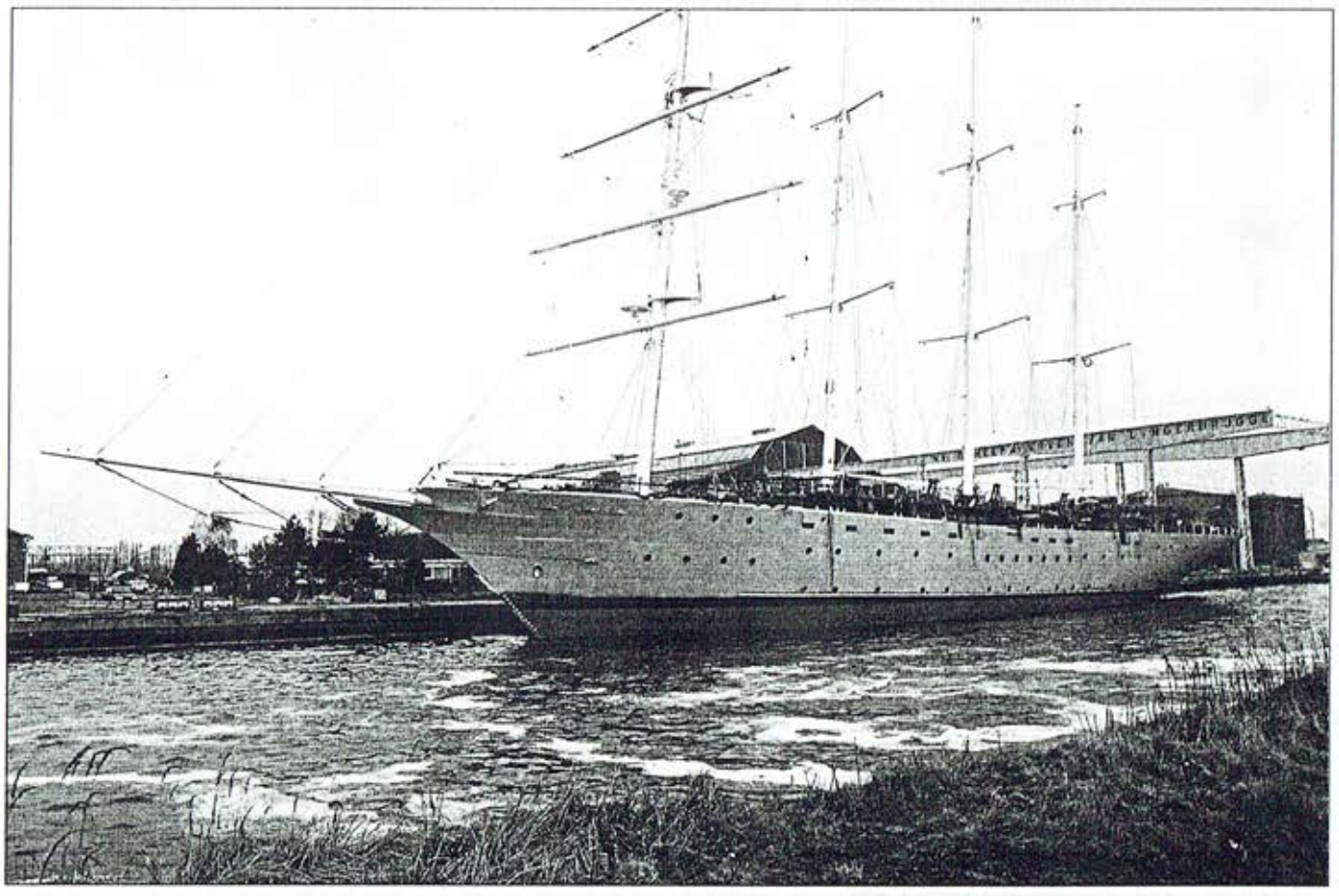
The original clipper ships were built to the limits of contemporary available technology. The tall masts would be made in three or four sections, the higher elements being hoisted into position by block and tackle, attached to the top of the lower sections, overlapped and painted together. This method was adopted because the masts themselves towered above the limits of any cranes that were then available.

