The SHOCK of the OLD

Part 14: 80 YEARS BEFORE THE MATHS

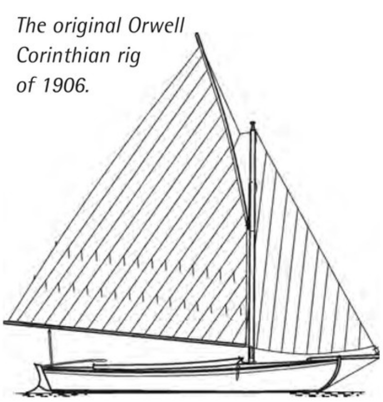
Way back then old rules of thumb prompted gaffers to carry big sticks; Moray MacPhail continues his series on refining traditional rigs.

There may have been times in this series when you wondered what the point of it is (! – Ed). Since we are shortly about to move on to running rigging, it may be useful to summarise the progression.

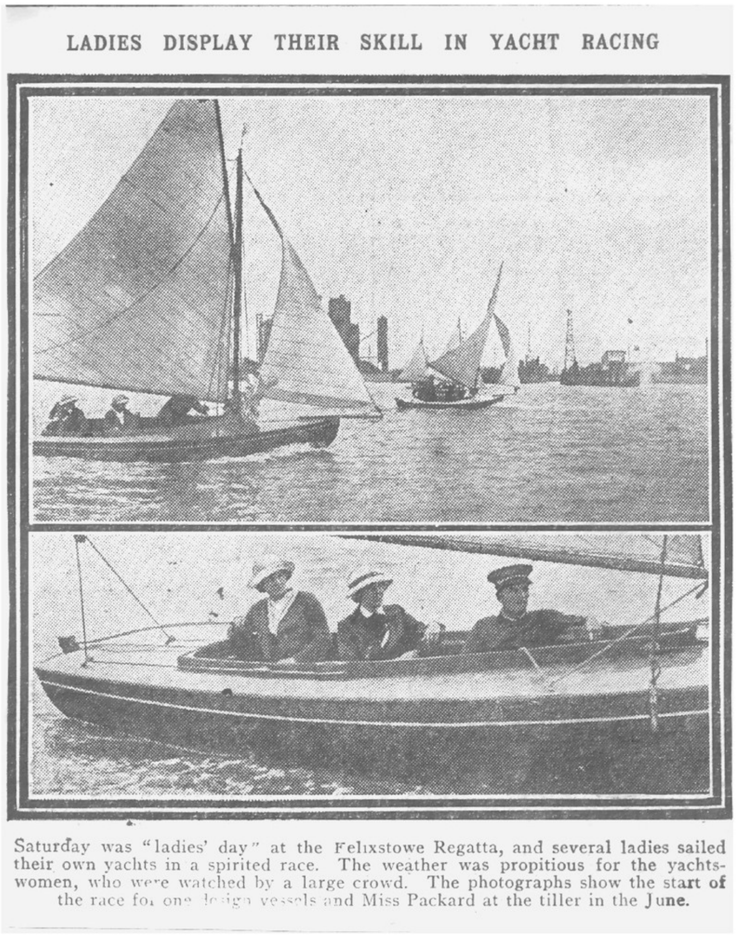
It goes roughly as follows:
W142-W144: Rig engineering and materials.
W145: Maths of unstayed masts.
W146: Traditional stayed masts.
W147-W149: Loads on stayed masts and their stays.
W150: Bowsprit loads and stays
W152-W156: Rigging materials, terminals and attachments.

All of which must seem rather dry and esoteric until you actually have to use it – as I should have done for the re-masting of my Orwell Corinthian. When making new versions of the 18' (5.5m) Orwell One Design in the late 1990s, the boatbuilder Nigel Waller and I decided to rig our boats with the 1906 gaff rig featured in the *Yachting Monthly* magazine of that year – see below. It is a typical Edwardian clouds-of-sail job of around 200 square feet (18.6m²). The old picture from the *Daily Mirror* newspaper – across the page – of the 1913 Felixstowe Regatta shows Miss Packard – incidentally the late sailmaker Austin Farrar's mother – taking part in her OOD *June* wearing a particularly fetching hat.

