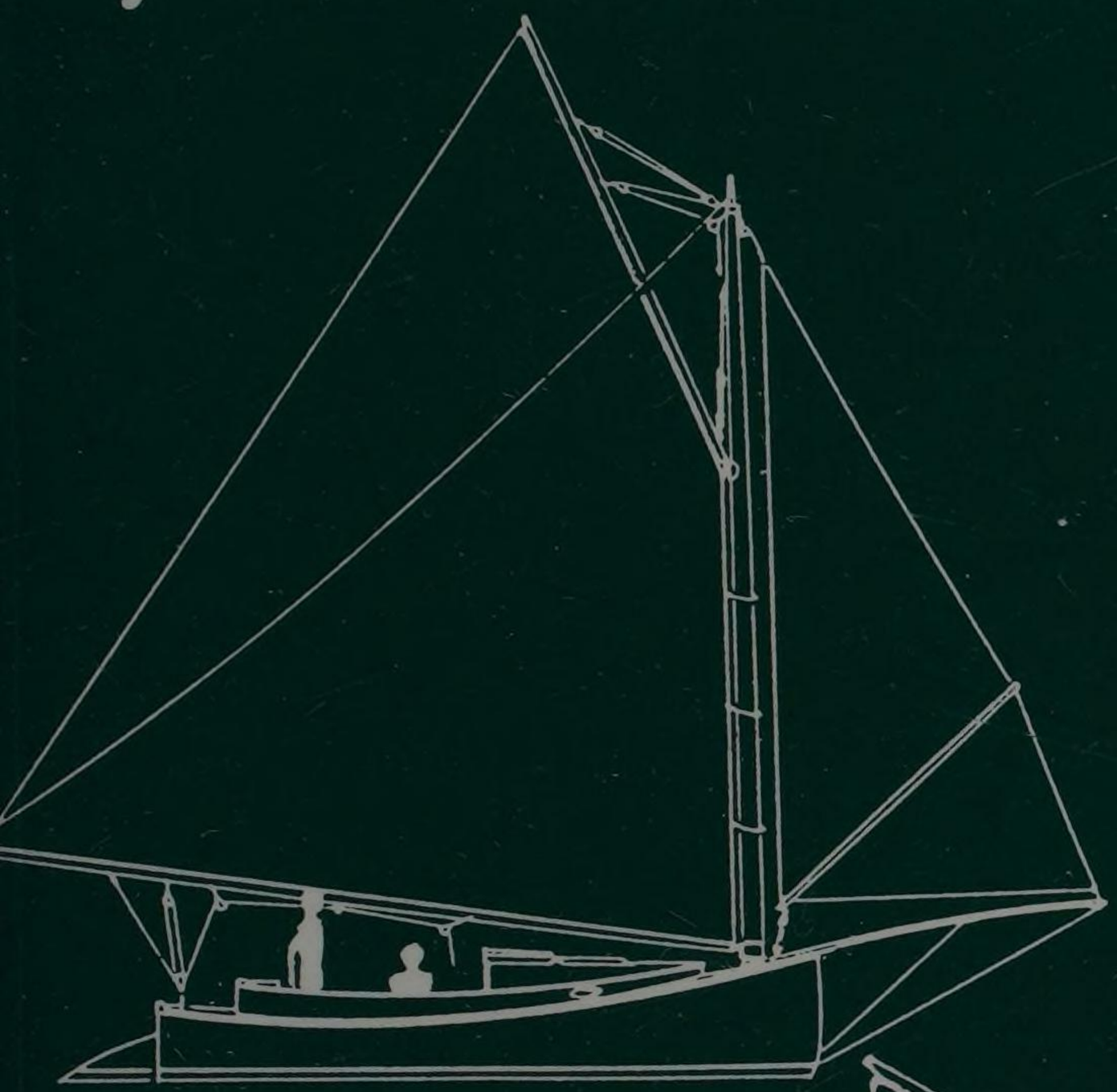