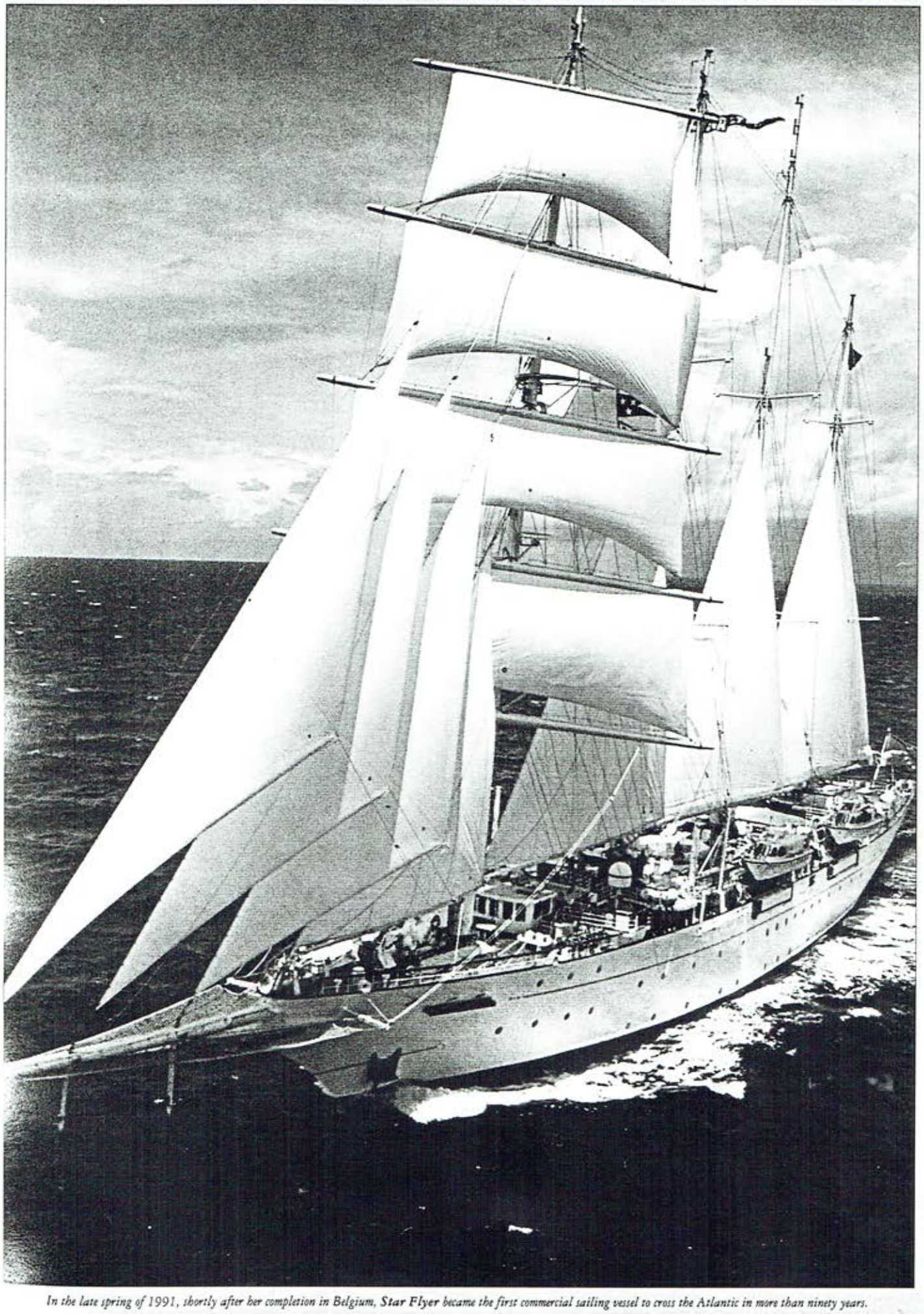
The masts of ***Star Flyer*** and ***Star Clipper*** are also at the cutting edges of technology and with the tallest single section of mast afloat the airdraft is 226 feet; the tallest of the tall ships.

Designing the masts presented its own set of unique problems. The latest regulations for their construction was published in 1922 by Lloyd's Register; the technology of steam ships had stopped further development. These rules were based on empirical data gathered from successful designs. Whilst the loads and forces themselves have not evolved, the materials available and construction techniques certainly have. In 1922 they could not possibly have envisaged that a



Furling the lower topsail





In the late spring of 1991, shortly after her completion in Belgium, ***Star Flyer*** *became the first commercial sailing vessel to cross the Atlantic in more than ninety years.*

mast could be built in one long section.

