

The Merits of Flat-Cut Junk Rig Sails

by Kurt Jon Ulmer

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Sail planform of mehitabel. Now that's flat...

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"But is this flat?"

Cambered sails are better than flat ones. An iPad is better than a Linux netbook. A diesel auxiliary, better than an electric motor. But I'm writing this on an old Linux computer, in the pilothouse of a flat-sail junk rig yacht with electric propulsion.

Why, when I could have... all the best?

Converting *mehitabel* to Junk Rig

'Practical Junk Rig' and my own brief study and common sense were all the resources I needed to create the junk schooner rig for mehitabel 10 years ago.

We still use our first set of junk sails, and they're lasting well. First set of battens too, with the original scantlings. Our top batten just below the yard is now doubled, as a preventative. The only-ever bend was minor, caused by my over-sheeting while hove-to for several days. Same yards, but I had to lengthen them because I ignored Hasler & McLeod on that detail initially. I cheated Hasler & McLeod for the sake of sail area on a couple of other points, and each has shown up as a mistake we live with. New booms, a gift from Paul Thompson. New fendering, since leather is abrasive and polythene is better. I've made few other changes, and never had any breakages nor the urgent necessity to repair anything at all.

(How far? How hard? How long? Approaching 6,000 junk sea miles, after about 10,000 under Bermudan cat schooner rig. Gales, yes. Lived aboard 17 years. In constant refit of something or other, but not the rig.)

By the time I was planning mehitabel's rig, Arne Kverneland had shared the details of his cambered panel sails, and other inventors had documented a few bend-and-stop batten devices. Why didn't I go for a then-state-of-the-art junk rig with some form of added camber?

I resisted the temptation because: Boats had sailed Well Enough on all the open oceans with flat-cut sails; I had no mentor for making the cambered panel rig offshore-reliable, while I had Hasler & McLeod for the flat-cut option; I could easily have gotten it wrong and then needed to re-sew the sails to put it right; The camber seemed so compromised by distortion at lifts and mast, that I wondered,

'Why bother?'; I wanted no flogging, flapping or fluttering problems; I had learned that strains were distributed in junk rigs, and I thought loosening up the fabric would result in point loading; I had only a few months before an offshore trip; Finally, I could foresee expenses, complexity and time going beyond what we were ready to commit.

Also, I saw a way to add camber in the future, by retrofitting and perfecting bend-and-stop battens. This gave any over-ambition an easy way out. The change later on wouldn't require new sails, wouldn't point-load the spars so, wouldn't lead to flogging. The battens could be phased in and taken out experimentally. 'Bend-and-Stop' sketches led me to 'Smooth-Curve-and-Stop' ideas - an intriguing design problem for idle hours, but I put off any extra work until I reckoned we needed added camber. Later.

It is later. The sails are still flat. Flat-cut, that is.



David Tyler

Twisty full sails, close-reaching in very light air, with camber enough

Cambered Panels Now

In 2012 there are excellent resources to get one started cambering. With study and common sense there's no reason someone can't make good-as-can-be cambered sails today. The Fays did, for Ti Gitu; Anthony Swanston, for Wild Fox; Annie Hill for Fantail; Graham Cox for Arion; David Thatcher for Footprints; David Tyler for Tystie.

There are many others, of course, and also several methods besides adding camber to each panel. Less discussion is heard these days about hinged battens, pre-formed curved battens, wingsails of various kinds, etcetera. But we can be sure there is still considerable 'messing around,' some of it with success.

Some of the people mentioned above, have had serious problems. They include frustrations with sail setting, severe bending of yards

and battens, breaking of battens, sails banging when rolling in a seaway, qualms about motor-sailing behaviour, and batten ends fouling sheetlets because of negative stagger when reefing and furling. They'd be called serious on mehitabel, that is. None of them happen.

They are products of departing from the tried and true, which always invites difficulty - now we've defined the word adventure pretty closely.

The problems of cambered sails will be solved. That's what humans do. In the process of perfecting their rigs, JRA members are lucky. They get the benefit of each others' sea trials in real time, and from all the oceans at once. This is a very cool and useful Association.