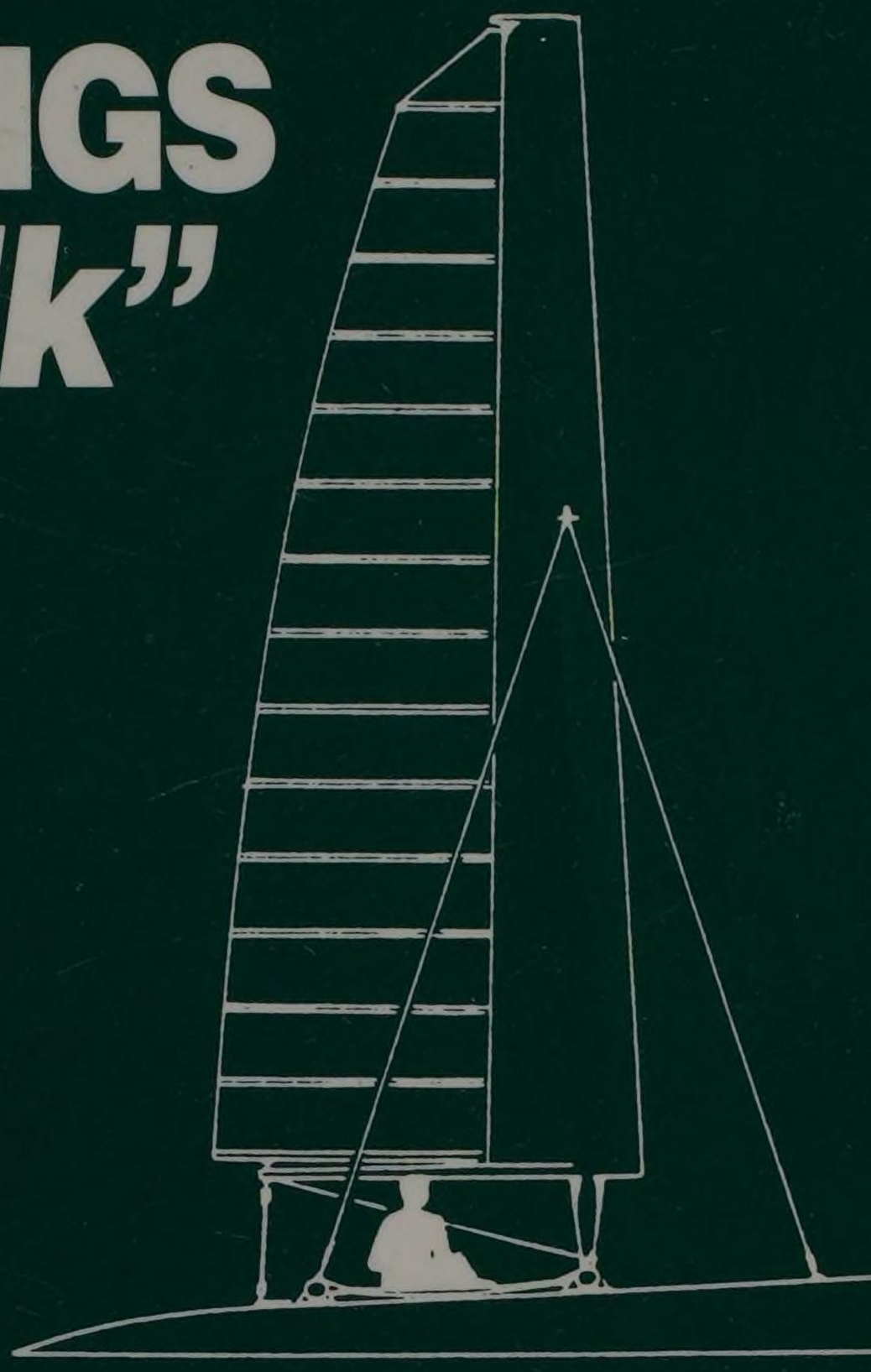
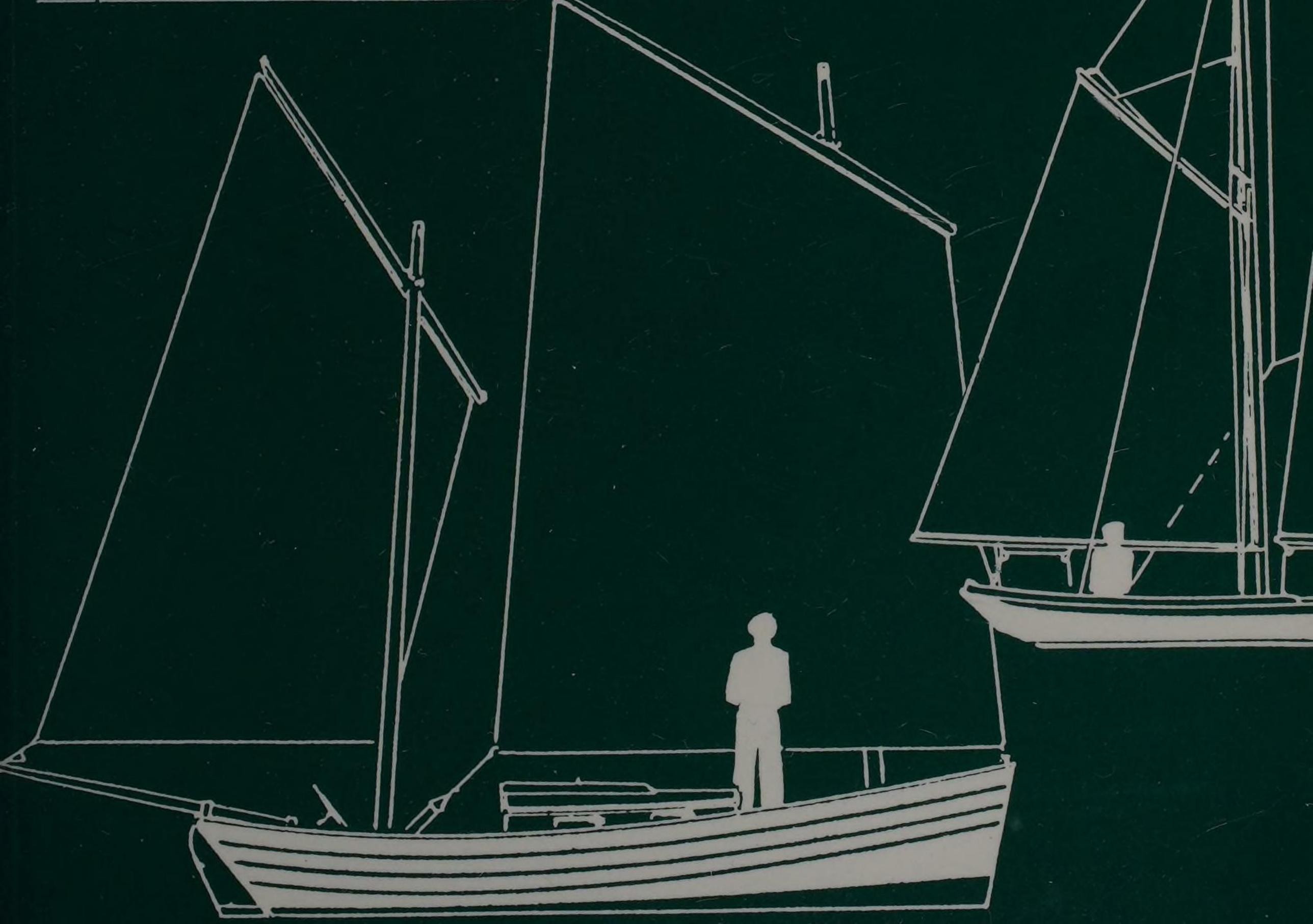
103 SAILING RIGS "*Straight Talk*"

