The cambered Junk Sail

(A not so..) Short description of how to make a junk sail using the cambered batten panel method

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(***Johanna***, mine since 1998, showing off her cambered panels)

Introduction:
Some years ago I made a short description on how to make your own junk sail with camber in the panels, and this has been updated several times. In this version, made for the *Yahoo JR Group*, I will add a little more to show the reasoning behind the rig, what conditions that makes me choose this or that shape, size or other parameters.

Cambered junk sails:
The members of this group should be well familiar with the need for some sort of camber in the junk sail (as in any other sail) to get better performance, particularly to windward.

As far as I know, there are four ways of making camber in a junk sail:

- Bendy battens. I have very little experience with them.
- Hinged battens. I used them on and off from 1991 to 1994. Quite good; a couple of bugs though.
- Camber through twist induced in low aspect ratio fanned junk sails. I know nothing about that.
- Cambered (..also called, baggy, bulging, full or quilted) panels. I have stuck to the method since 1994.

It is this last method that (.. eventually...) will be described here.

Boats suitable for junk rig:
Most boats that are good with other rigs, can take a junk rig, but some are better than others. If rather tall or heavy masts are to be used, I would shy away from the skinny bow and stern IOR

types. The added inertia of the heavier mast(s) may result in too much hobby-horsing in a head sea. Good, nice, moderate spoon-bows are fine. Fin-keels or long keels; they both work well.

As always however, I warn people against directionally unstable boats; boats that will throw themselves into a death spiral as soon as you leave the tiller. Also, boats with skinny bows and fat sterns are no good as cruisers, at least not for offshore work. Their weather helm increases too rapidly as the boat heels over. Combine these two deficiencies – and you have a possible widow-maker.

Rudders:
The junk rig, especially the sloop, calls for an effective rudder for safe reaching and running. The Chinese knew this; unlike the Europeans with their down-wind friendly square sails, they had to use barn-door size rudders to counter-act the yaw effect of their huge for-and-aft sails. Fin-keel boats with big separate rudders are ok. Folkboat-types (NF, IF, Marieholm 26, Contessa26 etc.) are very good. What I would avoid is boats with rather short integral keels, like 5.5meters, Knarrs, Dragons and even the Albin Vega (..the Vega could be used, but I would then fit a new rudder on its stern...). Too little focus has been put on the rudder on junk-rigged boat, me thinks.

Number of masts:
The number of masts depends not only on size of the boat, but also of its character.
On a boat with a good ballast keel I would use a sloop rig until the sail got too big to handle. The old rule-of-thumb has been to keep a junk sail below 50sqm. Recently we have seen sloops with 80sqm sails, and they work fine. Today electrical capstans are not too expensive (much cheaper than a second stick, sail etc.), and they make hoisting the sail a lot easier. Some will be put off by this idea, but unless you are a purist and don't have an engine on board, I can't see any reason for not using that capstan (..with a manual winch as back-up of course...).

I think the best reason for choosing two masts is that the boat is long, skinny and tender, say a sharpie type or something. The heeling moment of such a boat must be kept down and the long deck gives room for two sails and their sheets.

Stayed or unstayed masts:
One of the real joys of sailing with a junk sail is to be able to square the sail fully out (.. or even a bit beyond...). This way you will avoid a great number of accidental jibes. With stayed mast(s) this is not possible.

(The Chinese seems to have used unstayed masts from early on. However, these unstayed masts were very expensive – I read somewhere that the masts used to cost as much as the ship itself. When the steel wire became available (1880s?), I am sure many of these practical boatmen switched to the much cheaper stayed masts.).

For us, in our small boats; an unstayed mast needs not be more expensive than a stayed one.

Added inertia:
Most of us will not pay for a carbon mast, yard and battens (yet). Therefore we are so far stuck with fairly heavy masts. The added (static) heeling moment should be easy to understand by most of you. However, the matter of *inertia*, both in roll and pitch plane is a bit trickier. The inertia of a body, in this case the mast, is its reluctance against being accelerated in rotation, one way or the other.