White Star Clipper's design team were still obliged to fulfil the requirements of the rules and Lloyds, having published them, could not ask for more than they stipulated; but the masts were simply off the scale.

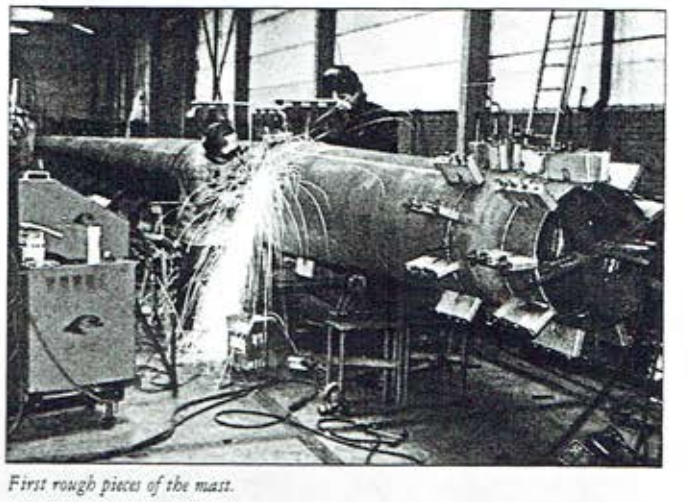
A great deal of research was undertaken, therefore, and studies made of the old clipper ship rigs from existing ships now preserved in museums and data of proportion used more than a century ago by the great clipper ship designers, such as Donald McKay. Their tables, giving sizes for given heights, were based on their experience of pushing technology forward; with each ship a taller, lighter mast was used until practical results dictated the limits. The uppermost section was often knowingly undersized for its length but allowed those extra few, crucial square feet of canvas to be carried which might allow the ship to be first in port. During the record breaking passage of the clipper ship ***Flying Cloud*** between New York and San Francisco, she twice broke one of her upper masts and twice the ship's master made and fitted a replacement, materials for which he carried aboard. This approach could not, of course, be adopted and the White Star Clippers' design team had to start from first principles and prove the calculations to the regulatory authorities.

The sails are of dacron and weigh just a fraction of the heavy canvas used on the original clipper ships, as well as being considerably easier to handle. A clipper ship's crew could number between 30 and 40 men; ***Star Flyer*** and ***Star Clipper*** need only 6 to 8 able-bodied sailors to handle the 36,000 square feet of sails over four masts. The square sails furl into the yards hydraulically; foresails, mainsails and upper sails stretch into position with the aid of power winches.

With another reference to the past it is worth noting that Herr Midenhof, owner of the Germanischer Lloyd Shipyard, later famous for its construction of many of the world's best-known trans-Atlantic liners compiled a 600 page book about the rigs of sailing ships when he was responsible for the construction of some of the last big iron-hulled barques, similar to the Pommern, the museum ship in Mariehamn. When he put together his reference book it was at the very moment in history that technology for the construction of sailing ships had peaked and it was this document that was used as a reference for the calculations of the rigging on ***Star Flyer*** and ***Star Clipper.***

The aerodynamic lift and drag forces exerted by the sails were calculated using classical formulations producing, in this case, a driving force of some 44 tons for the ship's propulsion. They also result in some tremendous bending moments on the tall masts which are essentially slender columns that can support only axial loads; they must themselves then be supported by a number of intricately placed steel wires, each of which is positioned in such a way that it does not interfere or hinder the sailing performance or any other aspect of the ship.

