The SHOCK of the OLD

Traditional boom with traditional head clearance on gaff sloop Gna; see W108. Photo: Ville Lindfors

Part 30: Head Bangers

Refining gaff rig, Moray MacPhail provides an enthusiast's exegesis of what the standards agencies and experts tell us about booms

It is neither accident nor fad that most sails are fitted with a boom, because they bring many advantages. To start with, you can use the boom to extend the sailplan aft to or beyond the limits of the hull since the sheeting point on the hull can be forward of the aft end of the boom. Plus the mainsheet can be rove to advantage in a variety of configurations to suit the boat. Finally, some independent camber control – at least of the lower part of the sail – is provided by having the clew – the low aft corner – of the sail attached to the boom with an adjustable outhaul. Whether you choose to adjust that as you go along is up to you but the option is there.

Design Loads

What is the loading on the boom? Let's take as our example boat – see Figure 1 – the 30' (9m) gaff cutter designed by the late Ed Burnett which we looked at earlier in the series. The 345 square feet ($34m^2$) mainsail has an 18' (5.4m) boom beneath it. Current thinking for modern boats assumes that the primary load on the boom is a distributed lateral load from the mainsail. This causes the boom to bend; the kicking strap and mainsheet counteract that bending.

To design the required boom, I'll use a couple of rules. Back in W147-8 when looking at mast sizing, we encountered the Nordic Boat System (NBS). This calculates the design heeling moment using the length of the boom and height of the Centre of Effort of the sailplan (Ref 1). The second, Bureau Veritas (BV), involves sail and boom dimensions (Ref 2). For comparison, I'm going to look at a hollow wooden spar of wall thickness of ¾" (19mm) and an aluminium alloy spar of ⅛" (3mm) wall thickness. The diameters which result are:

	WOOD	ALLOY
NBS	9" (240mm)	7.5" (180mm)
BV	8.25" (220mm)	7.5" (180mm)

These answers are about the same for both rules, which is encouraging but look too large for the boom on a 30' gaffer whose mast is only about 7" (180mm) in diameter as we found in W148. What's happening?

Well, both rules are geared to modern Bermudan rigs with relatively high aspect ratios and short booms fitted to relatively light displacement hulls. If I 'convert' the sailplan of our gaffer to Bermudan by putting a taller rig on our craft of the same sail area, the diameters come down to 7.5" (193mm) for wood and 6" (153mm) for alloy. These are still large but approaching the bounds of reality, particularly for alloy. Perhaps these are rules geared to help the selection of aluminium sections for the booms of modern yachts but that doesn't really help to develop an understanding of or guidelines for traditional rigs.

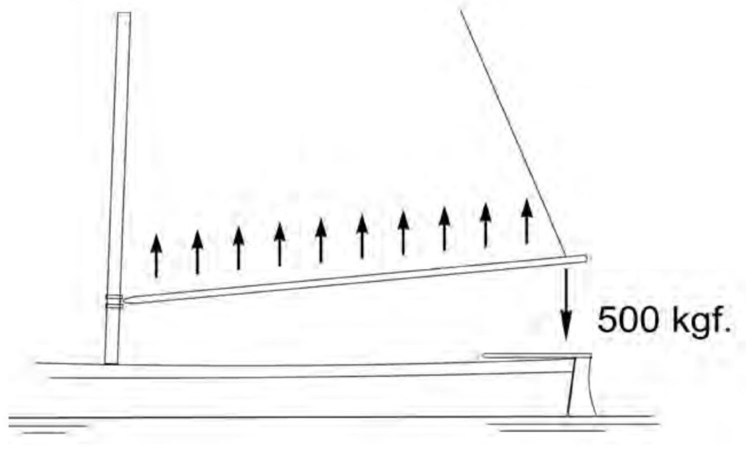
Can we estimate the mainsheet load and so deduce the loads on the boom from that? Harken provide some guidance which we'll look at in detail in future articles. Here if I calculate the force for both Bermudan and gaff options they both work out to be around 1100 lb.f (500kgf) at a wind speed of 20 knots, a good full-sail breeze. I'll assume no kicking strap because not many gaffers have them and an evenly distributed load along the boom – as in Figure 2 here.