In the roll plane the masts inertia slows the roll rate; the roll period gets longer. For inshore work I find this to be fine: As big ferries or gin palaces rushes past us, my *Johanna* just bobs up and down, hardly rolling at all. Offshore however, one may meet looong slooow swell that are in resonance with the boat – not quite as fun. For real offshore sailors (with any sort of rig) one

should look for a boat that has some inherent roll-damping in it. I guess my *Johanna*, with her round mid-section, is not the best.

> **Annie Hill once reported that their flat-bottomed, single chine dory *Badger* was very resistant against rolling. I believe her.**

In the pitch plane the mast increases the boat's reluctance to riding over the head seas. Since the inertia increases with the *square* of the mast's distance from the boat's centre of gravity, CG (..ok this is a bit simplified...), there are good reasons for keeping the mast low and away from the bow – if we can. However, the boat itself and its cargo are the main contributors to this inertia. We may compensate for the heavier mast(s) by moving things from the ends of the boat, and closer to the middle (e.g. anchors, anchor winch, cans of water and fuel, dinghies...)

Rig size, sail area and camber:

One main reason for switching from Bermuda rig to junk was that I hated the poor downwind performance of the former. A junk not only lets you set a much bigger sail on the same mast length, but the easy tacking and reefing of the sail invites us to be generous with the sail area. The limiting factor for a mast on a small boat is the length, windage and weight of the mast. How much can the boat take in the worst conditions you are likely to face? The height of the mast not only depends on the boat and weather, but also on how deep pockets you have: You can partly buy yourself out of the problem by going for lighter and slimmer masts; hollow wood, aluminium, GRP or carbon. Then it is just a question of fitting the biggest possible sail that the mast and deck space will allow, and that gives you correct position of the sails centre of effort, CE.

For small and weatherly keel-boats where manhandling the rig is not a limit, I think we should aim for a SA/disp. between 20-25, even for an offshore boat depending on the mast material and thus weight. For such a boat I would use a moderate camber of just 8% of the chord. With so little camber, the boat will be able to carry almost as much sail close-hauled as when running before the wind. This is fine for the cruising man. A die-hard speed freak would probably gain on increasing the camber to 10%. He would then more often have to adjust sail area between upwind and downwind legs.

For big and heavy boats, the SA/disp. must be reduced, either to make them more user-friendly, or because there is not enough deck space for a bigger sail. In these boats I would consider compensating for lack of area by increasing the camber to 10, or even 12%.

> **Remember; a big sail will keep the boat moving in lighter winds so the engine can rest more often. In other word, an effective sail boat, in strong or light winds, upwind or downwind is a GREENER boat.**

Choice of sail plan:

Apart from a (..not too successful...) exercise with the fan-battened Reddish sail, I have stuck to the Hasler & McLeod (HML) sail plan. My only diversion from it is in the top section where I have introduced the transition panel (panel 3). This reduces the size of the two top panels and makes for better twist control. I prefer the HML sail for several reasons:

- It is easier to make since several panels are identical. One may make a pattern for cutting the rounding in the lower panels, and use it over and over 7-8 times.
- Reefing the sail is easy, I never have to adjust the lazy-jacks on reefing and I can – and do – use all possible sail settings. In fact, I don't have running lazy-jacks.

- The HML sail has a vertical or next to vertical leech. This reduces trouble with sheet-spans being caught by boom or battens when tacking or jibing. With the Reddish sail I had to throw the sheet over every time I tacked.
- The HML sail gives a very long luff for a given mast length (..when counting with the 70deg yard...). Fine for upwind work.

However, if you don't like the look of the HML sail, you may well make a cambered sail with a fanned planform. In fact, this may be a good idea for two reasons (.. I haven't tested this myself...):

- The reported problems with reefing the fanned sails (..sail moving aft as they reef...), may well be eased or cured by cutting each panel with camber. The cambered panels will have Much reduced diagonal stiffness, so will move much less aft as you reef (..read later about Hong Kong parrels...).
- If you are to use double sheets, port and starboard, I guess the sheet spans will be less likely to catch battens than with a HML sail.