The original Orwell Corinthian rig of 1906.



The mainmast is about 18' (5.5m) from step to truck with 2' (0.6 m) bury through the deck. Nigel's original mast was 3" (76 mm) in diameter which fairly promptly fell over the side. So he found a mast of 3½" (89 mm) diameter which has worked fine for 30 odd years. I copied that when it came to my own boat, without doing any sums; I was younger then. I also thought it would be sufficient to rig with 1/8" (3mm) wire but fairly early on heard a ping. So I shoved the helm



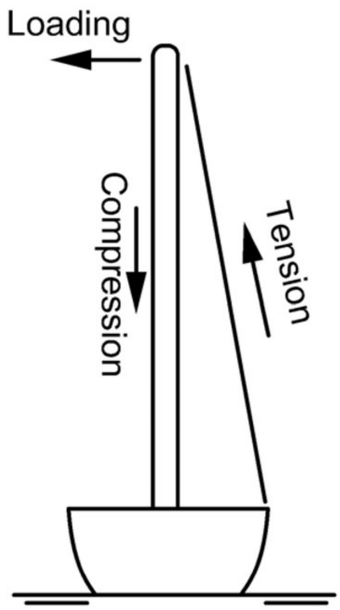
LADIES DISPLAY THEIR SKILL IN YACHT RACING

Saturday was "ladies' day" at the Felixstowe Regatta, and several ladies sailed their own yachts in a spirited race. The weather was propitious for the yachtswomen, who were watched by a large crowd. The photographs show the start of the race for one design vessels and Miss Packard at the tiller in the June.

hard over, put in a big reef and crept home resolving to use 5/32" (4mm).

Now I'm older, arguably wiser and with the benefit of having thought through these kind of rigs, I can at least re-visit these decisions to see if we ended up with a sensible solution. To get a feel for the situation, I'm going to adapt the analysis for sail loading that was developed in W145 for unstayed masts as per W147.

In those cases the load is applied sideways to the top of the mast to see if it breaks in bending. In the case of a simple single-stick stayed mast, I'm going to use that same load but add a stay and triangulate the forces. That will give me a compressive load in the mast and a tensile load in the shroud – as the diagram here shows. The advantage of this approach is that it doesn't matter how you resist the sail loading; it could be a ballast keel, the hull shape or hanging out over the side or all three like the keen types on the previous page of this episode.



Cutting to the chase, the sideways load from the sails works out to be 353 lbs (160 kg), which triangulates to a shroud load of 2504 lbs (1136 kg) and a mast compression of 2478 lbs (1124 kg). The 1/8" (3mm) wire was clearly a silly idea: its breaking load is 1543 lbs (700 kg), while 5/32" (4mm), depending on construction, is about 2200-2688 lbs (1000-1300 kg) as we discussed in W152.

What about the mast?

In W147 I mentioned the idea of a critical load which is the maximum a thin column can take before buckling. This depends primarily on the shape and length of the column. With a deck to shroud attachment length of 16' (4.9m), a 3" (76mm) spruce mast has a critical load of 1500 lbs (680 kg). Since we are looking for 2478 lbs (1124 kg) that may help explain why Mr Waller dropped his stick over the side. Increasing the diameter to 3½" (89mm), the critical load becomes more than 2822 lbs (1280 kg). As mentioned in W142, the result goes up with the diameter to the fourth power. In short then, a 3½" (89mm) mast with 5/32" (4mm) wire was a reasonable engineering solution.

The snag was that with fittings the mast weighed some 44 lbs (20kg), which for a boat intended to be used as a trailer-sailer is something of a lump to rig in the boat park. I did it a few times using cunningly contrived gizmos to pivot, align and drop the mast into place but it was a real pain, not conducive to much trailer-sailing.