by PHIL BOLGER







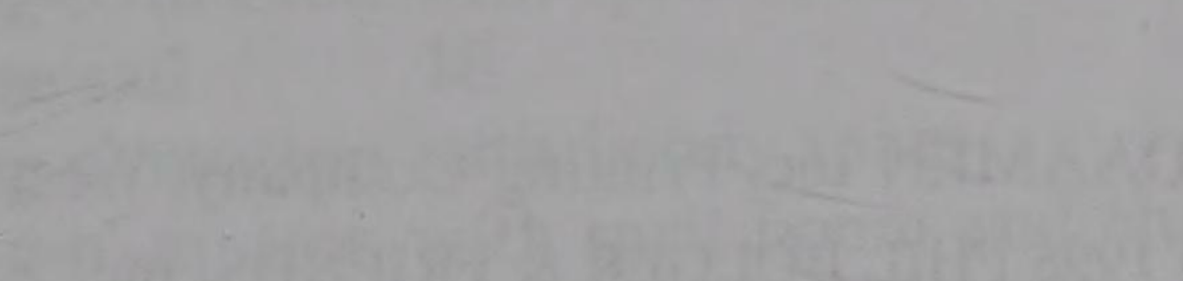
About the Author

Philip C. Bolger was born and still lives in Gloucester, Massachusetts. As a boy, he was constantly around small boats and, with his brother, was designing them as soon as he could hold a pencil. His professional career in boat design began with an apprenticeship to Lindsay Lord of Falmouth Forside, Maine. In 1952, he stepped out on his own and has since drawn over 650 boat designs, many of them unprecedented concepts which distinctly expand the horizon of boat-design.

In 1994 he married and went into partnership with Susanne Altenburger. Doing business under the name of Phil Bolger & Friends, their close cooperation in the design process builds on Phil's philosophy of rejecting both arbitrary 'rule' and generally unquestioned conventions. They see the point of their work in neither rehashing past ideas ad infinitum nor in indulging in dramatic concepts without realistic cost-benefit analysis. Due to their independence from the constraints of the 'mainstream', they are able to draw designs that are worthwhile doing, that are economically and ergonomically defensible, and usually push the state-of-the-art further towards rationality. As part of the effort to present the public a much broader scope of options in boat-design, they are publishing books of their designs with candid commentary and full study drawings. Look for their work and related sites on the web.

103 SAILING RIGS
"Straight Talk"

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PHILIP C. BOLGER

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PREFACE

There once lived in Newburyport, Massachusetts, an eccentric character who called himself Lord Timothy Dexter. He published a book with no punctuation. At the end he added a full page of periods, commas, semicolons, colons, exclamation points, question marks, and hyphens, so readers could "pepper and salt it as they choose."

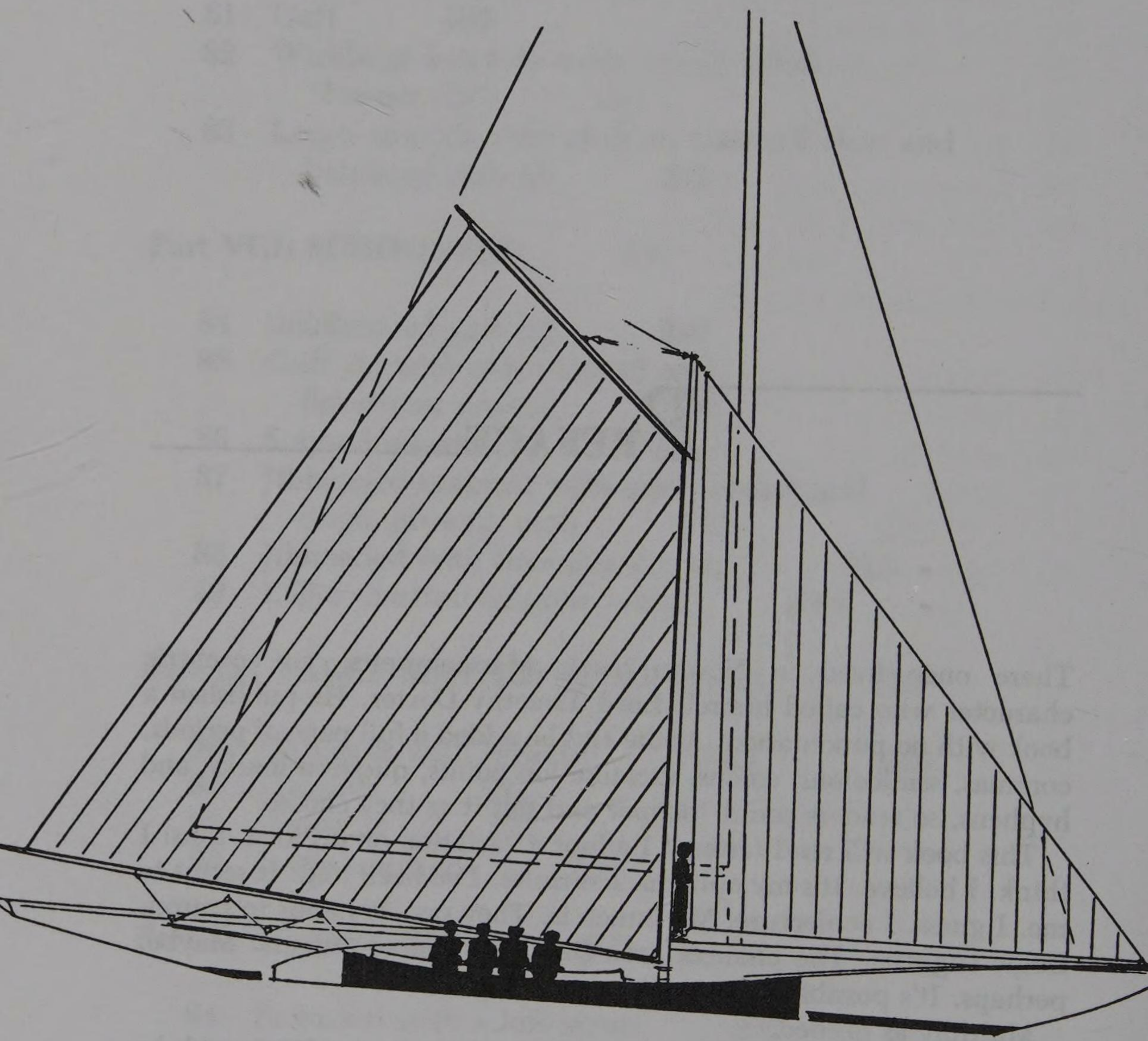
This book will read faster if I adopt a variation on his idea, thus: I think. I believe. It's my opinion. I surmise. I've been told. It seems to me. I guess. I conjecture. My hunch is. They say. It stands to reason. Logic suggests. The chances are. Qualified people tell me. Maybe, perhaps. It's possible.