Deciding the centre of effort and lead:
Generally I design the sail with the max camber point well forward of the middle; between 35 and 45% from the luff. Experience has told me that the effective CE of the sail is far forward in such a sail (more than in the flat sail). For this reason; you may well move the geometrical CE of the junk sail at least 5% (of the DWL) aft from where it was with a Bermuda rig. In fact; if you are forced to put your mast and rig so far forward in the boat that you fear for lee helm, you can cut the sail with the max camber point as far aft as 40, 45 or even 50% aft of the luff. This should compensate for up to 5% too much lead, I guess.

I have fiddled a lot with different rigs in my first junk rigged boat, *Malena,* so I actually know a bit about this.

Making the sail:
This short description is for people who have some basic knowledge about the junk sail. I strongly recommend that you read one of these books before starting rigging a boat with a Junk Rig for the first time:

- "Practical Junk Rig" by Hasler and McLeod. (ISBN 0-229-11798 8),
- "The Chinese Sailing Rig" by Derek van Loan.
- There is also useful information on the www.

1. Draw up the sail-plan (.. yes, draw - pen and paper...). Have several copies of the boat plans ready, so you can make 2-3 versions of the sailplan, until you get the right sail area and correct centre of effort (CE) in the sail-(plan). Be generous with sail area, but avoid fitting too tall and heavy masts. I use hollow (dug out) spruce.
2. Decide how much camber you want in each panel, and calculate the necessary rounding in each panel to achieve that camber. The result may end up like the enclosed sail-plan for *Johanna* (sheet 3). The 'Arne's chain calculator' and "chain calculator sketch" is a useful aid in this process.
3. Alternative 2. If you already have a drawing of a junk sail that you like in your hands, with lengths written on, you can scale it up or down to the area you want and see how it looks on your boat. Just remember that linear scale factor is the square root of the area factor. E.G. if you want your sail to be 30sqm instead of 40, the area is reduced to 75%. The lengths of battens etc should then be reduced to square root of 0.75=0.87, or 87% of original lengths.

4. I use to make a pattern in cardboard or plywood to show the rounding in the lowest panels (.. by now you understand why I use 4-5 identical panels on *Malena* and *Johanna*…). Use a bendy wooden batten to scribe the curves on the pattern. By the way, choose a slightly stretchy, soft canvas for sailcloth, not the firm, heat-treated and doped Dacron sailcloth. The softer cloth will more easily take up the compound curves in the bulging batten-panels without showing creases. Hopefully your sailcloth /canvas is wide enough to cover a whole panel, at least in the lower ones. If not, you will have to build them up from smaller panels first. Don't forget to add cloth-width for hems and along battens (see step 4-5 and Afterthought #1).
5. Before assembling the sail, panel for panel, make the hem on all the outer edges of the sail, 2-4 cm wide, 2 seams. Sew in a 3mm thick inner bolt-rope in the hem, cheap polypropylene or something. (See also Afterthought #3)
6. Sew the panels together (se enclosed *sewing sketch*). Staple the panels together first to make sewing easier. You may want to make gaps in the batten-pockets where batten-parrels and Hong Kong parrels are to be. On *Malena*'s sail, I just burned holes with a solder-iron afterwards. The strong, doped nylon has never ripped. (See Afterhought #2)
7. Now, with the sail almost completed, it is time for the outer bolt-rope, a most important item. This is a continous rope around the whole sail. I start somewhere on the foot of the sail and hand-stitch it to the inner bolt-rope (remember?) with about 3-4 locking stitches, then 15cm pause, then 3more locking stitches etc. Close to the battens or corners I may add extra sets of "3-stitch". This outer bolt-rope is to carry all the accumulated stresses in the sail, so it should be fairly strong, and not elastic. On *Malena* I use a 7mm pre-stretched 3-strand polyester-line. Make sure that the roping is taut enough, i.e. that the weight comes on the rope and not the sail. The reason for the inner bolt-rope should now be obvious: To give a good grip for those 3-stitch groups. This is the Chinese way of doing it; remember their 'sailcloth' was very thin and fragile. (See also Afterthought #3)
8. Fit a telltale made of nylon-ribbon at the leech of ach panel. These will keep you from over-sheeting (stalling) the sail. If you over-sheet, the telltales will fall behind the sail. Very useful, don't skip this!
9. The sail is now ready for the boat. The openings in the boltrope come now in handy when you are to lace the sail to the yard and boom. The batten-ends (with hole in) are also laced with thin line to the bolt-rope. *Note!!* I spliced a hoop of line to the outer bolt-rope at each batten-station prior to sewing the bolt-rope on. It is done so that the protruding batten will rest in this hoop. In other words, that hoop will take up all the vertical forces from the battens. This is necessary because I fix sheetlets/sheetspans and luff hauling parrels directly to the battens. This works well, but it means a lot of splicing! (still, I roped Malena's sail this way in 8hour's sharp)
10. Hoist sail on a dead calm day, and fix batten parrels, Hong Kong parrels one by one as you hoist the sail. After some sailing, you may need to make adjustments on the batten parrels, and also on those diagonal Hong Kong parrels - whose job, by the way, is to avoid diagonal wrinkles in each batten panel. The bulging panels do not have much diagonal stiffness themselves.

