

FABRIC FOILS

The Journal of Sailmaking

What is different about sails for planing dinghys, catamarans, and trimarans?

HIGH SPEED SAILS...

A better understanding of high speed sails can aid in the design of other sails.

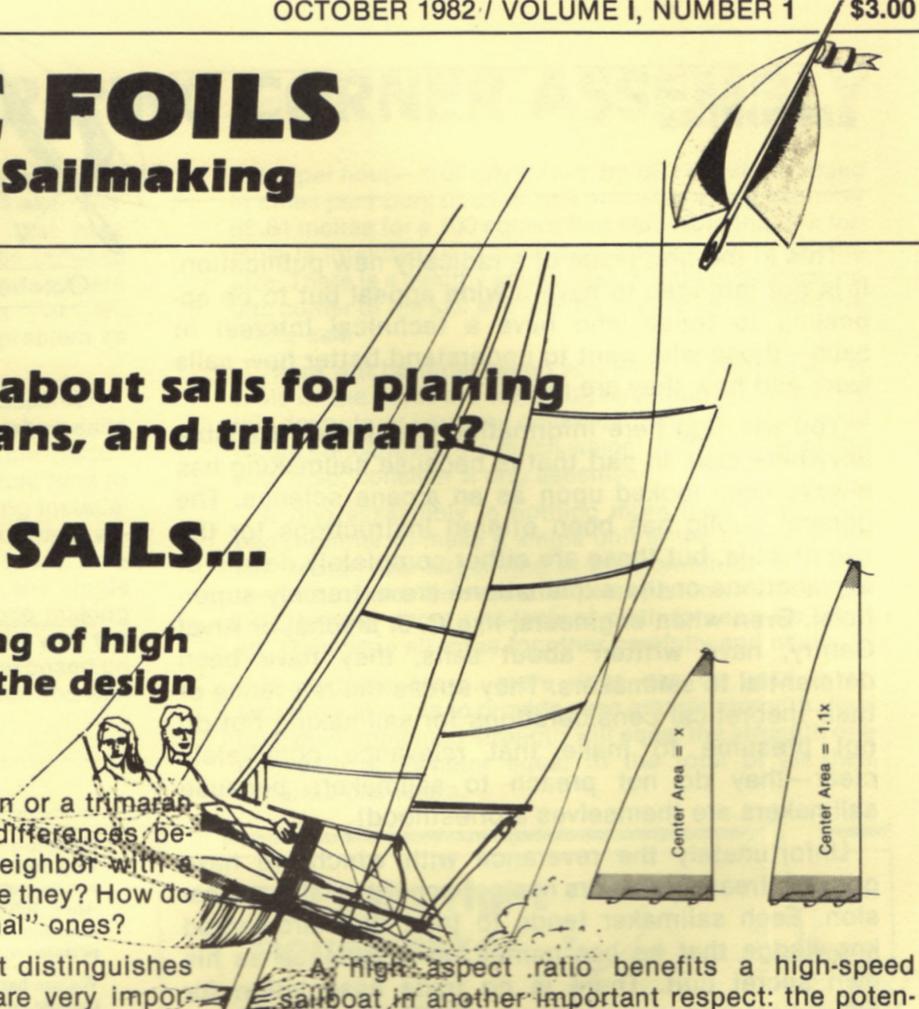
Everyone who owns a catamaran or a trimaran knows that there are important differences between his sails and those of a neighbor with a displacement sailboat. But what are they? How do high-speed sails differ from "normal" ones?

It is the design of the sails that distinguishes them. These design differences are very important, but they are differences of degree rather than kind. Indeed, the discussion below should be useful even for those who never intend to build catamaran or trimaran sails, since it will point the way for those who need a bit more speed from the sails that they are using. By discussing the extreme, it should be possible to elucidate the middle ground.

There are three places to look for differences: in the two-dimensional shape of the sails, in the design of their draft or fullness, and in the manner in which they are rigged. We will take up each one in turn.

High Aspect Ratio

High-speed sails benefit from a very high aspect ratio. In part this is because high aspect ratio is most effective when going to windward and high speeds tend to move the apparent wind forward to the point where almost every point of sail is a beat. When wind is flowing over a sail from front to back, air circulates over the top and under the bottom of the sail. This circulating air both reduces the efficiency of the foil and creates induced drag. If sail area is distributed over a high and narrow foil, the relative importance of this bypass flow will be greatly reduced. Thus, any given area is more efficient when it is distributed over a long leading edge, so long as air flows over the foil rather than "around" it.



A high aspect ratio benefits a high-speed sailboat in another important respect: the potential speed generated by the foil will be higher. The velocity of the air moving over the foil will be greater along its leading edge. At this point the friction drag of the sail has not slowed the flow of air or rendered it turbulent. As a result, thrust can be generated into a higher range.

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EDITORIAL

This is the first issue of a radically new publication. It is not intended to have a wide appeal but to be appealing to those who have a technical interest in sails—those who want to understand better how sails work and how they are made.

You will find here information that is not available anywhere else. In part that is because sailmaking has always been looked upon as an arcane science. The general public has been offered instructions for the use of sails, but these are either completely devoid of explanations or the explanations are extremely superficial. Even when engineers, like C. J. Machaj or Arvel Gentry, have written about sails, they have been deferential to sailmakers. They stress the relevance of their theoretical considerations for sailmaking but do not presume to make that relevance completely clear—they do not preach to sailmakers because sailmakers are themselves a priesthood!

Unfortunately the reverence with which we have come to treat sailmakers has not benefitted the profession. Each sailmaker tends to treat the hard-earned knowledge that he has gained by experience as his own secret cult. There is no trade association for sailmakers because knowledge in sailmaking is jealously guarded. In the absence of any widespread common sense understanding of sailmaking, each loft is free to develop sail design and advertising campaigns that make very little sense. The public is forced to accept and reject new designs either on the basis of experience (which can be expensive) or on the basis of the ballyho created by advertising agencies.

FABRIC FOILS will strive to overcome the secrecy that shrouds sailmaking. The journal will be valuable to professional sailmakers, but it is also intended to be read and easily understood by those who use as well as make sails. Indeed, the magazine has been created with the intent of spreading the knowledge of sailmaking design and construction.



FABRIC FOILS

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A FOUR-RING CORNER ASSEMBLY

The weakest link in a sail is usually its corner hardware. Nearly 65% of all repair jobs that sailmakers encounter involve clew, head, or tack rings that have pulled from the sail. This figure will never be reduced very much below 50% just because of the way sails are used—stresses are focused at the corners. We can, however, take every measure to reduce the problem as much as possible.

One technique is the "four-ring corner assembly." Such assemblies were common in the days when sails were made by hand to very high standards of craftsmanship. Perhaps a look to the past is justified from time to time. The assembly technique for multiple ring installation may take more time, but it distributes stress extremely well and provides extra safety from chafe. As a result, it is stronger and more reliable than any single ring corner installation, except perhaps those making use of D-rings and webbing straps. (The trouble with the latter is that they leave a good deal of metal exposed on the edge of the sail and are dangerous when the sail begins to flog.)

Ring Assemblies



So how do you make up a four-ring assembly? First select the ring sizes that you will use. I will assume here that the rings will be sewn in place. Hydraulically pressed grommets could be used to make up an assembly, but they would not give the flavor of old-time craftsmanship that is part of the appeal. Most of us try to keep our selection of rings and the die sets they require to a minimum in order to reduce our capital investment. This is perfectly justified since there is such a wide latitude of choice possible in ring sizes. Indeed, the use of the four-ring assembly makes that latitude even greater since it is possible to use the assembly in places where a much larger single ring would be required.