But to react with heavier scantlings as solutions, is to use brute force instead of natural toughness. To fix

things by pulling harder than before on certain points, ignores the fact that it's the distribution of strains in the junk rig that makes it innately robust even with weaker individual parts.

Putting skinny slick tyres onto a mountain bike gives instant results. It goes faster, rolls smoother, steers easier. You wouldn't like it in winter in Canada. Risky on jumps. And it still won't win a road race.

To some people, a mountain bike is a whole concept, an organism almost. Evolved to be something, with its own integrity; best if uncompromised. If a mountain bike isn't Good Enough at something important, well, there are other bikes.

My primary aims for this long bold article are to argue for the functional integrity of the basic ancient junk rig, and to elevate the strange idea of Good Enough.



Reefed fans - more effective than they ought to be

Topical Thoughts

Genoas and Dipping Lugsails

Gorgeous camber, a fine clean leading edge, smooth tailored curves undamaged by the press of mast or lifts - why aren't we talking about these? We can discount dipping lugs because wonderful as they are, they don't make for an easy, general-purpose rig.

Although some of us would enjoy the lift genoas can provide, sometimes, and some of us would like to win races against them, they offer nothing to compare with the handling advantages and versatility, and the inherent robustity, of the well-sorted junk sail.

Junk sails have one huge advantage

over genoas. No, two. They can present a large area of sail, high up and pulling, when a genoa will flop pitifully. And they don't need such strong corners. But there's more. Self-tacking, reefing without going all baggy, sheeting without winches...

Camber Itself

Imagine that we hang two bedsheets on a line some breezy day, one a fitted sheet and one plain. Pin the plain one with 8 pins evenly spaced along the clothesline, and the fitted one with 1 pin, or 4 pins if you like, only at each of two corners. No, that's not fair. Cambered panels are attached to their battens much the same as flat ones. It's from then on that they behave differently. You may use 8 pins, then, spread along the edge. But be ready to catch them. Which sheet will unpin itself or tear itself, in a gusty afternoon sea breeze?

All analogies limp, but I'll venture one more point from that one. The plain sheet can feather itself with the wind, while the fitted one has no choice but to pull. Our flat-cut mainsail can be left fully raised at anchor in very strong wind, without damage or drama.

Nothing happens. Motor-sailing, rolling in a sloppy sea, anytime the sheets are let go, nothing.

More power from cambered sails induces more heeling, all else being equal. Not only more heeling, but more changes in heel angle with changes in the wind, self-steering corrections, speeding and slowing over swells, etcetera. On a sport-sailing day nobody minds a little excitement. On passage I don't welcome it particularly. There might be a cake in the oven.

It makes sense to position the sheet over to windward when hard on the wind with cambered sails, in order to make best use of the different, improved entry angle at the sail's luff. Athwartships horses or other inventions are useful if you sail that way a lot. A big hook on a purchase to the weather rail might be the Chinese answer, and a crew member to manage it.

Flat-cut sails are more tolerant of sheeting angle when sailing to windward, and don't need an answer. You may joke that they're not sailing to windward, but be kind.

When camber meets the hard lines

of lifts and mast, it suffers deformations. Excuses can be made that the air skips over the dents and bumps, deceived, and nothing is lost, but I don't buy it. Smooth is smooth, or glider pilots wouldn't wax their wings.

We can hardly praise the junk rig for having no standing rigging and praise the kind of junk camber I see in many photos, in the same breath. After all that careful broad-seaming or shelf-shaping, don't you just want to let the lifts go slack? Ah, but this is a junk rig, so it's not usually done. It would be more work.

Yards and Battens

It's a tough life! Yards press and then bang against the mast and the lifts, and get gusted around unpredictably, gybe roughly sometimes, and may even get pulled hard and unfairly against a forgotten sail tie. Occasionally. I'm getting better. Battens suffer from sheeting forces that are inevitably too-much-downward, from compression, from Hong Kong or luff hauling parrels' demands, and from having their smooth bending interrupted by taut lift spans and a mast.