Afterthoughts:

1. On bigger sails (over 35sqm) I may fit patches at each batten-end, prior to fitting the outer bolt-rope. Remember, that diagonal Hong Kong parrel should act on the batten, not on the cloth in the batten pockets (only on rope type boltrope...)
2. Now (2003) on *Johanna*'s sail I have a 20cm gap between the fore and the aft batten pocket. They have been sewed on from separate strips of canvas. The fore batten pocket by the mast is made from heavy pvc-like canvas to avoid shafing.
3. On *Johanna*'s sail I have "roped" the sail with webbing (saves a lot of time with a sewing machine). The hoops through which the battens are run (at luff/leech), are also made from the same webbing. Smaller webbing hoops are fixed to the head and foot of the sail to fix them to yard and boom. Such small hoops are also fitted to the luff/leech at the battens. Time will show if it works. *(Comment 20060618: It does, but I wonder if the webbing I have used is a little too elastic. This winter I might fit a boltrope all round the sail,* Malena-*style. It takes just about 6 hours.). (Comment 20071228: Maybe some day...).*
4. (20060618) The way of assembling panel to panel along the battens seems terribly crude on my sketch. Still, *Malena*'s sail has been in use for over 10 years now, and we have not had to replace a single stitch yet. Remember, it is the boltrope which carries the loads. The load per metre or ft along the battens is very low indeed.