Multiply as needed.

No glossary is furnished. I don't think any word is used that can't be found correctly defined in *Webster's New International Dictionary*, unabridged. The second edition was used for checking.

I'm told, though it's hard to believe, that there are individuals, even households, that don't possess an unabridged dictionary. Such people ought to put a higher priority on the dictionary than on a boat. An unabridged dictionary would be my first choice for the proverbial desert island library.

Each of the cartoons that follow represents a possible boat, but none was carried beyond the bare concept. There are no more plans for any of them. The two scales on the cartoons are, roughly, feet and meters.



INTRODUCTION
Crude Aerodynamics

A thousand cubic feet of air weighs about 80 pounds; more if it's cold, less if it's hot. That's the contents of a room 12 feet by 12 feet by 7 feet. It doesn't take a large sail to affect that much air. If that air is moving 10 or 20 m.p.h., it will exert a strong push against anything that interferes with its motion.

A sail at right angles to the wind and allowed to move directly downwind functions by briefly slowing the motion of the air that impinges on it. I suppose the first sail was a leafy bough held up to speed a log raft on its way, perhaps up the Nile. (It would have been a palm frond in those parts.) An air mass strikes the sail, and is stopped by it. More air piles against the first mass, pressing it harder against the sail. Pressure builds up, highest in the center. The high pressure squeezes the air out toward the edges, against the moving streams of air beyond the edges. When it spills past the edges, it is pushed back in to the low-pressure volume on the lee side. The reversal being abrupt, it can't make the turn smoothly, and a zone of eddies results. The eddies are aimless and unpredictable. "Big whorls have little whorls, which feed on their velocity, and little whorls have lesser whorls, and so on to viscosity." They don't form the cone-shape on the lee side of the sail you might expect. They surge around, and the surges have momentum that can carry the turbulence well out beyond the edges of the sail.

These surges represent shifts in the pressures on the sail, and are one reason downwind sails produce wild steering.

The spinnaker, squaresail, or palm frond works by slowing down the movement of air. The air moves laterally as it works its way around the sail, but the lateral movement is in all directions equally. The boat moves in the same direction that the air mass is moving. Picture a shallow, gently rounded scow hull with her centerboard and rudder fully hoisted. She skates straight down the wind, not necessarily bow first.