A Hong Kong parrel wrenches the wrinkles out of a cambered panel by taking all the sail-shaping stress at two points on the battens with one piece of line, whereas a flat-cut panel pulls along the whole length of two battens and the whole multi-diagonal matrix of the fabric panel to do the same job, and hardly wrinkles in the first place, compared to a cambered one.

Hauling the throat and/or upper luff aft with some combination of running parrels will solve sail-shaping glitches for most of the cambered panel boats on the water, and Hong Kong parrels will be well dispensed with. But the poor old yard ends up taking more of a load at the throat. Not the idea.

If the top panel is cambered, all the luff and leech forces weigh on the ends of the yard. If that panel is flat, the sail fabric distributes the load along the yard. Beams made for end point loading have to be

stronger than beams made for even loading. A yard is more than just a beam, but it is that at least.

With end loading and the powerful peaking-up force required to shape the sail, how many cambered panel sailors have looked up and seen a visible curve in their yard in normal use, as a welcome to the world of better windward performance?

One could use a bridle on the main halyard, plus a gaff-style peak halyard, plus a throat hauling parrel. That would spread the load to several points, but only when all are properly trimmed at once. Not in the spirit of the junk rig's automatic ease of handling.

A yard has a lot in common with the shackle that joins a chain to an anchor. It's a bad place to make lightness a priority. I fail to see a good reason for aircraft-style lightweight design in yards,

especially since we can't predict in which direction nature will try to break them. On mehitabel, weight helps the fore yard fall all the way to the bundle at once, the moment I go forward to drop the anchor. On a good day. I wish it were a touch heavier, actually.

The cross-sectional shapes that make most sense to me for yards are fat oval and circular. The fat oval is a concession to the routine weight-bearing direction, which I think is reasonable enough. Our timber yards are fat ovals. Their thickness was meant to follow Hasler & McLeod's scantlings, but they ended up a little thin - all I could get out of the timber. I added unidirectional glass to reinforce them - a 'tendon' let into a groove along the top, and a heavy layer on the surface. Their middles are grabbed with substantial wraps of rope. Each yard is lashed all along its length to a flat panel of heavy



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Fan camber pulling well, on starboard & port tacks

fabric. If our yards were to break, I honestly don't know what I'd do.

Uppermost Panels

People must puzzle over whether to add camber to the uppermost panels. In a Hasler & McLeod pattern sail, some fan-style camber with twist is naturally present up there. I reckon adding fabric to the top panels doesn't produce useful camber so much as it disturbs an airflow that might follow the fan shape if it had its way.

In a David Tyler Fantail sail, I think added camber in the narrow panels of that beautifully twisty upper fan is likely to be detrimental in a similar but sadder way.

Aphrodite and La Chica follow Van Loan's sail planform with low-yard-angle sails. They have ample camber sewn into the panels, and no attempt at fan camber. While sailing on Aphrodite, it seemed to me that every panel's camber was in line with the path of the air. Even the top panels could use considerable camber, if we picture a slightly spanwise flow near the top, and if we ignore the next paragraph.

The top panel or two of a junk must become the stormsail when the lower panels are all safely tucked away. Our flat-cut top panels make for a pair of sleek, well-behaved little crab-claw sails on mehitabel, when we're down to that. How much camber, how much drive, how much extra cloth, do you want in your stormsail? I want very little, so for me there's no puzzle at all.

Our top panel is flat, with webbing in the slightly hollow-cut leech; lots of independent lashings to yard and batten; a strong yard above and a double batten below. The next panel down is flat, believe it or not, and has a double batten above and the whole bundle below.

Concentrated Loading

Lashing a flat panel to its battens allows the web of fabric to distribute all its tensions to each

whole batten in any direction. There isn't only one diagonal in a junk panel, there's a matrix of forces in warp, weft and bias. If camber is added to the panel, the fabric can only pull on the ends of the battens. And all the battens' own loads are unsupported except at the ends.

Thus a Hong Kong parrel can bend a batten upwards grotesquely in a cambered panel sail.

Compression - that evil force that will take advantage of any out-of-column-ness to bend or break a batten - is acting only at the opposite ends, worse than compression acting at each lashing all along the batten. To simulate the same end-loading with a flat panel, picture a batten pocket instead of lashings, fairly loose, and smear grease on the batten so it will let all the tensions in the panel go to its ends and compress the batten.