Generally speaking the largest ring diameter used in a sail should meet the following requirement:

$$D = q \times S_A \times C / 700$$

where D = the diameter of the ring

q = .00119 \times the square of the velocity in ft/sec of wind

S_A = the area of the sail

C = the aerodynamic force coefficient for the shape of the sail

700 = the assumed strength (in pounds) of each one inch of sewn ring.

This formula is derived from the work done by C. A. Marchaj in his *Sailing Theory and Practice* (N.Y.: Dodd, Mead & Co., 1964), pp. 65-70. If we assume an aerodynamic force coefficient of 1.33 (Marchaj found this an appropriate maximum for a common sail shape, page 70) and a wind velocity of 60 feet/second (40.92

miles per hour—multiply ft./sec. by .682 to get the speed in miles per hour), this formula indicates a ring diameter of .81 inches for a 100 square foot sail. Note that the formula is intended to provide only a rough guide for ring size. There is a healthy safety margin built in because no one corner of the sail will ever be required to support the entire sail.

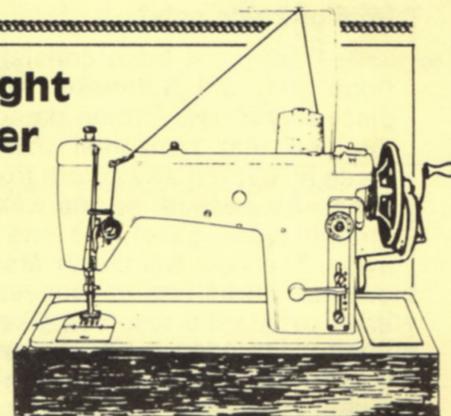
There will be times when you either do not have the tools or the hardware for a ring large enough to satisfy this formula or you may conclude that a ring that large would concentrate too much weight in the corner of the sail. If so, consider a ring assembly.

A ring assembly is nothing more than three rings tied together to make a single unit in the corner of the sail. Install one larger ring in the normal location and then fix in place three smaller ones just inward from the first, leaving about one-inch of cloth to separate them all. Then whip all three together carefully and neatly.

In extreme cases, more rings can be used in an assembly like this to provide even greater strength. As a rule, their combined strength will equal the strength of a ring with a diameter equal to the total of all their separate diameters.

The Sailwright Moneymaker

At last, the sewing machine for you! Until now sailmaking and sail repair have been carried out either with small, lightweight, and often underpowered sewing machines designed for home use or with heavy and ridiculously specialized machines intended for volume commercial work.



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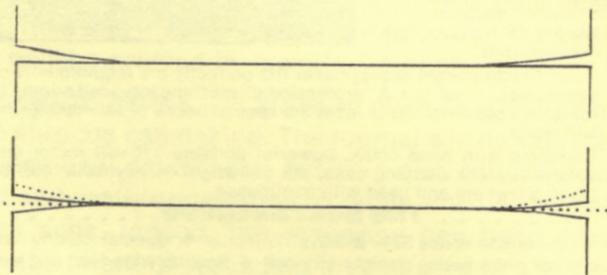
General interest questions from subscribers will be answered in print here. We cannot promise to reply to all questions personally—but we will try. Send your questions with sketches or photos to: Jim Grant, Editor / Fabric Foils / Route 1 / Columbia City, Indiana 46725.

These first questions are a composite of many that I have received recently. In the future we will attempt to give full credit to those who ask them.

Ask Jim Grant

Q: I understand how broadseams are used in sails, but I am not sure just how they should be made. If material is cut away from the panels, should it be cut from both sides of the seam or from one side only?

A: I have not been consistent in my instructions. The old **Spinnaker Manual** (recently replaced by a new edition dated September 1982), directed that horizontal panel broadseams be made by cutting away cloth from one side of each panel. As a result, seams were formed with one straight-sided panel and one with a wedge cut away. The new **Spinnaker Manual** suggests that one-half of the total broadseam be removed from each panel. The result is a seam where both adjoining panels have equal stretch characteristics.

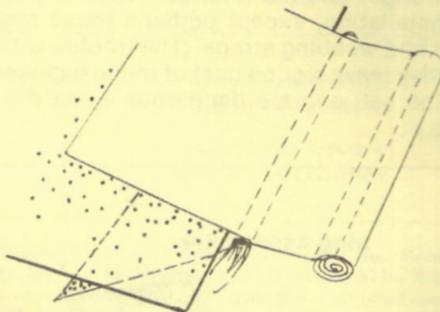


The old method sometimes resulted in seams that would develop small stress puckers due to uneven stretching after some use. In addition, with the new method panels are shortened equally by the broadseaming so less trimming is required in order to fair the edge of the sail.

There is nothing wrong with shaping a seam by bending just one side of the two panels to be joined. The sail will be given proper shape, but a smoother sail will result and less edge trim will be necessary if both panels are bent in roughly equal amounts.

Q: How should continuous support tape be matched up to a sail luff? That is, should the tape be stretched when it is applied just as a rope would be? Should the sail luff have the "gathered" look of a normal roped sail when it is not under tension?

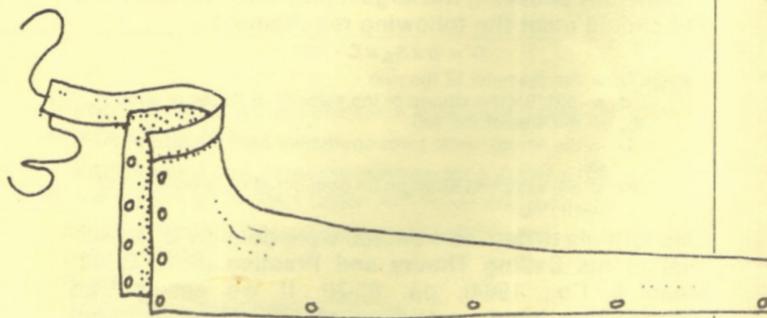
A: Continuous support tapes used in headsails are primarily for the sake of permitting quick sail changes and a smooth entry curve for the sail. In order to accomplish these two goals you should match the tape to the sail with only enough tension on both to remove all wrinkles. If the tape were sewn on so that it puckered the leading edge



of the sail, that edge would not slide freely into the tunnel. And since the tack and the hoist are aft of the reinforcement in the tape, it is difficult to tension that reinforcement sufficiently to remove the wrinkles.

Q: How long does it take to build a sail cover?

A: The length of time to make a sail cover will depend upon the maker's experience and upon the size of the cover. Even so, there are some rules that can be used to estimate time requirements. For example, sailmakers charge about \$9.15 per foot of boom length. Roughly half of this is for the Acrylic cover cloth and other materials. If we assume a labor rate of \$20.00 per hour, the sailmaker would have to complete five feet of cover each hour. Depending on your experience, you may want to double or even triple this figure, but it will provide a starting point.



FINE TUNING A SEWING MACHINE

(The following is taken, in part, from an article by Jim Grant for the April 1982 issue of SAIL magazine.)

The sailmaker's best friend or worst enemy is his sewing machine. Fortunately, each of us can do a good deal to make sure that relationship between us and our machine is a friendly one. All it takes is understanding: the more we know about our machine, the better it will work for us.

Given this fact, it is surprising that the companies who are making and selling sewing machines do not make information concerning their mechanical needs available. User handbooks are generally not even provided when industrial machines are packed, and those which come with home machines are written as though the companies expect mechanical skills to be completely beyond the user. In fact, sewing machines are relatively simple and their adjustment is totally within the capabilities of the average user. All that is required is a little knowledge and practice. The following should help.

Sewing machines are remarkably simple. One of Singer's great achievements was to convince sewing machine inventors to pool their patents. Thus, around the turn of the century, sewing machines became essentially similar, with only three basic types of both home and industrial machines emerging.

Within each type of classification, machines do differ. They can be more rigid (and thus generally weigh more). They can have distinguishing features in the form of unusual stitch options or subtle design nuances. And they can be built to greater or lesser standards of precision.