Drop the board and point her somewhat to one side of straight downwind. She moves off at an angle to the wind. The wind now strikes the sail at an angle and the pressure is relieved more to one side than the other. The passing streams are influenced more on that side. What's happening now is that the airstream is not just slowed down, but shoved to one side. "To every action there's an equal and opposite reaction." The boat is shoved the other way. The greater the weight of air the sail can force out of its straight course, the harder the boat will be pushed the other way.

A flat plate at an angle to the wind will move the air to one side, but less than a curved plate will. The air going around the sharp, upwind edge breaks into eddies on the lee side. The eddies move along to the downwind edge, but not with the force of a smooth stream. Less weight of air is diverted a shorter distance by the eddying action than by the stream. This is the "stall" that causes airplanes to lose half their lift and drop out of the sky.

A curved plate can be turned to bring its upwind edge straight into the wind's eye. This way there's nothing to start eddies, the stream is smooth on both sides, and a large weight of air is diverted. The curve has to be suited to the speed of the moving air; if it's too sharp for the speed, the pressure from the lee side won't be high enough to maintain the smooth flow, and there'll be turbulence over at the lee edge that, again, takes away some of the momentum of the stream. If the curve is too gentle and the sail is too flat, the flow will be smooth, but the air isn't moved out of its natural path as much as it could have been; more or less potential force is wasted.

Notice that sails are free to assume the exact angle that makes the sharp edge split the wind. Wings are not free to take up the right angle. They have to develop a minimum force to support the weight of the machine. At low speeds, the sharp-edged, curved plate isn't diverting enough air to support the weight, and if the angle to the wind is increased, the edge no longer splits the wind smoothly. An eddy starts at the edge and spreads along the top (lee or low-pressure) side. The wing

suddenly loses lift, just when it needed more. That's why airplanes have thick, smoothly rounded leading edges on their wings. A few airplanes do have almost sharp leading edges because the sharp edge slows them down less at supersonic speed, but such planes are liable to drop like rocks without warning.

A centerboard or bilgeboard, or a keel apart from its ballast function, is analogous to an airplane wing. It has the same problem; at low speed, when the designer would like to have it small to reduce the surface friction, and working at a small angle to reduce the head-on resistance, it needs to be big and to work at large angles to keep the boat from making leeway.

Sails are different. The angle of the airflow can always be perfect if enough trouble is taken. If a sail were the smooth, curved sheet used in diagrams, it would never generate turbulence.

(I speak of the flow as smooth, but actually it's almost never perfectly so. There's usually a thin layer of eddies right against the surface even when the mass of the stream is flowing smoothly. In flow past small, smooth objects of certain shapes, it's possible to have what's called laminar flow, in which there's no turbulence at all. That results in extremely low drag, but it's hard to produce and unreliable when you get it. There are a few types of light airplanes that produce laminar flow and can lift amazing weight for their power, but they won't lift nearly as much if they get dusty or wet. That's all it takes to spoil laminar flow. It's worth mentioning because small test models often have it simply because they are small. When they do, the test results are highly misleading because the full-sized boat won't have it. I surmise that the disappointments with some sailing foilboats were due to the test models performing beautifully with laminar flow.)

In the real world, most sails are working partly stalled. They're not curved correctly, or trimmed just so. They have their flow spoiled by spars or by the boat pitching and rolling. They work nevertheless, though not as well as they no doubt do in Paradise. A stalled sail is getting little use out of the eddies spinning away from its lee side, but the weather side is working with positive above-atmospheric pressures and it's not so sensitive. It will generate a strong stream, divert a substantial weight of air, and drive the boat.

The longer the edge of the plate that is splitting the wind, the larger the affected volume of air will be. Making the plate broader will move the air a greater lateral distance and turn it through a larger angle. On a given length of edge, diminishing returns set in quickly as the plate is made broader, because the air running over the lee side will tail off in eddies

and lose power. Length of edge is limited by the stability of the boat, and by the difficulty of making a very long plate hold the desirable curve and angle to the wind. Breadth is limited only by considerations of control and behavior in bad conditions.