I allowed you to pin the fitted sheet to the line with 8 pins spaced out, but now maybe you see why I was reluctant.

The taut sail membranes on mehitabel are like resonant drumskins. I can literally send a wave through the whole by banging on the fabric or plucking on a sheetlet. When camber is added to panels, an opportunity is lost - not mainly of playing the drums on your sails, but of every part sharing every strain, of the music...

Performance and Trade-Offs

The points above accent the inherent strengths of flat-cut sails, and the problems inherent in cambered panel sails as I see them. Now to turn the tables.

What can be gained with cambered panels, and what's wrong with flat-cut sails?

One advantage has been cited: Sails with added camber are more powerful with the wind forward of a beam to broad reach, noticeably so in light winds, and especially when pointing close to winds of,

say, 10 knots or less.

One disadvantage is brought out against flat sails: Poor performance in the region of headings closer than 60 or even 70 degrees either side of the true wind, unless there's something more than 10 to 15 knots of wind. Above 15 knots, it gets down to 50 degrees for mehitabel.

Poor performance, we'll say, means excessive leeway, too little speed to be useful, or inability to tack with authority. Good Enough performance is harder to define.

First Question arises: How important is that close-hauled region of sailing, to me?

On an ocean passage, pointing high is miserable. The faster, the more so. In coastal sailing it's fun, if the sea is only a chop. In very light wind, I almost wish for a big inflatable dipping lugsail. No, I should freely admit the wish. I do. More likely, though, we'll anchor until the breeze fills in, or take some help from the motor. (Electric motor-sailing is a bit special, and seems to suit junk cruising especially well, but that's another topic.)

Second Question suggests itself: How good is Good Enough, for our boat?

A few fellow junk sailors saw mehitabel sailing last year and were impressed. She's lively, weatherly, heels little, steers well, tacks smartly, carries decent coffee, etcetera. It isn't that she has a magical hull, keel or rudder. And her electric motor was indeed off the whole time.

It's just that a flat-cut junk rig can be that good! mehitabel is only one example, and not necessarily the best.

The boat matters quite a lot, of course. But the result can be as good as a particular boat could ever be, less a few percent, or x degrees or so, in some conditions, off of some arbitrary ideal value. Small losses, unless your First Answer was, 'Very important!' If

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Yard lashing at peak, distributing strains at every opportunity

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Yard sling point, not to be doubted

your ambitions do run rather high, what draws you to the junk rig? Not that you need an excuse...

If the admission of such inferior performance as I imply makes flat-cut junk rigs, suddenly nowadays, suitable only for downwind sailing in the Trades, my goodness... what has changed? They've been everywhere. With and without engines.

Ours is surely Good Enough to satisfy us. But here, I should admit that I personally like 6 knots better than 8 knots at sea, and I can be Happy Enough with 4 and a bit for days and days. Her crew doesn't share all of mehitabel's ambition, flat as that is, and reefs are normal.

Given 15 knots of wind, mehitabel doesn't lack power or performance on any point of sail, for anything we would want her to do. Most of her offshore sailing has been close-reaching, and she keeps needling me to go to Chile from here.

Second Thoughts

Suppose all else were equal. That is, the cost and effort of making, simplicity of repair, good behaviour in use and misuse, tried-and-trueness, innate robustness, distribution of strain, storm-worthiness, documentation equal in rigour to 'Practical Junk Rig' - suppose all were the same for flat-cut and cambered panel junk sails. What reason would I have then, not to recommend cambered panel sails to a friend, especially as I surely wouldn't want a friend to suffer, as we might be supposed to,

No, on second thought, not even then. Accepting such a small loss as that, allows us to use sails free from vices, and an ancient rig with its ingenious principles intact. I accept it. Now the wrinkles and extra sewing and adjusting and uncertainty and pioneering that go with cambered panel sails, as they are at this point in their evolution, need not occupy me at all. I can go sailing.

under flat ones.

Well those things are not equal. And besides, we suffer not at all.