As well as easing aerobics in the boat park, it's useful to reduce the weight of the mast to:

- Limit the total weight of the boat
- Lower the boat's centre of gravity
- Reduce the polar inertia if the boat has a tendency to pitch into a wave.

On a carbon mast, fittings can be built in, like the mast crane left, bonded on – gooseneck or clamped on – spinnaker ring.

Mast constraints and options

- Length 18' (5.5m) step to truck; I didn't want to change the sailplan
- Max diameter 3½" (89mm) at deck
- Round for the gaff saddle to work
- Parallel for cheapness and for the saddle to work at all heights.
- If aluminium, use a standard section
- If carbon, a standard mandrel
- A reasonably robust construction to withstand the localised load of the gaff and the rough and occasional tumble of trailer-sailing
- Cost this side of the stratosphere.

I ended up with a $3\frac{7}{16}$" (87mm) carbon tube with a $\frac{1}{8}$" (3mm) wall, mainly because it was a bargain. In converting from wood, I used T terminals for shrouds, ran the jib halyard inside and bonded on the gooseneck and masthead crane with epoxy. Eyeplates were riveted on for peak and throat halyards. The intention was also to rivet on an eyeplate for the spinnaker pole but to start with it was just put on with a couple of hoseclips covered with tastefully colour-co-ordinated insulating tape. This works fine on a carbon fibre spar – it would crush a wooden one – and has remained in use for 20 years; see the photographs above

What other options could I have considered? The table below looks at some alternative solutions.

Solutions for a critical load of 2183 lbs (990kg) on a mast 14' (4.3m) from deck to truck.

	Wood			Aluminium			Carbon Fibre		
Outer diameter	3" (76mm)	3 ½" (89mm)	3 ½" (89mm)	2 ¾" (70 mm)	3" (76mm)	3 ½" (89mm)	60 mm (2 1/3")	80 mm (3.15")	87 mm (3 3/8")
Wall thickness	solid	solid	5/8" (16 mm)	10g (3.2 mm)	10g (3.2 mm)	10g (3.2 mm)	2.5 mm (3/32")	2mm (5/64")	3 mm (1/8")
factor	0.61	1.14	0.92	0.93	1.2	1.96	0.63	1.25	2.7
Weight (bare, kg)	12	16.4	9.2	9.7	10.6	12.5	3.9	4.3	6.9
Notes	1	2	3	4	5	6	7	8	9

1: This is the one which failed.
2: This one works but weighs more.
3: If hollow the wooden mast would need to be larger in diameter and probably more expensive.
4-6: Aluminium is a possible in the larger sizes and saves some weight. The tube is not very expensive but having the fittings welded on can be.
7-9: The larger carbon tubes save a good deal of weight. But the bare tubes cost about four times the aluminium equivalents.

A weight saving of around 26 lbs (12kg) did make a huge difference when rigging and of course brought the other benefits. One unexpected consequence was the noise: during a light weather race the saddle was squeaking loudly on the hollow tube. Before it drove us completely mad, we dropped the sail and I greased the saddle with mayonnaise from one of my sandwiches. It sort of worked for a while but I lost one sandwich and the leather on the gaff smelled horrible for weeks later.

Next time earplugs!

Was it a good move? Undoubtedly. Could I have done it better with the help of some analysis like that expounded in this series of articles? Certainly. Smaller $3^1/_8$" (80mm) dia. carbon tube would have worked just as well and saved weight, even though that would have required a new saddle. If cost had been more of an issue, then the 3" (76mm) aluminium tube could have been an option. So it is worth doing the sums, even if as recently happened, one customer decided the exercise was not really worth it.

The next job is to re-spar my small canoe yawl, where I'll test the theory for unstayed spars further, hopefully not to destruction; see below.
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A candidate for carbon spars? Selway-Fisher's 15' (4.6m) canoe yawl Lillie, inspired by George Holmes' Ethel of the 1880s.