As a general rule, sail and canvas work will be carried out more easily by heavier machines without fancy stitch options. These characteristics are easily recognized. Manufacturing precision is also highly desirable, of course, though it is difficult to judge quality except in terms of price. This is not always a reliable indicator with sewing machines, because a high price often reflects dealer service and distribution costs rather than intrinsic machine quality.

Perhaps the best test of precision is to disengage the drive motor, raise the presser foot, and turn the machine over by hand without any thread in it. If it is silky-smooth through a complete revolution of the balance wheel, the machine is probably of satisfactory quality. If there are "glitches" or rough spots, you can generally assume manufacturing shortcuts. Some very close tolerance industrial machines will re-

quire a short break-in period before they turn freely, but there will still be no harsh spots in the revolution of the balance wheel.

Another test for quality is to run the machine at high speed without thread. A well-made machine will vibrate very little.

The machine type is just as important as quality, weight, and mechanical simplicity. Machine types are distinguished primarily by their bobbin shuttle hook, and only three variations are in common use among zigzag home machines.

The majority of home sewing machines have a "class 15" bobbin system. The shuttle hook (in the bottom of the machine) oscillates (Figure 1), driven by a crankshaft linkage. This mechanism is reliable and inexpensive to produce. Almost all of

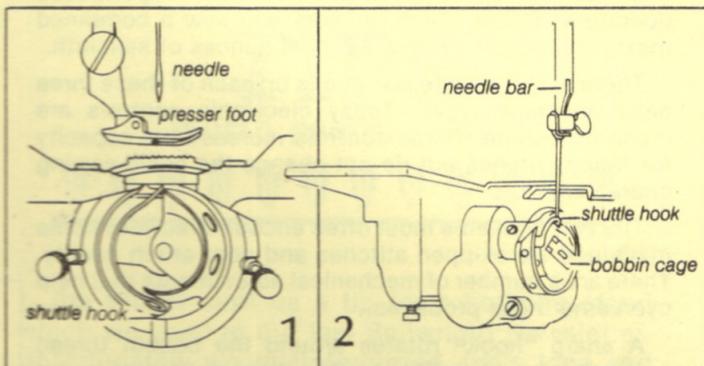


FIGURE 1: Most common type of machine has oscillating class 15 bobbin system.

FIGURE 2: Roary hook bobbin often found on European machines.

these machines are assembled of parts produced in Taiwan. Quality is generally rather low, but the machines are nevertheless a good value for the money, ranging from \$125 to \$600; prices at the high end are usually for machines with features like fancy stitches and expensive marketing systems that do not benefit sailors. In fact, it is quite possible to sew from 32 to 48 ounces of sailcloth (total weight of layered material) with a \$200 class 15 sewing machine.

The second machine type makes use of a full rotary bobbin shuttle hook (Fig. 2). The rotary hook is a recent innovation, first appearing on the White Rotary, a machine produced in the United States. European manufacturers quickly seized upon it while those in this country ignored it and consequently lost their competitive edge in the market.

Rotary machines produce a more consistent zigzag stitch quality than the class 15 type. They are also capable of much higher speeds, and they run more smoothly. The top and bottom shafts in these machines are either gear or timing-belt linked. Production tolerances are, of necessity, extremely fine. As a result, the machines are relatively expensive (from \$500 to \$1,200).

Unfortunately, the extra expense of the rotary machine does not always guarantee better perfor-

mance in sail and canvas work. The precision required for the sophisticated system is so sensitive that many lightweight rotary machines continually require timing adjustment. The more heavily constructed machines are marvelous tools, clearly superior to the class 15 machines, but the lighter ones can cause extreme frustration. As a result, the maximum sewing thickness range for rotary bobbin machines is rather broad—from 24 to 56 combined ounces of sailcloth.

The third machine type is a variation on the second, using a rotary shuttle hook that is mounted horizontally in front of the needle. This design is clearly for easing the task of reloading bobbins; indeed, some of these machines feature in-place bobbin winding.

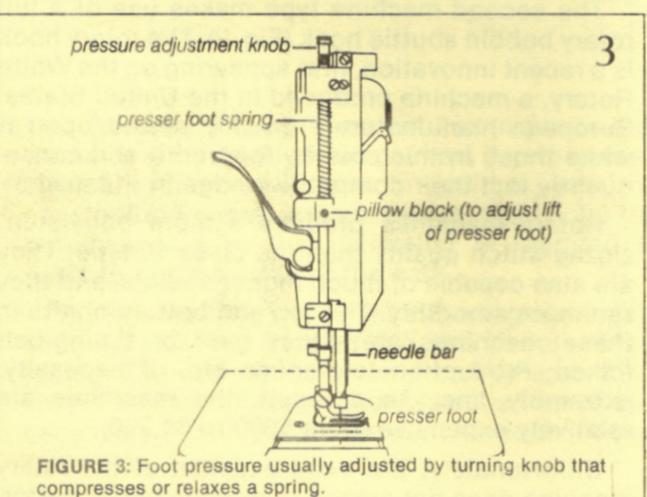
This system, unfortunately, requires extremely fine adjustment. Otherwise, the rather brittle Dacron thread used in sailmaking results in an inconsistent stitch quality. Some of these machines cannot be used for sail and canvas work by even the most experienced operators. Those which do work will sew a combined maximum weight of from 24 to 40 ounces of sailcloth.

There are, of course, variations on each of these three basic machine types. Today electronic controls are much in fashion. These controls increase the capacity for fancy stitches but do not change the basic sewing characteristics.

The two problems most often encountered with home machines are skipped stitches and poor stitch quality. There are a number of mechanical adjustments that help overcome these problems.

A sharp "hook" rotates around the bobbin thread under the machine. This hook passes right next to the rising needle and catches the upper thread. Then it pulls this upper thread down until it circles around the entire bobbin of lower thread; the two are thus interlocked, and a stitch is formed. When stitches are skipped, most often it is because either the thread is not being held by the fabric as the needle is withdrawn (thus, a loop of thread is not formed for the hook as it passes the needle), or the hook is not in proper "time" with the needle.

The first problem can be resolved by increasing pressure on the cloth. Heavy, closely woven materials like sailcloth and canvas can make the withdrawal of the needle from the fabric difficult. If the fabric lifts with the needle, there will be no thread loop formed below. Increased foot pressure will stop this "bounce."



The foot is a spring-loaded device. Often the spring pressure can be increased simply by pressing a plunger or turning a screw at the top of the machine (Figure 3). If this adjustment is not available, the spring can often be replaced with a stronger one, purchased at a hardware store. A maximum pressure of 25 pounds can be applied without any danger.

If skipped stitches continue to be a problem even after the presser foot bounce is eliminated, the hook timing is probably out of adjustment. If the hook is too far from the needle or is too far advanced or retarded in its rotation, the loop of the thread at the needle will be missed and no stitch will be formed. The proper relationship between the hook and the needle eye depends on the type of machine.

Sewing machine timing is accomplished in two steps. First, set the height of the needle bar and then adjust the rotation of the shuttle hook so that it passes the needle eye at just the right time.

The needle bar height is adjusted by loosening a single set screw that locks the bar in place. Oscillating bobbin machines usually have a hole on the inside of the arm through which a screwdriver can be inserted and seated in the set screw slot when the needle is at the bottom of its travel (Figure 4). Rotary bobbin machines (both types) use a set screw that is accessible from the front of the machine (Figure 5). Remember, the needle must be at the bottom of its travel.