In most racing rules, area is limited or penalized indiscriminately, creating confusion about what is "efficient." Inefficient rigs result from slipping into habits of arbitrary comparison. If a large sail can be designed that is cheap, easy to handle, and has little heeling effect, it's more efficient than a small sail that's expensive, hard to handle, with large heeling effect, even if they have the same power to drive the boat.

The history of driving boats with sails amounts to a series of improvements that started the first time a boat slanted away from a course straight downwind. After cosmic ages, the possible choice of courses grew to 180 degrees, with the boats able to move at right angles to the wind. Now we've reached the point at which a boat that can't choose her course through an arc of 270 degrees is not respectable, and there are some that can do quite a bit better than that. More learned people than myself have trouble explaining how the wind can be made to drive a boat back at itself, and the diagrams they produce don't seem to help much. Years ago there was an interminable discussion of this in the correspondence pages of the British magazine *Yachting World*. It went on for years, the general tone of each letter sounding about thus: "The matter is really quite simple, if only all your other correspondents would stop obscuring it with their unsound theories and confusing examples."

The obscurity lies in the invisibility of the forces generated by the various air pressures. It clears up somewhat if you stop worrying about what the air is doing, and why, and concentrate on where the force is being transmitted to the hull. To be told to "get a small pull on the jenny sheet" is to get a vivid lesson in what kind of force is moving the boat. There it is, leading away from the turning block on the lee rail, bar-taut and trying to uproot the winch from the deck. The arrows of force dragging the boat along are as clear to the eye as if there were a towboat on the other end instead of the clew of the sail. You don't have to know what kind of airflow and pressure pattern produced the pull on that line. You can feel it, and see the direction of it, at a glance.

The thrust of the boom against the mast is not quite as obvious, but it doesn't take a very elaborate experiment to convince anybody that it's there, and once its existence is noticed, the direction is clear enough. Those are the forces that are towing and pushing the boat upwind. It really is quite simple . . . .

If you want to complicate it, you can start listing other forces the rig is imposing on the hull. The mast at partners and chainplates and step is trying to twist the boat's feet out from under her. The slides and hanks on the luffs of the sails are pulling her backward and to leeward. The halyards and tack pendants are fighting each other. The sheets of the boomed sails are pulling the deck up or out to leeward, depending on the angle of heel. A lot of these forces can be seen to be canceling each other, but some are only canceled "equal and opposite" by the pressure of moving water against the boat's underbody. Every one can be felt working on some tangible part of the boat and clearly visualized.

I've never seen an attempt made to measure all these forces, put a vector arrow on each for magnitude and direction, and reduce the whole diagram to a final aggregate vector. It would be a fine exercise for some student. The result ought to be illuminating about helm balance, among other things. The study would be a tedious business, but simply looking at a proposed rig with the force vectors in mind is helpful in seeing what the designer of the rig ought to be trying to accomplish.

PART I

Cat Rigs (One Sail)