Annie Hill: "...that last 5% of efficiency comes very expensive."

Maybe if I were a racing sailor, or staying close to aluminium tubing suppliers, or we were wealthy, or sailing inshore, or not living on the boat with our stuff, or trying to go

engineless in a light-wind area like British Columbia in summer, or if I were more intrigued with the problem-solving process than with the actual solution at the masts, then I might consider going for cambered panel sails.

But wait. For the top few percent? Maybe 5 or as much as 10 degrees? When the wind's below 10 knots, that is?

Flat-Cut is Not Flat

Camber in a flat-cut sail comes from stretch within each panel, from slight bending of battens, and from the panels' fanned presentation to the wind, acting with the twist of the sail. In a Hasler & McLeod pattern sail, these will add up to... not very much camber. And the full sail will have, proportionately, the least when common sense would want it to have the most. And it's all too far aft to be terribly efficient. Oh my. Yet somehow I'm saying it's Good Enough.

From my experience of mehitabel, I put it down to the camber of the fan, mostly. The twisty curve is visually obvious and yet it seems even more effective than it ought to be. I reduce sail to what looks like too little for the light breeze, and beat my way leisurely into the bay, explore it, stop the boat and set the anchor. Yesterday afternoon it was light, and switchy and gusty besides. It's easy and more fun than I deserve. Add more to the breeze, it's still fun and easy. Leisurely or sporty, are then negotiable.

We built a little more fanning into mehitabel's sails than Hasler & McLeod's recommended plan has. Even better might be a design that enhances fan camber on purpose.

Secrets - How to Sail Like mehitabel

I don't really mean that. What I mean is, this is what I would recommend to a friend, or what I would do myself at this point in history, to meet these priorities:

- Good Enough performance for practical offshore and enjoyable coastal cruising.
- Natural robustness and serviceability.
- Buildable by mere mortal sailors who might even have other projects on the go.
- Proven over centuries, recent decades, many rigs and many sea miles - highly evolved, not experimental.

- A good chance it will work well 'out of the box.'

- Needn't be expensive.

Secret One - As Good as Ever.

Choose the best sailboat for your purpose, or make the boat you have as good as you can. Design a junk rig with flat-cut sails mainly after Hasler & McLeod's recommendations in 'Practical Junk Rig' but with only one batten near the yard at the throat, and with some additional progressive fanning of the upper battens.

Refer to Figure 1.4 in Practical Junk Rig - my favourite sail design and my inspiration for ours. I recommend it confidently. I made all our spars the same length for practicality, though, and the lowest 3 panels are parallelograms. Not as beautiful...

Our spar angles in degrees are about 10,10,10,10,13,20,60. I might use 10,10,12,14,17,22,60 now. As in that design of Hasler & McLeod's, make the lowest panels the smallest in height, progressing to larger 'P' dimensions upwards. It helps with sheeting clearance, and gives tidy 'balancing' first reefs. Check your variations for their effect on batten stagger. This plan will suit a sloop, schooner or ketch. Aspect ratios of 2-point-something will be fine.

Since this is a Hasler & McLeod sail, the invaluable guidelines contained in 'Practical Junk Rig' can be applied directly. Follow them for planning the sail(s) and rigging, centre of effort, the sheeting geometry, indeed all aspects of fitting the rig to the boat, and give thanks! Those gentlemen did their homework. Cheat on them at your peril!

Use light sail fabric if all your sailing will be light, and heavy soft fabric otherwise. Lash the whole rig together with an emphasis on distributed loading and maintainable simplicity.

Secret Two - As Good or Better.

This is what I might do if it were

me, and it were now, and our boat were single-masted and smaller than about 10 metres. I intend to make one of these for our 4m dinghy in the next while, but don't wait for me.

Make your sail to David Tyler's Fantail pattern, but cut the panels flat. Yes, flat. If you want to be in the position of expecting better windward performance in exchange for some added effort and complexity, put added camber into the bottom 3 or 4 panels. Tempting. There will be camber in any case, when the wind sees the sail and you play with its twist.