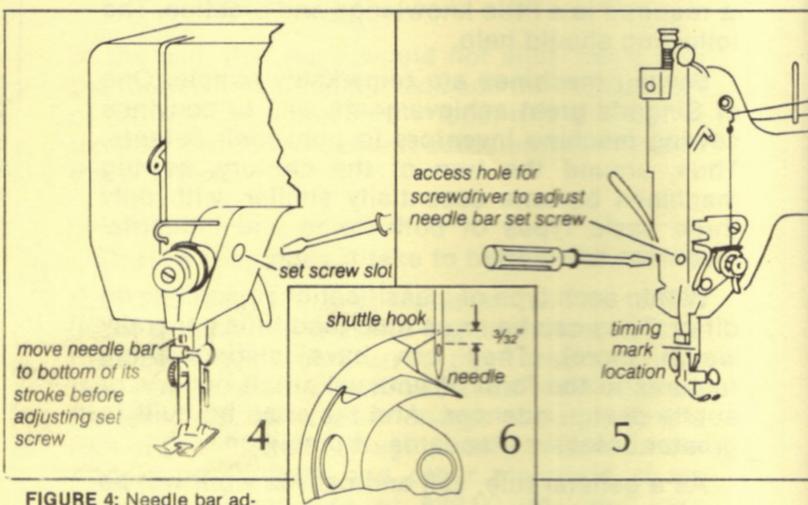


FIGURE 4: Needle bar adjustment in oscillating bobbin machine usually found on inside of machine's arm.

FIGURE 5: Needle bar adjustment in rotary bobbin machine usually found on front of arm.

FIGURE 6: Proper needle bar height for oscillating bobbin machine.

The proper height of the needle bar in an oscillating bobbin machine is found by measuring from the top of the needle eye to the hook when the needle is as far down as it will go. This distance should be 5/32-inch. Remove the shuttle race cover so that you can readily see the needle and the hook. (This cover comes off easily once two retainer clips are released.) Note that the hook is not yet behind the needle. When you rotate the machine until the hook is just back of the needle, the top of the eye should be 3/32-inch below the point of the hook (Figure 6).

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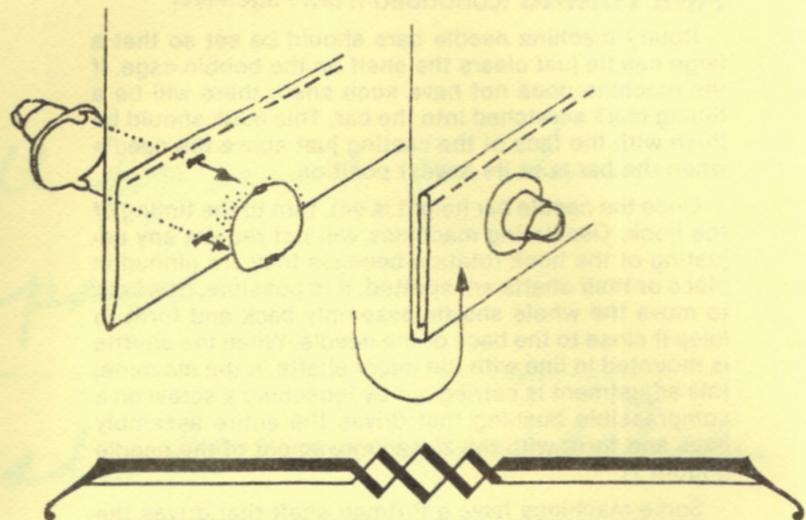
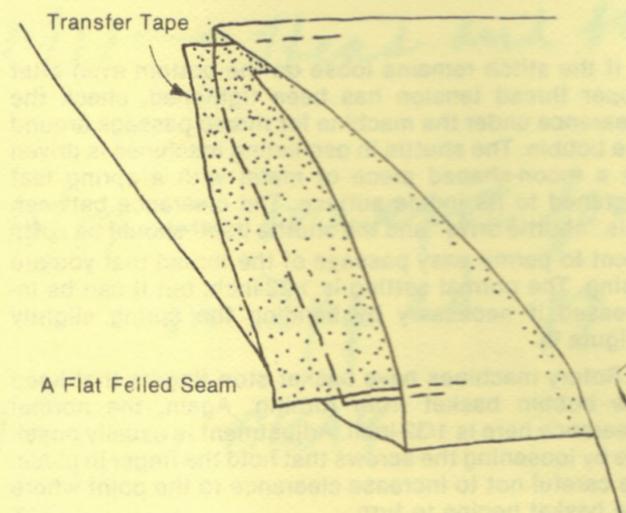
Please feel free to send any ideas that will be of interest to other readers. We will print as many as we can.

When common sense fasteners are used to close a sail cover or a foredeck bag, the back side of the male fastener will be exposed if the seam is closed face-to-face rather than overlapped. Some prefer the face-to-face closure, especially in the case of a foredeck bag, in spite of this drawback. But the cosmetic flaw can be corrected. A three-layer hem can be used to cover the offending metal.

Fashion a hem wide enough to accommodate the fastener with an extra half-inch or so of hem width. Do this by folding a single layer of fabric inside the cover. Sew it in place. Then install the male common sense fasteners so that they face in the wrong direction. The final step is to fold the fastener inside the cover. Its base is now inside this last fold and properly covered. Stitch the last fold in place with a row of straight stitches.

Note that this method of covering the fasteners requires an inch or so more cloth than the simple two-layer hem. Make sure allowance is made for that extra cloth.

There are folders available for quickly and accurately seaming spinnakers and other items that make use of a flat felled seam. They are expensive and require some skill to use them effectively. Linda Evison has devised a simple technique to accomplish the seam almost as quickly and as neatly without a folder. She bastes the seam together with transfer tape as a simple 1/2-inch overlap. Then she forms a "Z" of fabric with the basted portion forming the center slant of the letter. The transfer tape stiffens the material sufficiently to make accuracy possible. A row or two of stitches can then be put down each side of the seam. ▽

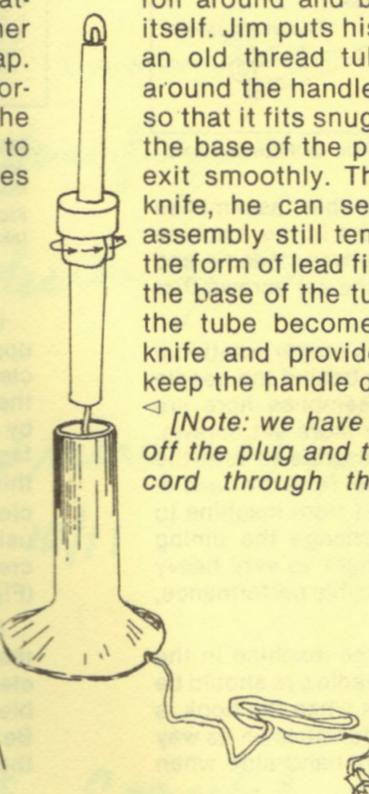


TIPS worth passing on...



Jim Shafer sent us a tip for a hotknife stand which we used in our last Sailwright Newsletter. Unfortunately we misinterpreted Jim's idea and described it totally wrong! His idea deserves to be put right.

Hotknives are a constant problem in the loft. Unless they are put aside very carefully, they can roll around and burn either the floor or the sail itself. Jim puts his knife handle first in the end of an old thread tube. He wraps some duct tape around the handle just in front of the blade guard so that it fits snugly. Then he cuts a small relief in the base of the plastic tube so that the cord will exit smoothly. Then, when he is done with the knife, he can set it on this solid base. If the assembly still tends to tip over, a little weight in the form of lead fish line sinkers can be taped into the base of the tube. An added advantage is that the tube becomes the gripping surface of the knife and provides enough extra insulation to keep the handle quite cool.



[Note: we have found that you may have to cut off the plug and then splice it after threading the cord through the neck of the thread tube.]