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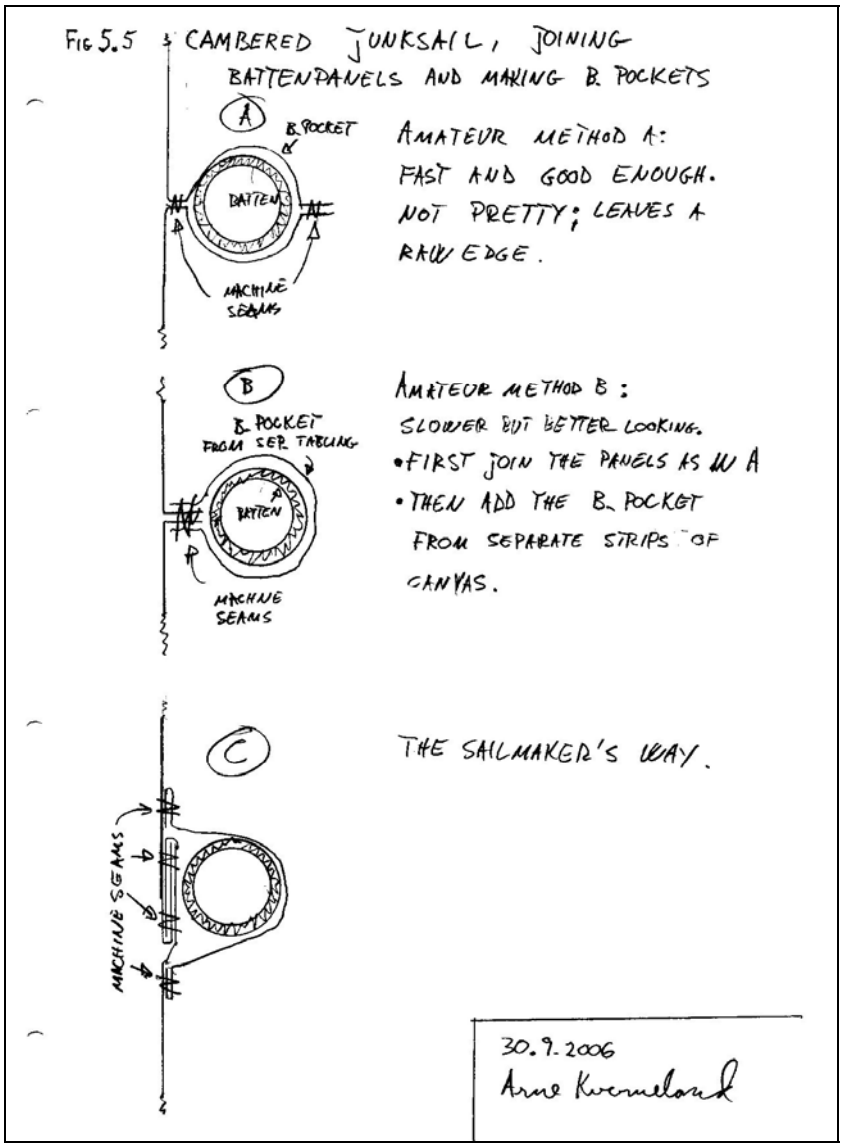
That's all folks – for now.
Hopefully I may write up a section on problems and their solutions, small tricks etc. Some files with sketches will also pop up in this folder as I get them ready.

Stavanger, Dec. 28th 2007.