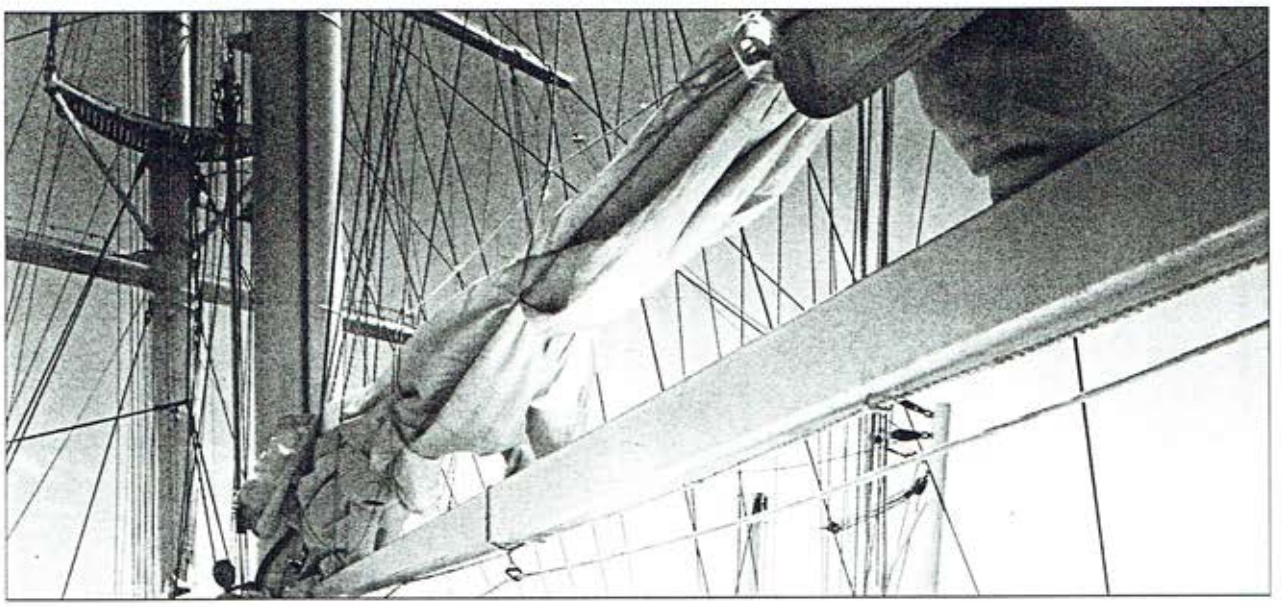
The matrix of sixteen different sails, each with its own set of aerodynamic forces, the masts with their axial loading and a veritable labyrinth of supporting wires were then assimilated by computer modelling. The latest finite element

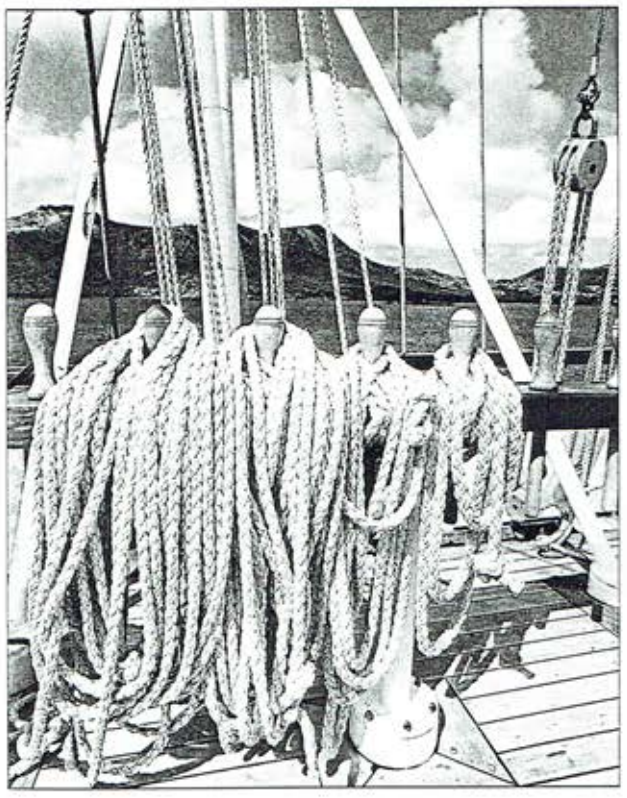


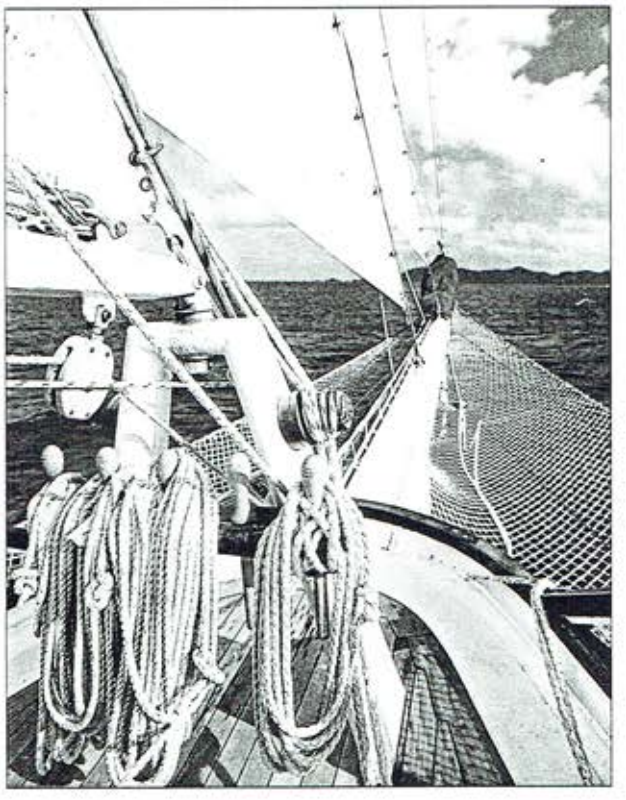
First rough pieces of the mast.