FINE TUNING (Continued from Page Five)

Rotary machine needle bars should be set so that a large needle just clears the shelf on the bobbin cage. If the machine does not have such shelf, there will be a timing mark scratched into the bar. This mark should be flush with the face of the casting just above the needle when the bar is at its lowest position.

Once the needle bar height is set, turn to the timing of the hook. Oscillating machines will not require any adjusting of the hook rotation because they are pinned in place or their shafts are spotted. It is possible, however, to move the whole shuttle assembly back and forth to keep it close to the back of the needle. When the shuttle is mounted in line with the major shafts in the machine, this adjustment is carried out by loosening a screw on a compressible bushing that drives the entire assembly back and forth with the zigzag movement of the needle (Figure 7).

Some machines have a Pittman shaft that drives the bobbin assembly back and forth. Here the screw that locks the Pittman on its shaft should be loosened (Figure 8), then light taps will move the assembly in either direction. Get the hook as close to the needle as possible without actually touching it. Once adjusted, it will remain constant even when larger or smaller needles are used.

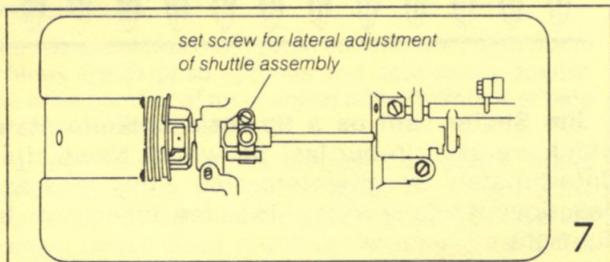


FIGURE 7:
Adjusting shuttle drive mechanism in axial shaft machine (oscillating type) to set hook timing.

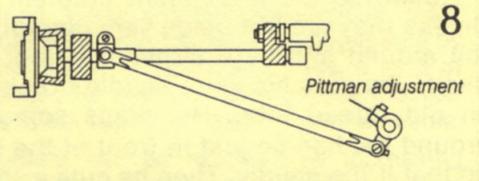


FIGURE 8: Adjusting shuttle drive mechanism in Pittman shaft machine (oscillating type) to set hook timing.

In oscillating machines with bobbin assemblies mounted transversely, the main shafts in the machine can be adjusted for the clearance between needle and hook in the same way by loosening the set screws that lock the assembly to the short shaft.

Rotary bobbin hook timing requires proper rotational orientation as well as the positioning behind the needle eye described above. The hook assemblies here are usually secured in place with two or more set screws. Loosening these screws makes it possible to turn the hook as well as move it closer or farther from the needle. The rotational timing here varies a bit from machine to machine; often it is necessary to change the timing somewhat when moving from very light to very heavy fabrics in order to obtain the best possible performance, so don't be reluctant to experiment.

As a general rule, however, with the machine in the straight stitch mode, the top of the needle eye should be 3/32-inch below the point of the hook when the hook is just behind the needle and when the needle is on its way up. If the machine skips on the right-hand side when

zigzag stitching, the hook should be retarded. If the skips are on the left, the hook should be advanced. Note, however, that a counter-clockwise hook rotation is assumed here. If the machine hook mechanism rotates clockwise, these directions should be reversed.

Once the machine is set up to sew without skipping stitches, it may still be necessary to make adjustments to improve stitch quality. The primary problem when using a heavy thread in a home machine is inadequate upper thread tension. Most machines have a limited upper tension adjustment: a knob on the front can be turned one revolution to compress a spring that squeezes two disks together. The upper thread runs through these disks.

The one turn limitation can often be overridden by pressing the "numbered ring" in and turning the knob past the stop at the same time. When the ring is released, the one turn limitation will remain, but it will be exercised at an increased pressure level.

Some new machines have no provision at all for upper thread tension adjustment. These machines use a "nipper" tension system, where pressure is tightened and released in time with the movement of the needle. Stitch quality will frequently be very poor in heavy fabrics when using these machines. If the machine cannot sense the thickness of the material, the stitch knot will be too close to the bottom of the cloth. The solution is to mount a normal, constant friction tension device. These devices are available at any sewing machine shop and can be easily mounted on the machine at any point ahead of the original tension device. Continue to thread the machine through the original tension device even after mounting the new one.

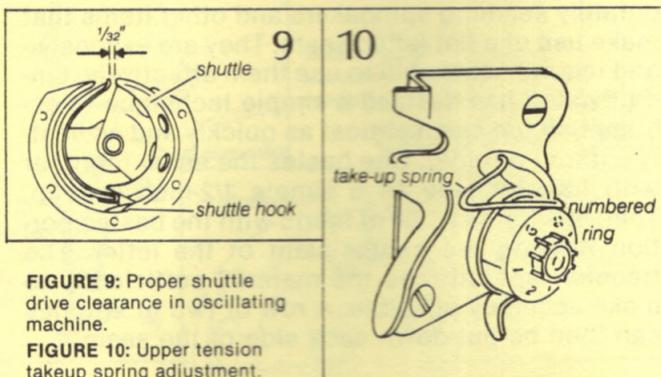


FIGURE 9: Proper shuttle drive clearance in oscillating machine.

FIGURE 10: Upper tension takeup spring adjustment.

If the stitch remains loose on the bottom even after upper thread tension has been tightened, check the clearance under the machine for thread passage around the bobbin. The shuttle in oscillating machines is driven by a moon-shaped piece of metal with a spring leaf fastened to its inside surface. The clearance between this "shuttle drive" and the shuttle itself should be sufficient to permit easy passage of the thread that you are using. The normal setting is 1/32-inch, but it can be increased if necessary by bending the spring slightly (Figure 9).

Rotary machines have basket stop fingers that keep the bobbin basket from turning. Again, the normal clearance here is 1/32-inch. Adjustment is usually possible by loosening the screws that hold the finger in place. Be careful not to increase clearance to the point where the basket begins to turn.

HIGH SPEED SAILS (Continued from Page One)

Note that I am not suggesting that total force will be higher; the force generated by a foil of given size is a constant, assuming all other variables are constant, but the same force can be generated by a small volume of air at high speed as by a large volume of air at a slower speed. High aspect ratio sails characteristically work with smaller volumes of air but at a higher speed than sails with low aspect ratios.*

High aspect ratio is not enough to make a sail efficient on a high-speed boat. The three-dimensional shape of the foil must also be appropriate. Obviously the sail must be relatively flat. Flat sails generate less power than full ones but can be used effectively at lower angles of incidence to the wind and operate effectively at higher speeds than fuller sails.

The appropriate depth for any given sail is not easily determined apart from experience. The weight of the boat, the size of its rig, the shape of the hull(s), the water and wind conditions on a given day, even the helming technique of the skipper—all of these play an important role in determining the proper fullness for the sails. As a general rule, however, it can be assumed that light, fast boats will be best served by sails of from 1/14 to 1/17 draft ratio, that is, for every inch of depth in the sails, they will be from 14 to 17 inches in chord.

There is a second aspect of three-dimensional shape. The depth of the sails must be in the proper place. High-speed sails always benefit from draft's being farther forward than "normal." This forward draft can be conceived as working with air that is moving at speeds

*This discussion is somewhat simplified. If you are interested in more detail, see C. A. Marchaj, *Sailing Theory and Practice* (N.Y.: Dodd, Mead & Co., 1964), pages 84-88.



The machine should now be performing fairly well, but there is one final adjustment that can put the finishing touch on stitch quality. Most machines with a friction upper tensioning device also permit adjustment of the takeup spring (Fig. 10). In normal use the spring should tension the thread until the point of the needle hits the fabric. For super-light material, it is helpful to move the spring so that it relaxes sooner. For heavy material, it should be moved so that it tensions the thread until well after needle penetration. The manner of adjustment will vary a bit from machine to machine, but it is generally easy to perform.