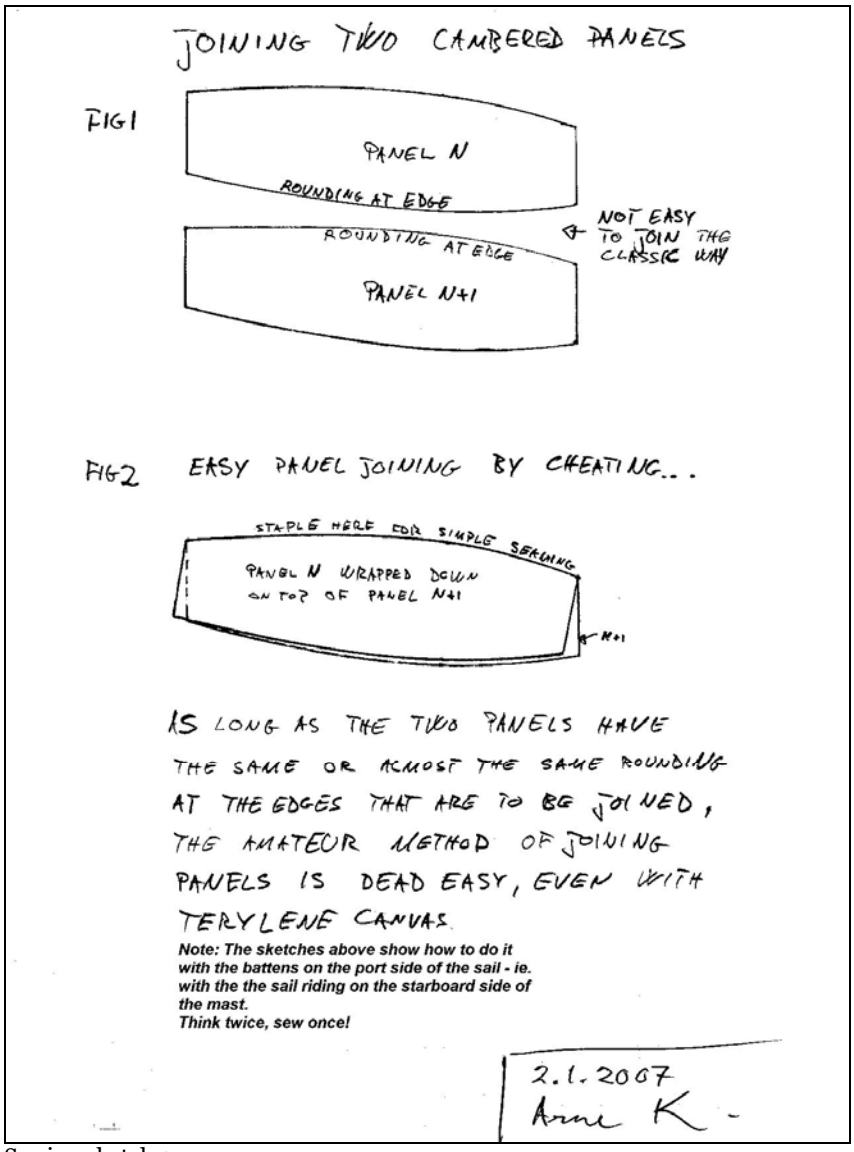
Arne Kverneland

PS. No doubt I have forgotten things. Still I hope, with some sensible feedback from you, maybe I can fill the worst holes – and straighten up my Stavanger-English too.



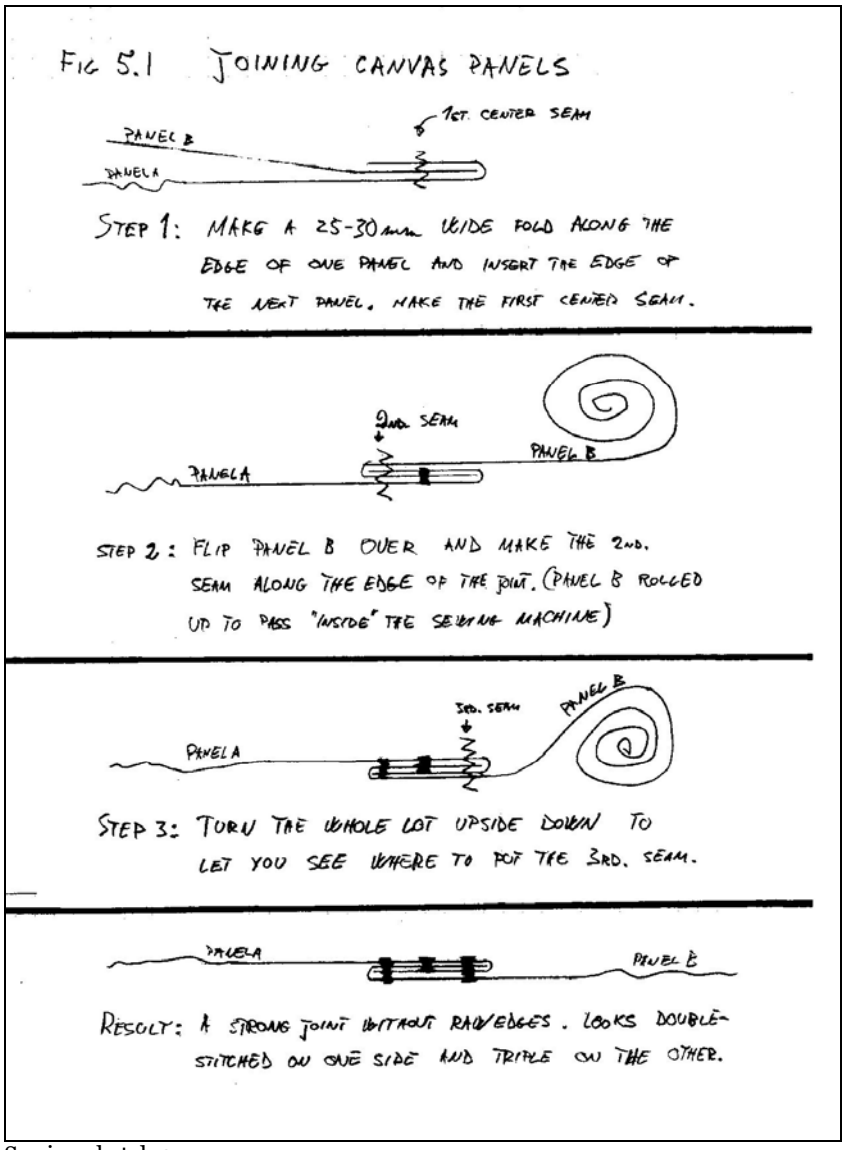
Sewing sketch 1.