What happens now? With no kicking strap and the mainsheet at the very end of the boom, the diameters work out at around 8" (200mm) for wood and 6.5" (160mm) for alloy.

Assuming that the main loading is bending, the outcome is about the same as the answers we've derived. The snag is: it still doesn't seem right. Why not? Because the boat in question exists, has a hollow wooden boom of 4½" (110mm) diameter and has covered thousands of miles in all weathers. Also from experience booms are typically about 60-75% of the mast diameter for traditional rigs, which you'll recall we worked out as about 7" (170mm) and again that gives around 4½" (110mm). So

Figure 1: *The late Ed Burnett's very-capable-looking 30' (9m) gaff cutter design.*

Figure 2: *A calculated force of 1100lb.f (500 kgf) distributed evenly along the boom.*



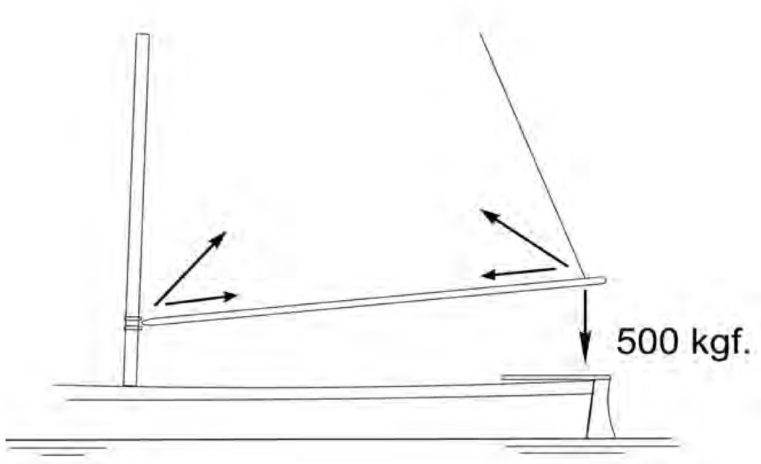


Figure 3: *A resolved compressive force along the boom from loads at tack and clew.*

the assumption that the major issue is bending may not apply to traditional rigs with relatively long booms and no sail tracks.

Perhaps a better starting point is to think of point loads at the tack and clew. This is certainly true for loose footed sails of traditional type. It would also apply to any sail when slab reefed, since the sail ties do little except tidy the bunt of the sail. Except where reefing is achieved by rolling the sail around the boom, it would seem both from the way sails are constructed and reinforced – and their appearance in use – that the major loads are taken radially from tack and clew, with not much loading from the middle of the foot.

So perhaps a better approximation to the force in the boom is not sideways bending but a resolved compressive force along the boom from the point loads at tack and clew. Using the same mainsheet load as before – and with a few assumptions – I can get to the loading conditions sketched in Figure 3.

What happens now? With a factor of safety of 5 – which is prudent for buckling; see W147 – both the wooden and alloy spars end up with diameters of 4 1/8" (104mm).So there we are then, that solves that.

Not quite, because however hard you try, there is always going to be an element of bending present. This might come from the mainsheet take-off not being directly below the clew, especially when the sail is reefed or if the blocks are distributed along the boom. In addition, a kicking strap must exert a lateral load, though not necessarily when close-hauled because of the pull of the mainsheet.