Handling the sail will be sweet with respect to batten stagger when reefing and furling. It won't ever flog or bang fabric-wise if you choose flat panels. Shaping the sail by gently peaking up the yard and upper luff will obviate the need for Hong Kong parrels. Strains will be distributed all over the spars and fabric, in keeping with the ancient junk rig's inherent wisdom.

It's a low-aspect design, but avoid too long a batten length. For scantlings, be strong plus a confidence-inspiring notch, which will pay more than it costs, or weighs. Light fabric will suit the small panel widths, on a boat of suitable scale. For sail size and many other aspects of the design and rigging, seek David Tyler's advice. 'Practical Junk Rig' will be a useful companion, but not so directly applicable.

Secret Three

Sail the rig with an eye to keeping it evenly relaxed throughout. Watch it - it all breathes together. The wind won't concentrate stresses if you don't.

Conclusion

An iPad processes images, and most other data, elegantly and easily. For the computer tasks I most often do, it's powerful enough. Nimble, in fact. And using it suits my intuition. There are more powerful machines available, but I really have only

myself to please. Beyond keeping it clean and protected, I seldom need to do anything to it. It's pretty much perfect as built, and it seems to embody for today that timeless idea of appropriate technology. I'm constantly amazed.

A Linux computer requires tinkering to make it work properly, that is without wrinkles. It's especially good at some troublesome processing that, now it occurs to me, I rarely choose to do. But I could. I'm still learning how to get the best out of Linux, so it involves me in fine-tuning exercises quite often. It's fun to tweak and customise. There are gurus available when I need advice. It will all come right. I'm sure it will. Soon I'll have the performance I've dreamt of, and I'll forget the extra work and initial troubles.

I'm not really considering a Windows computer. No, not yet. But then, a lot of people seem to be happy with them, tacking their jibs and all.

So which junk sail is more the iPad, and which the Linux netbook?

Suggested Sources

'Practical Junk Rig' by Hasler & McLeod

'Voyaging on a Small Income' by Annie Hill

All the documents Arne Kvernelend makes accessible through the JRA website.

Paul Fay's articles under the heading 'Ti Gitu's New Sails' as published on the JRA website

http://www.junkrigassociation.org/technical_articles

David Tyler's work on the Fantail sail design. Tystie is at sea as I write, so keep an eye...

<https://www.box.com/s/e2d899dda29d80e51798>

Paul Thompson's designs for Aphrodite and La Chica - Reports will hopefully come soon...

Bibliography of links to relevant JRA Forum Topics

Used for background to this article, and containing a wealth of people's thoughtful inputs.

Titles are approximate, and links are current as of 6 November 2012.

Thanks to the participants.

A Perspective on Junk Rig History

http://www.junkrigassociation.org/general_forum?mode=MessageList&eid=490656&mlpg=2147483647

Flat Sails are Okay

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=490687&tpg=13&mlpg=2147483647

Flat Sails are Still Okay

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=594527

Fabricated Aluminium Alloy Yards

http://junkrigassociation.org/technical_forum?mode=MessageList&eid=868877&tpg=3&mlpg=2147483647

General Drawing of Fantail Tystie Sail

http://junkrigassociation.org/technical_forum?mode=MessageList&eid=1060993&tpg=0

New Sail for Tystie

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=833895&tpg=2&mlpg=2147483647

Cambered Panel Sails on Wild Fox

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=770677&mlpg=3

Comments invited on Schooner

Sailplan

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=872150&mlpg=2&rid=873637

Making CFRP Battens

http://junkrigassociation.org/technical_forum?mode=MessageList&eid=911490&mlpg=2147483647

JR Conversion for Freedom 33 - Flutterby

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=531461&mlpg=2

Arion's JR Conversion - pros & cons

http://junkrigassociation.org/technical_forum?mode=MessageList&eid=1105936&tpg=0

Cambered Panel Sails on Ti Gitu

http://junkrigassociation.org/technical_forum?mode=MessageList&eid=766440&tpg=0

Luff Parrels for Cambered Sails

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=1067661&mlpg=2147483647

Possible new mast

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=650160

Help Point a Newbie in Right Direction

http://www.junkrigassociation.org/technical_forum?mode=MessageList&eid=936679



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