Three ways of assembling the batten panels. The two first let you do it without passing a big roll of sail inside the sewing machine. Looks crude, but it works.



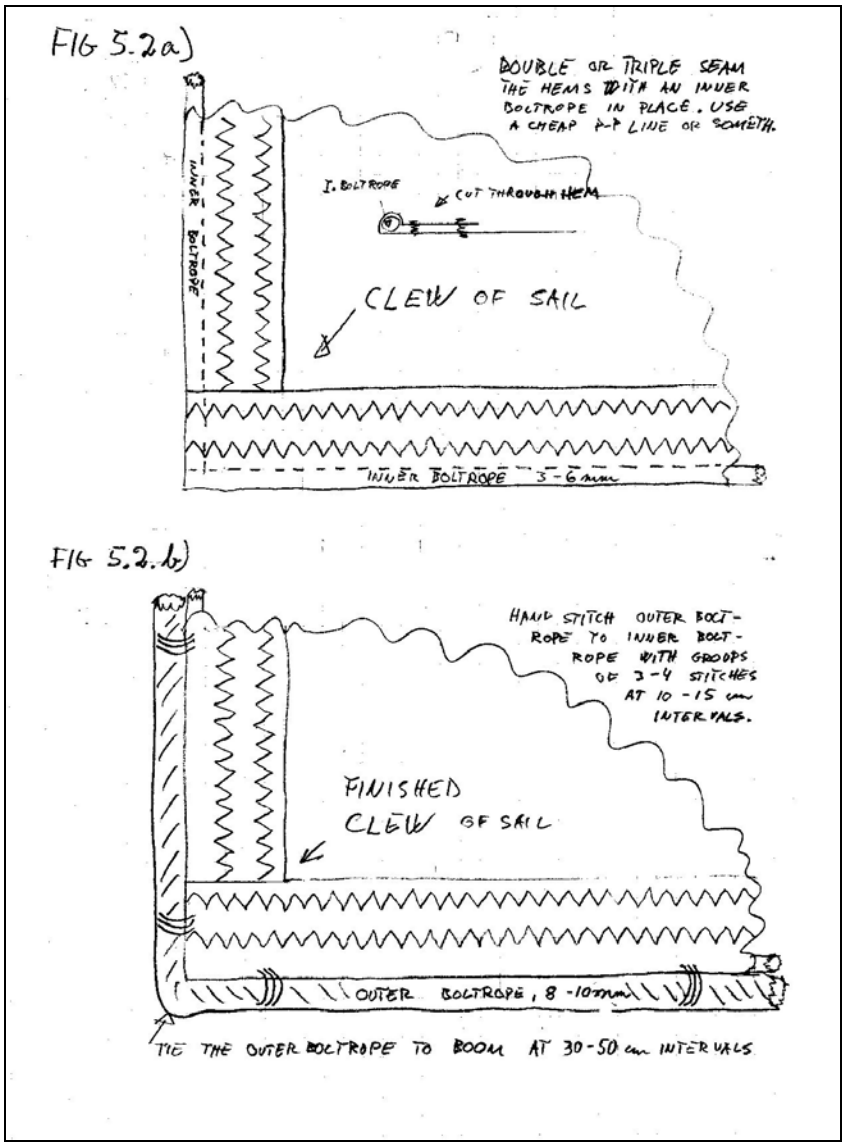
Sewing sketch 2

Shows how much easier it is to join two panels with camber cut in, if you use the amateur method. No need for passing big rolls of sail inside the sewing machine.