With these techniques in hand almost any home sewing machine can be used for sail repair. Doing this work has advantages far beyond the money saved. It provides a confidence and satisfaction that come from self-reliance, and it is surprisingly easy to move from simple repair work to recutting to sailmaking itself. Each step in this progression is an important step on the way to becoming a better sailor.

close to those in the free stream. Chances are that air will also still be moving smoothly in a boundary layer flow. Aft draft may result in the sail's affecting more gross volume of air, but it is accomplished only by slowing and disturbing the air flow to such a point that potential speed to be derived from the sail is much reduced. Unfortunately, just as in all mechanical devices, an increase in power requires a decrease in potential speed.

The cat rig is capable of higher speeds than a sloop rig.

So, the faster the boat, the farther forward draft should be moved. This can be carried to an extreme, since the entry curve for high-speed sails should also be very rounded. A rounded entry curve or leading edge tends to reduce stalling tendencies. This does not directly lead to increased speed potential, it is nevertheless necessary with high-speed boats since they are generally very light. As a result, they are hard to maintain on a constant course. In addition their rapid acceleration or deceleration leads to rapid change in the apparent wind directions. All of this requires a sharply rounded leading edge in their sails.

Cat Rig and Battens

Finally, consider the rig appropriate for these high speed boats. You will have noticed that most high performance catamarans have a cat rig. This follows from our discussion of aspect ratios. The sloop rig tends to spread sail area out, in effect, decreasing aspect ratio. That sloop rig will make possible more power, but it will cut down the potential speed of the boat. If the boat is so easily driven that this power is not required in order to get it moving, it is best to place all sail area in a single, tall sail.

One more thing: high speed sails should have full-length battens. These battens are tied into the sail with enough compressive force to bend them into the desired shape. As a result, the sail becomes so rigid that the sail must be "popped" from one side to the other when the boat is tacked. This rigidity holds the sail in shape in spite of rapid acceleration and deceleration and in spite of the abrupt apparent wind shifts which accompany those changes in speed.

The rigidity imparted by the battens also lets the sail operate at higher angles of incidence than would otherwise be possible (see Marchaj's *Sailing Theory and Practice*, page 70). Once again, this can be very useful on a boat that moves the apparent wind well forward just because its own speed is so high. The power developed by such a sail will be relatively low, but its potential speed will be very high.

There are, in conclusion, no secrets in the building of high-speed sails. They are simply the result of extending the same lessons we have learned with "normal" sail design.



A RULE FOR BROADSEAMING

Broadseams are very important in the construction of modern Dacron sails. The fabric stretches so little that a good deal of the shape in such sails must be built in by the sailmaker. Broadseaming is the technique used to accomplish this. It is used by sailmakers just as darts are used by dressmakers.

Indeed, the accuracy and the degree of broadseaming used in sailmaking are just as important to the sailmaker as the proper installation of darts is to the dressmaker. The depth or "draft" of the sail, its location, and the actual shape of the foil—all three are heavily influenced by broadseaming. That influence with regard to the first two parameters, draft and its location, are rather easily understood—the amount of broadening and the point at which it is initiated have an obvious impact upon them. But the influence of broadseaming on sail shape is not at all clear, and very few sailmakers have established any rules of thumb regarding it. Most of us are simply building sails with broadseams that look good to us. I want to develop some rules here that will make it possible for the oldtimers to reproduce more easily their winning sails and for the newcomers to avoid some costly errors which, heretofore, were the heart of what we all call experience!

The source of these rules is a "spline curve" formula. It is not necessary to understand the mathematics in order to use it, but I want to discuss it for the sake of those who have a mathematical bent.

The formula is: $y = Cx^2(Dx + 1)$

where y is the percentage of offset at the point x along the length of the broadseam. That percentage is expressed in terms of the maximum width of the broadened part of the seam—its excess width over normal seam width. C and D are constants computed from a model broadseam length and maximum offset along with a desired offset at a point one-half of the total length of the broadened part of the seam. Given the length of a representative broadseam and its width—let's use 30 inches and 1/2-inch (many of you will recognize a common broadseam suggested in the **Sailrite Manuals**)—almost any broadseam curve can be put down. If we specify the depth of the broadened part of the seam at the halfway point—let's say it is to be 25% of the total width at that point—then there is only one curve that can be put down joining the three points indicated, the point of initiation, the mid-depth point, and the point of maximum depth.

C and **D** define the unique curve that will fit the three points for any given broadseam. These two constants are calculated as follows:

$$D = (R - .25) / (.125 - R)$$
$$C = y_1 / [(D + 1) \times (L_1)]$$

where R is the mid-point offset as a fraction of the maximum width of the model broadseam; y_1 is the maximum depth of the widened part of the seam in inches; and L_1 is the length of the model broadseam.

Let's assume the model broadseam above: 30 inches long, 1/2-inch wide at its maximum, and 25% deep at its center. D will equal 0 and C will equal .0167. If the same model curve were measured at three other points, the results would be the same. Thus, if the model seam were 60 inches long with a 1 inch width and a 25% mid-depth, D and C are still 0 and .0167. That is why they are referred to as constants that define the curve represented by the model.

Now let's proceed to use these constants to determine the proper offset at any point along a broadseam of any length. To do that, we must return to the initial spline curve formula and modify it slightly to introduce the impact of the variable "length":

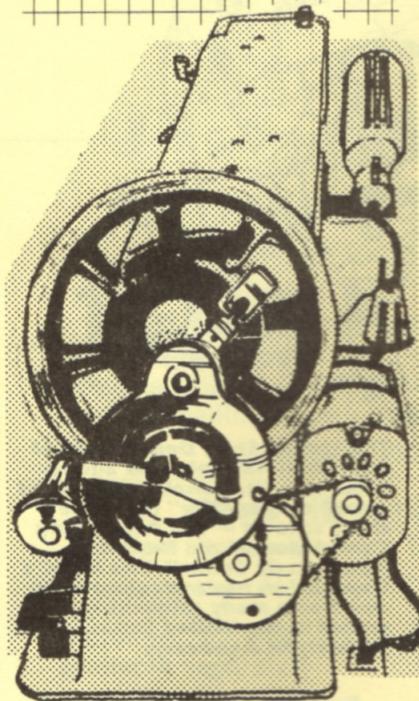
$$y = Cx^2 [(D(x/L) + 1) / L]$$

If we want to know the width in inches of broadseam 60 inches long with a maximum width of one inch and a center offset 25% of maximum, we put 60 in the place of L in the above equation and the distance from the beginning of the broadseam in the place of x . Thus, at six inches the offset is .01 inch; at 12 inches it is .04 inch; at 18 inches it is .09 inch, etc. Note that we are stepping along the broadseam at intervals one-tenth the length of the seam—the resulting answers are thus equal to percentage offsets at one-tenth stations along any comparable broadseam since the maximum offset here is unity. These percentages will remain constant at one-tenth stations for that broadseam curve no matter what the length of the seam.

Thus it is possible to set up tables to guide those who find these calculations tedious:

STATIONS ALONG SEAM	10% at Center	15% at Center	20% at Center	25% at Center	30% at Center	35% at Center	40% at Center
1/10	0%	.2%	.6%	1.0%	1.3%	1.7%	2.0%
2/10	.1	1.4	2.7	4	5.2	6.5	7.8
3/10	1.4	3.9	6.4	9	11.5	14	16.5
4/10	4.4	8.3	12.1	16	19.8	23.6	27.5
5/10	10	15	20	25	30	35	40
6/10	18.7	24.4	30.2	36	41.7	47.5	53.2
7/10	31.3	37.2	43.1	49	54.8	60.7	66.6
8/10	48.6	53.7	58.8	64	69.1	74.2	79.3
9/10	71.2	74.5	77.7	81	84.2	87.4	90.7
END	100	100	100	100	100	100	100

Move'em out!