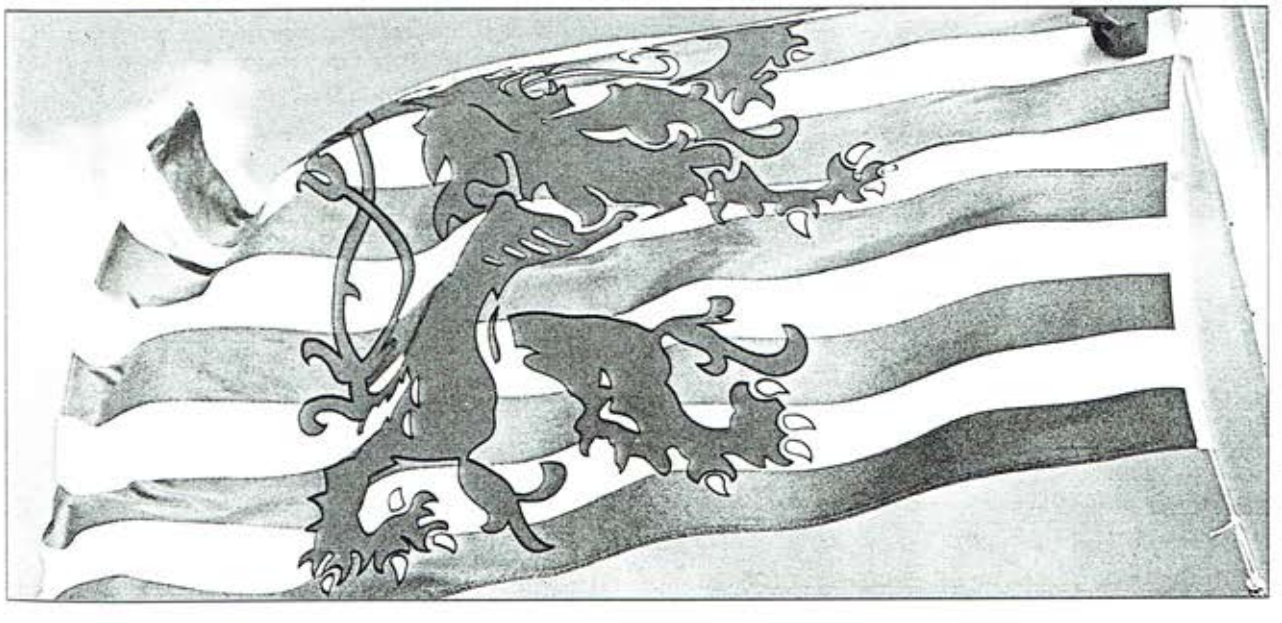
programmes were used to calculate the loads at each node. This complex arrangement; varying loads from different wind directions, sail configuration and the fact that steel wire cables do not follow Hook's law of elasticity, continuously threw errors into the calculation forcing the designers to return to first principles and do it by hand with the empirical tables as a guideline. The calculations were proving the empirical tables of more than 100 years ago to be very accurate; even the weak link of the upper masts was evident by the calculation.

The masting and rigging was thus modelled on the original clipper ships and, true to the spirit of those great 'ocean greyhounds,' pushed the limit another step further. Additional advantages have also been provided by the choice of materials and methods of construction available today. The high tensile steel of the mast is three times the strength of its historical counterpart, steel wire six times the strength and flax canvas sails bare no comparison to today's polyester derivatives.