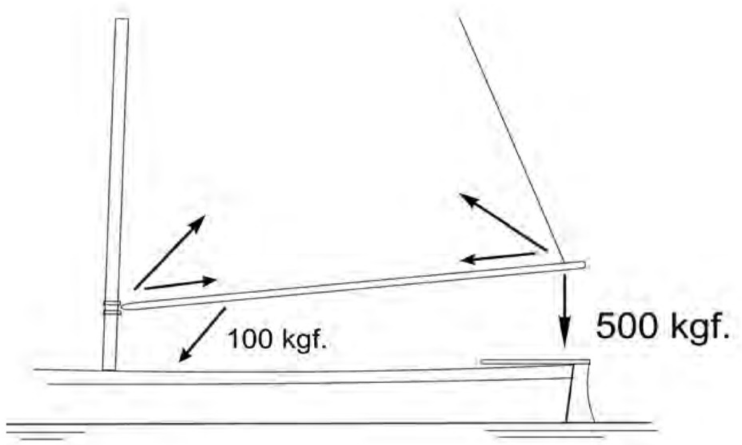
So let me do the sums again with a combined end and side loading, making some heroic assumptions about the side loading – 'heroic" in this context means impossible to rigorously defend, by the way.

Figure 4 shows what I am trying to do and the sideways load represents either a kicking strap or a mainsheet set along the boom forward of the clew, perhaps aligned with the leading reef cringle.The sums are fearsome – Ref 3 section 11.5 – but we get to 4 7/8" (124mm) for wood and 4 1/8" (104mm) for aluminium, which is somewhere in the realms of reality.

Now I'm not going to suggest for a moment that MacPhail's Theory for Boom Loading is in any sense 'correct' and should be used right away by all designers; it hasn't been developed with anything like the rigour needed to make it safe. But it does illustrate a few things, namely: –

- The use of existing rules beyond their range of applicability. Both the NBS and BV rules are very sensitive to boom length. This means that a traditional rig, with characteristically long boom, tends not to fit the model. As discussed many articles ago in W146, rules of thumb with implicit assumptions can be very misleading.
- The choice of loading assumption affects the choice of materials. In W142 we established the capability to resist bending depends on the size and shape of the cross section, and

Figure 4: *And what happens when the effect of a kicking strap forward is introduced*



Bend it like MacPhail? No, it's the sail. Crewed by Vicenzo Ciminale, organiser of the Velalonga Raid in Venice and – right – the late Nick Newland of Swallow Boats, the author helms his 18' (5.5m) Orwell Corinthian One Design gaffer. *Photo: Kathy Mansfield*

the strength of the material involved. Resistance to buckling is a function of the cross section and the stiffness of the material but has nothing to do with the strength. Aluminium is four times heavier than wood, four times stiffer but eight times as strong. As we found in W144, if you shift the emphasis from bending to buckling – from side loads to axial loads – the more important stiffness becomes, and the more useful wood becomes as a material for booms.

• It has been argued that a heavy boom on a gaffer is a good thing to control the shape of the sail. I have seen somewhere the ideal boom should be shaped somewhat like an elongated baseball bat, with the thin end toward the gooseneck. But even if you make the wooden boom solid in the examples above, the weight would represent some 5 to 10% of the force in the mainsheet. How much twist will that control? As a heavy boom comes whonking over the cockpit at head height either during a gybe or when reefing, I can't help feeling that a lighter one would make life better.

Looking back on the conclusions reached for bowsprits, masts – see W146-150 – and now booms, it would seem that the more you can go for compression and avoid bending your spars, the better. If that is so, then the primary need is for a light and stiff material So you are looking for the best specific stiffness – stiffness for a given weight. If you are unable to run to the expense or complexity of carbon fibre – see W157-8 – then wood is your next best bet.

Plus ça change!

Finally, if all of the above is a bit nerdy, experience indicates that the boom of a gaff rig, at least at the gooseneck end, should be around 60-75% of the mast diameter.

How do you know what the mast diameter should be? See W147. Or if your mast is OK in service, use that!

In the January/February 2026 issue, we'll look at the fittings on the boom.

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REFERENCES & FURTHER READING

Ref 1: *Principles of Yacht Design*, Larsson & Eliasson. Adlard Coles, 1994

Ref 2: *Sailing Yacht Design*, Claughton et al, Longman, 1998

Ref 3: *Formulas for Stress and Strain*, Roark & Young, McGraw Hill 1976