407
5003



We consider the broadseam curve that is 25% deep at its center "normal," but the table can be used to build sails with more flair in the broadseam by using curves with less fullness at their center or with less flair by using those curves with more fullness.

CONNIE'S CORNER

Some of you will remember a Sailrite Newsletter where Connie gathered together all the discontinued and shop-worn items and offered them for sale at very **low** prices. This section of the Fabric Foils is an outgrowth of that. We will use it to keep you informed of the miscellaneous items which we want to get off our shelves.

It is also a good way for you to do the same. Classified ads are **FREE** for current subscribers. The ads are subject to editorial selection and space availability. They are limited to one-of-a-kind opportunities and small lot sales. Standard commercial products are **NOT** eligible.

Free ads are limited to a maximum of 50 words. The only payment is your current **FABRIC FOILS** mailing label to verify your subscriber status. Photos of items for sale are also printed free — space permitting. Just submit a clear black and white photo along with your ad copy.

The deadline for ads is the 15th of November, February, May, and August. The issues will appear two months after these closing dates, in January, April, July, and October.

Sailwright Sailmaker Sewing Machine. An unused machine damaged in shipment and now repaired with completely new parts. This is a model 651 machine (model prior to current 652). Equipped with new two-speed drive. White oak case is slightly scratched. \$795 plus UPS shipping in two boxes. Charge cards acceptable or we ship freight collect. Sailrite Kits, Route 1, Columbia City, Indiana 46725. Phone (219) 244-6715.

Nylon Backpack Netting Seconds in Charcoal. Great for "drying" bags and hammocks. Strong but not suitable for trampolines since nylon sags when damp. Flaws primarily in the color. \$2.49/yd. (44 inches wide). Sent postpaid in quantities of five yard or more. Sailrite Kits, Route 1, Columbia City, Indiana 46725. Phone (219) 244-6715.

EZ Splice Kits. Tools and instructions for splicing 5/16-inch braid-on-braid or 1/4-inch hollow braid line. Discontinued item. \$1.45 each, sent postpaid. Sailrite Kits, Route 1, Columbia City, Indiana 46725. Phone (219) 244-6715.

Write to Connie Grant,
Whitley County Publishing, Inc.,
Route 1, Columbia City, Indiana
46725.

Stablekote III Seconds. Often called 3/4-oz. ripstop nylon spinnaker cloth. Lots on hand. Surprisingly good condition. Rolls often less than five yards; some flaws in color. Give color preferences but don't hold us to them since we cannot order in colors when supply is exhausted. 40 inches wide. \$2.45/yd., sent postpaid in quantities of five yards or more. Sailrite Kits, Route 1, Columbia City, Indiana 46725. Phone (219) 244-6715.

Adhesive-Backed Numbers. Old stock in assorted colors, sizes (red, black, blue, 10" 12" 18" high). Outmoded by new Dacron insignia material but perfectly usable. Some numbers vinyl, some ripstop nylon, some even new Dacron fabric but in off shades. Give us color and size and number preferences; we'll fill order as necessary with stock on hand. \$2.00/12 numbers, sent prepaid if 12 or more numbers are ordered. Sailrite Kits, Route 1, Columbia City, Indiana 46725. Phone (219) 244-6715.

Rope. Dacron and nylon rope in assorted types (braid, 3-strand, prestretched) and sizes (1/8, 3/16, 1/4, 5/16, 3/8). Roll ends (generally less than 10 feet long) and stained or otherwise flawed pieces. \$1.50/lb, sent prepaid in quantities of three pounds or more. Sailrite Kits, Route 1, Columbia City, Indiana 46725. Phone (219) 244-6715

Learn Sailmaking at Home

Sailmaking has always been taught through apprenticeship. It is an art, and the teaching of any art requires personal interaction which apprenticeship makes possible. Traditional apprenticeship has some real disadvantages. It requires a full-time commitment over an extended period. Apprentices often complain that they are trained in particular tasks and left to perform just those tasks, and as a result they may not learn the work completely.

The **SAILMAKER'S SERIES** retains all that was good in traditional apprenticeship but does so without the disadvantages. Students work under the direct supervision of Jim Grant.

Grant, who has a Ph.D. in Political Science from the University of Chicago, is recognized as Master of the Sailmaking Art. He founded Sailrite Kits in 1970 to make material and instructions in sailmaking more widely available. His five manuals on sail construction have become classics and are used by sailmakers everywhere. Even the largest, most respected lofts like Ratsey and Lapthorn, Hood, and North make use of the books to train new employees. These books are excellent texts for professionals working in a loft and are satisfactory for individuals building just a few sails for personal use. To teach the art of sailmaking properly, however, there must be an interaction between student and master...and this is the purpose of the **Sailmaker's Series**.

The Series is the first attempt to teach sailmaking in a carefully structured and organized way. This instruction is not compromised by any requirements of production efficiency. Moreover, it is possible for students to move at their own pace through the material. Indeed students can even decide for themselves what level of expertise they wish to achieve. The Series is divided into four units.

Unit One: Sail Design

UNIT ONE of the Sailmaker's Series provides a thorough introduction to sailmaking, defining terms, setting forth principles, and developing techniques. Practical skills are also introduced—several scale model sails are constructed during the work. This series of ten lessons will convey a complete knowledge of sail design and construction that will make any skipper a better sailor, laying the groundwork for actual sail construction which begins in Unit Two.

Lesson 1 / The Words and Measures of Sailmaking: An introduction to the unique terminology employed by sailmakers. Organized to make a useful reference tool.

Lesson 2 / Sailmaking Fabrics and Materials: This section starts with a review of sailmaking in the recent past and moves to a detailed consideration of modern sail fabrics and hardware.

Lesson 3 / Sewing Techniques: Covers the principles of sewing machine usage in sailmaking, sewing machine repair and adjustment, as well as hand sewing techniques.

Lesson 4 / Mainsail Design and Construction: A complete study of the mainsail, moving from design considerations, such as aspect ratio and roach width, to construction details, such as boltrope attachment and broadseaming techniques.

Lesson 5 / Jib sail Design and Construction: Structured like Lesson 4 but focused on headsails and the design parameters peculiar to them. Emphasis is on draft needs and draft placement in sails.

Lesson 6 / Spinnaker Design and Construction: Covers bloopers as well as horizontal cut, radial, spherical, star cut, and tri-radial spinnakers. Effects of cloth stretch are analyzed.

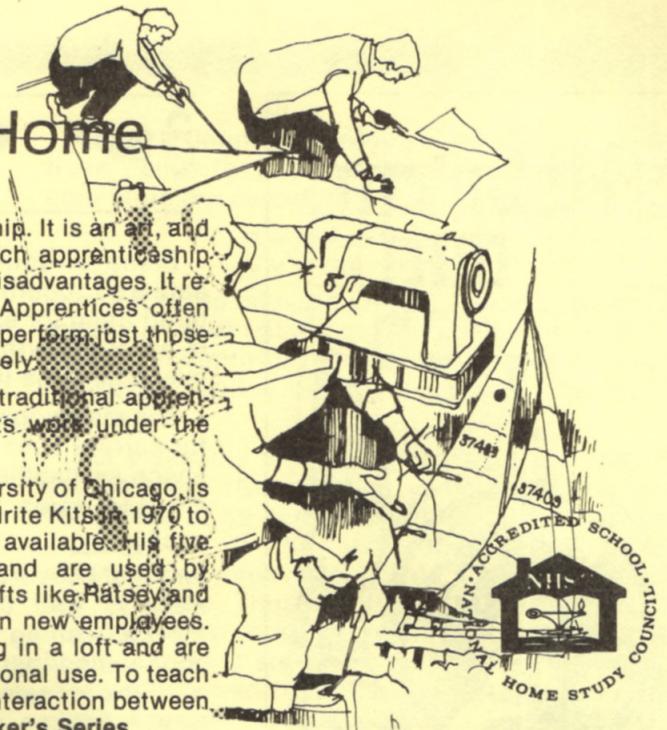
Lesson 7 / Staysail Design and Construction: Here the primary focus is on the theory of sail interaction. Design and construction of six distinct staysail types is considered in the light of this theoretical grounding.