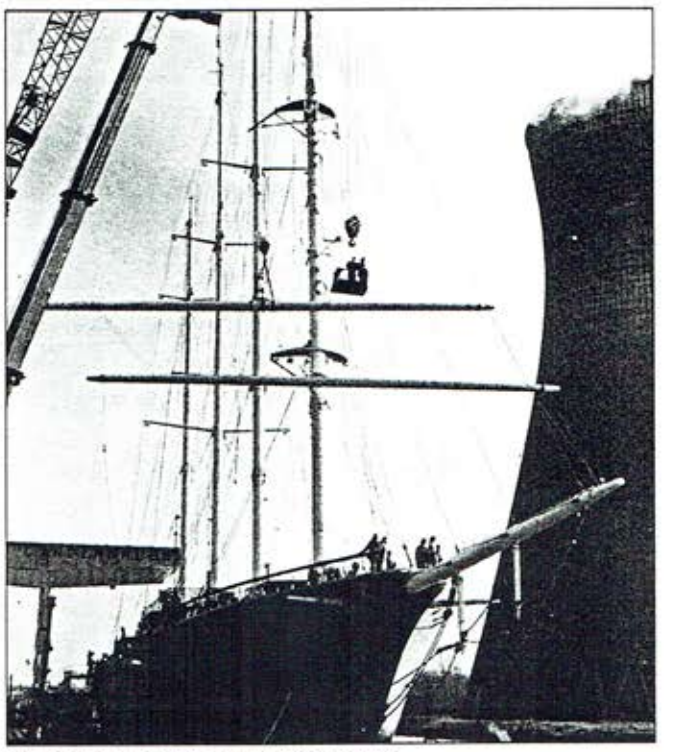








Olivier F. van Meer, Naval Architects & Yacht Designers and Van Meer Rigging Group B.V. were approached by White Star Clippers to act as consultants for the designing, calculation and provision of rigging and deck equipment for ***Star Flyer*** *and* ***Star Clipper.*** *Their descriptive explanation of the rigs, sails and masts is outlined below:*



The 25 metre yard for the lower topsail is attached.

"It was an essential requirement of the ships' design that they should give an authentic feel of what it was like to be aboard a clipper ship. This has been achieved by adopting the barquentine rig, with the foremast crossed by a full set of squaresail yards: course, upper and lower topsails, topgallants and royals. Overall the rig is one of the most interesting aspects of these ships. We were responsible for concept, overall design, rig detailing, specifying materials, purchasing, installation, bending sails and conducting trials.

The squaresails are furled into the hollow aluminium alloy yards using a system designed and developed by Van Meer, which is patented. The rollers are powered by geared hydraulic motors in the yard arms which have removable end covers. The yards are long enough overall to accommodate the full width of each sail's foot, which is greater than that at the head. The hydraulic lines from the power until run up inside the foremast.

The four masts and booms are of steel, apart from that of the mainstaysail which is of aluminium alloy to minimise deviation effects on the magnetic compass at the steering position on the forward superstructure over which it swings. The masts are stepped through superstructure and upper decks and supported on steps deep in the hull, or on struts worked into main bulkheads where required by the structural arrangement. The Corten A steel exhausts of the three diesel engines aft are led up through the jigger to its head, well above decks. Standing rigging is of steel wire rope, typically 25mm-30mm, with socket terminals. Masthead stays are duplicated.

A last inspection before stepping.

The foremast has forestays to stemhead and bowsprit/jib boom, the latter having bobstays and dolphin strikers. The foremast also has shrouds and standing backstays. The remaining three masts have shrouds and both standing and running backstays, the last with purchases tailed to Barient mechanical winches, although on the jigger mast the after hydraulic warping capstan is used. Other running rigging is handled on electrical winches and snubbing winches located at various points at deck.

All masts have forestays with staysails, four on the foremast (including three jibs), two on the main, and one each on mizzen and jigger. The upper mainstaysail is furled on a hydraulically powered roller of a standard available type. Remaining staysails tacked to the deck are boomed and loose-footed and fitted with lazy-jacks and downhauls. On main and mizzen there are sails running on tracks the full hoist length of the aft side of the mast, sheeted to the mast next astern, staysail schooner fashion. On the jigger is a Bermudian-style spanker, loose-footed to a boom, with lazy-jacks. All sails are of Terylene.

The squaresails provide authenticity and atmosphere, enhancing performance with a fair wind. The considerable area of fore-and-aft canvas ensure respectable windward performance, taken with the sailent keel.