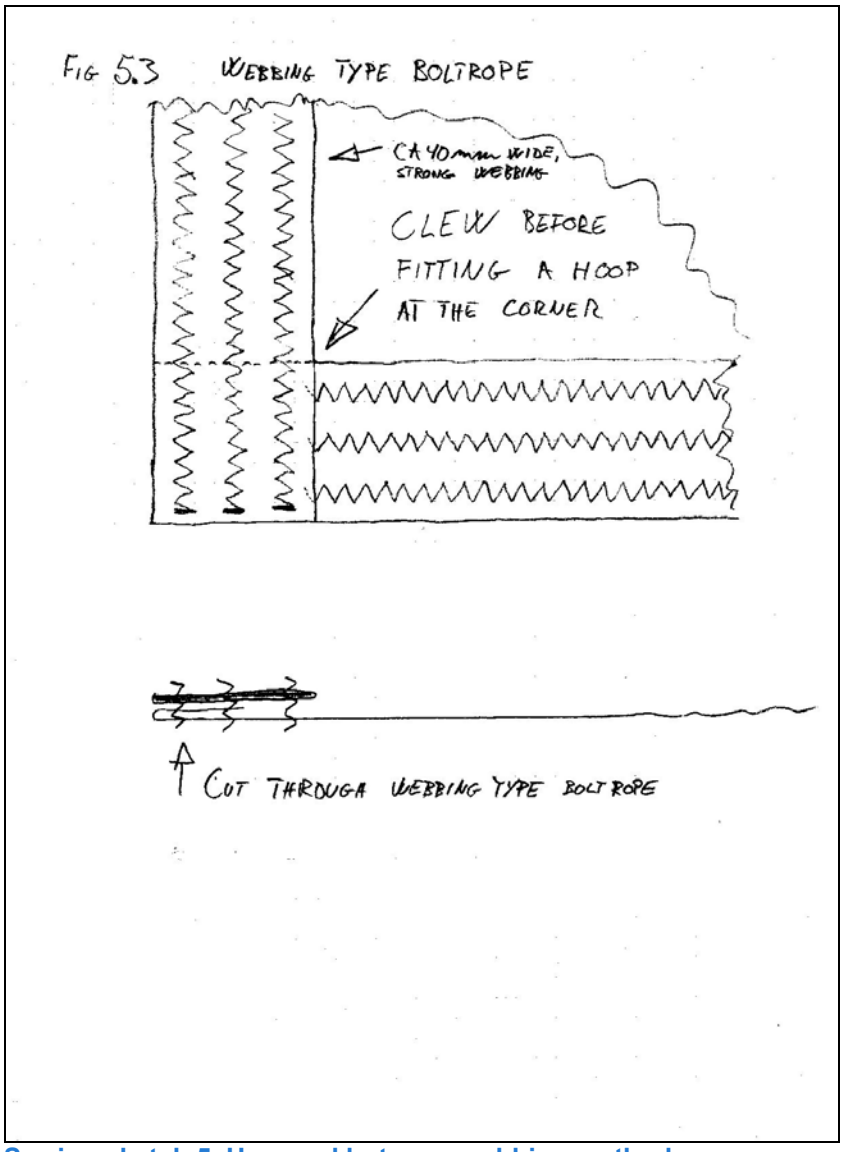
Sewing sketch 3

Shows a good way of joining straight canvas panels. Lets you make the first seam without needing to pass any canvas inside the sewing machine. You hardly need double sided (basting) tape.



Sewing sketch 4. Hem and botrope, double rope method

How to hem and rope the sail with an inner boltrope in the hem and an outer boltrope, hand-stitched to the inner one...



Sewing sketch 5. Hem and botrope, webbing method

How to hem and rope the sail with a thick webbing...