Lesson 8 / Stormsail Design and Construction: Strength and seaworthiness in stormsails are the primary objectives emphasized in Lesson 8.

Lesson 9 / Sail Repair Work: The maintenance of sails from a sailmaker's point of view is presented here.

Lesson 10 / Canvas Work: Sail covers, boat covers, bags, awnings, dodgers, weather cloths, and many other projects, spelling out principles of construction.

Upon completion an Apprentice Sailmaker's Certificate will be awarded.



The United State Department of Education has only one agency listed as a "nationally recognized accrediting agency" for home study schools — the Accrediting Commission of the National Home Study Council. The NHSC's Commission has accredited only one home study sailmaking school in the United States...our Sailwright Academy.

Enrollment Agreement for UNIT ONE of the Sailmaker's Series

Please enroll me in Unit One of the Sailmaker's Series. I understand that the entire tuition and materials fee is \$395.00. In addition to ten lesson books, supplies for the construction of model sails, ten assignment papers, and one final examination, this fee includes the following texts:

The Sailrite Sailmaker's Library	.....	\$25.00
The Sailrite Sail Repair Kit	.....	35.00
Marchal's Sailing Theory and Practice	.....	20.00
The Best of Sail Trim	.....	14.95
The New Canvas Worker's Library	.....	25.00

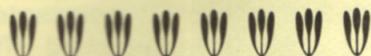
Students who own any of the texts listed above should deduct their value from the total cost of Unit One.

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PLAN A / I enclose \$100 as a non-refundable registration fee and agree to pay \$29.29 by the tenth day of each month to Sailrite Enterprises for 11 months or until the total payments (including registration) amount to \$395 plus interest (annual interest rate is 18%; total payment if the full 11-month term is used will be \$422.19). Prepayment without charges is permitted and will reduce interest charges by the Rule of 78.

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<input type="checkbox"/> The Stormsail Manual	\$7.95
<input type="checkbox"/> The Spinnaker Manual	\$7.95
<input type="checkbox"/> The Jibsail Manual	\$7.95
<input type="checkbox"/> The Sail Repair Manual	\$6.95
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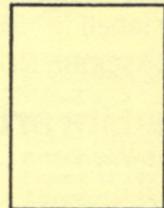
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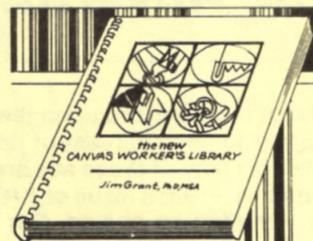


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These are simply the best texts on sailmaking available. No effort is made to simplify the subject, yet the instructions are well organized, well illustrated, and detailed, so that almost anyone will find sailmaking within grasp. Whether the goal is actual construction of sails or just better understanding of the sailmaker's art, these books make it possible.



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All five of the manuals above by Jim Grant, Ph.D., M.S.A., and the Sailmaker's Catalogue in a convenient and attractive box.

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The 1982 Sailmaker's Catalogue presents the finest collection of fabrics, tools, and instruction materials for the serious sailmaker, amateur and professional alike. We are proud of our offering and stand ready to help you...making your own sails **is** one of life's satisfying experiences. We are only as far away as the phone and available toll free. Give us a call: 800 348-2769. Or write: Sailrite Kits, Route 1, Columbia City, Indiana 46725. American Express, Master Charge, and Visa accepted.

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All the rules of thumb and theory concerning mainsail design and construction. A complete guide with numerous illustrations.

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Storm foresails,trysails, and Swedish mainsails are considered. These sails are vitally important on boats of 20 feet or more.

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Running spinnakers, reaching spinnakers, spankers, storm spinnakers, poleless spinnakers, and bloopers are considered in their distinct cuts (horizontal, star cut, radial, tri-radial, spherical).

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The Jibsail Manual

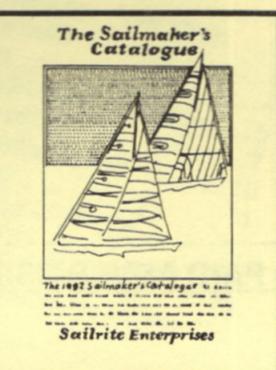
All about working jibs, genoas, topsails, mule jibs, drifters, and reachers. A complete handbook for those who want to build their own sails or who want to understand better those they have.

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Explains the use and adjustment of sewing machines as well as common hand-stitching techniques. The analysis of sail faults and the proper procedures for their correction are also completely described.

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The Advertising Game

Most of us depend upon the ads placed by sailmakers in order to keep abreast of latest developments. Unfortunately many of those ads are more misleading than informative. In each issue of **FABRIC FOILS** we will focus our attention on one ad. Our comments should not be construed as merely critical. Our concern is to unravel the meaning of the advertising prose; if it appears to have no meaning, we will say so. We will also do our best to decipher the import of any claims.

The September *Cruising World* features an ad by Hood for a cruising genoa "MPG" with an unusual cut. It has a radial head. The lower portion is also made up of gores that radiate from the clew. According to the ad, this sail has the following characteristics:

1. A 160% LP
2. Special low-stretch nylon sailcloth
3. Built-in shape that works in light air
4. Can be hanked on the headstay or set flying
5. Surprisingly affordable.

Let's consider each of these points in turn. The 160% LP is not unusual or even noteworthy. The point is that this is a big sail intended for light to moderate winds (from 1 to 15 knots).

We can be permitted some skepticism about the claim for the cloth. There have been no recent breakthroughs in fabric technology. Chances are that this is the same nylon sailcloth used in sails built last year. But we believe that there is some reason for the claim given the unusual cut employed here. The radial clew and head will tend to take advantage of the inherent stability of the cloth warp. The sail will not

stretch so much as a similar nylon sail made up of crosscut panels.

The fact of the matter is that shape is built into such a sail just as the ad proclaims. It must be because there is so little stretch radiating out from the clew. This has an advantage, but it also has a disadvantage.

This cut will no doubt increase the useful range of the sail, but at the cost of some efficiency in light air and smooth water and when moving to windward. The standard crosscut pattern makes it possible to flatten the sail by moving the sheet lead aft. The stretch characteristics of the cloth are actually an advantage here. This flattening would not be possible with a radial clew and head. Perhaps that is why this sail is advertised as a "cruising" genoa.

The advertised ability to carry the sail hanked on the forestay or set flying should be qualified. Certainly light air sails can be cut to allow for a good deal of sag so that they can be set flying. But such a sail would function very poorly if hanked on the forestay. The design must assume one or the other method of flying the sail. If the sail is not designed thus and used in the prescribed manner, performance will suffer. The ad suggests more versatility than can be delivered.

All sail designs are compromises. This particular one is best suited to boats over 35 feet where the stretch in nylon light air sails can get out of hand and to those individuals who desire to cruise in a leisurely way, without concern for adjustments to sail shape. If the cut does not increase the cost of the sail over a normal crosscut (and that would seem to be the meaning of the last claim made in the ad), it would be a reasonable choice for some sailors.

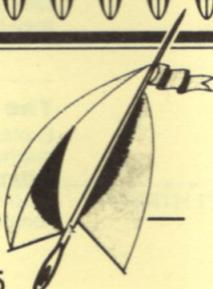
This is a rather decent ad. It may suggest more than can actually be delivered, but that is a characteristic of good ads.

16 / October 1982 / FF



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