RIG 1 Leg-o'-mutton, boomless

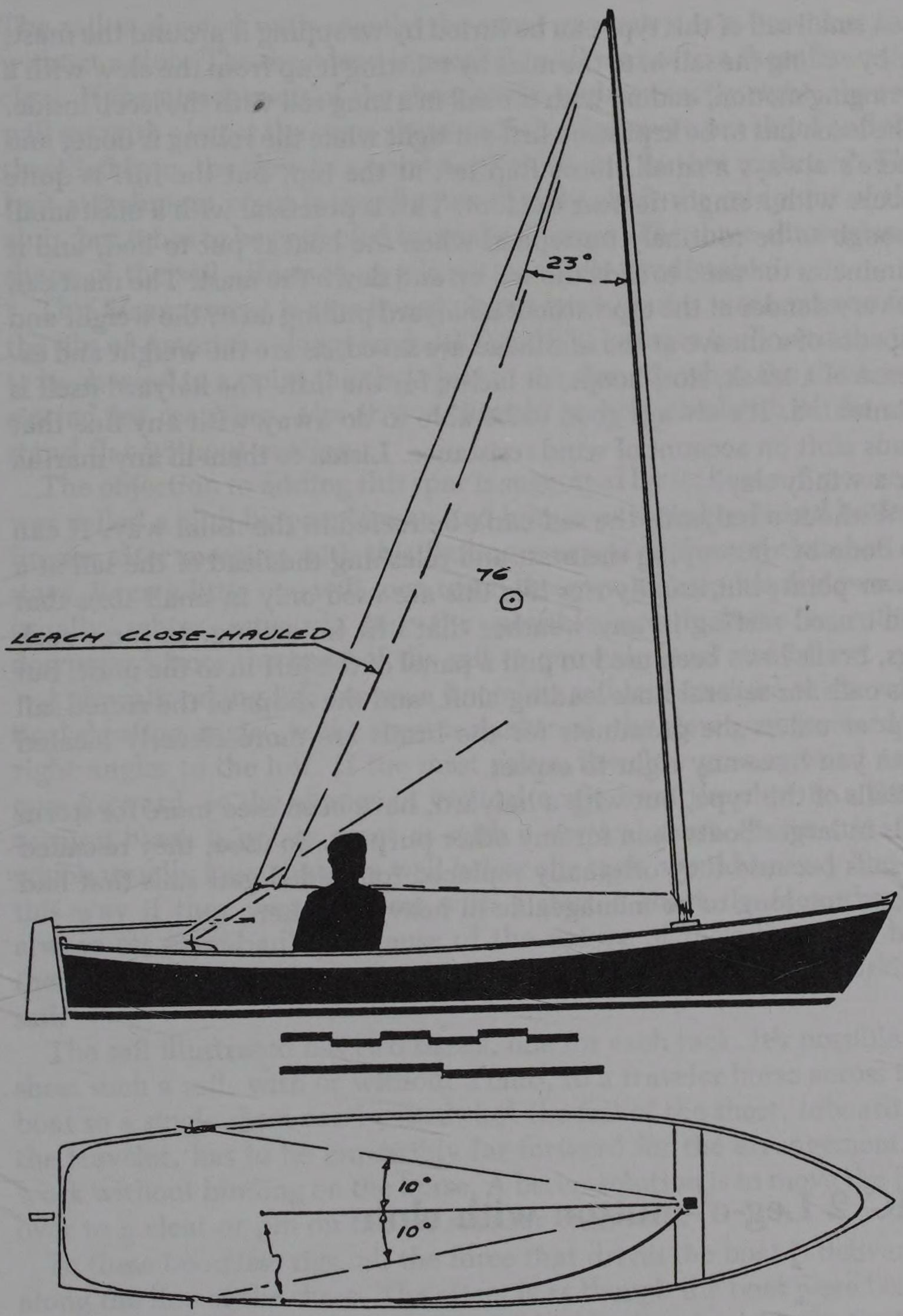
This rig has also been called jibheaded, thimble-headed, Bermudian or marconi, but the last was meant for the elaborately stayed types, not for the simple ones with no standing rigging. Without a boom it's the simplest of all rigs, needing only one spar and one controlling line.

A sail set without a boom needs to be sheeted to a point well off the boat centerline to draw well. Ten degrees from the intersection of the luff of the sail with the deck is the rule of thumb. The clew of the sail has to be well inboard of the stern. The narrower the boat is aft, the farther from the stern the sail needs to be set.

A boomless sail needs a sheet lead that will divide the load evenly between the leech and the foot. If the sheet came off the sail nearer to horizontal, the clew would lift, the head of the sail would twist out of line with the foot, and the boat wouldn't be close-winded. If the sheet is too vertical, the leech will be stretched tight and pull the sail into a bag shape that pulls the boat to leeward instead of ahead. The sheet should be somewhere close to splitting the clew angle. This will vary slightly according to the three-dimensional shape of the sail, but the real deceiver is that the sailplan, as drawn, shows the sail pulled out flat on the centerline of the boat. In fact, the angle and curve of the sail as carried move the clew forward as indicated on the cartoon in dotted lines. Split the clew angle from that point to get the lead in a vertical plane. The intersection of that line with the 10-degree line from the mast in the horizontal plane is a likely point to sheet the sail close-hauled.

It's a drawback of all boomless sails that the ideal sheeting point moves with every change of course and conditions over a large area extending far outside the boat. When the sheet is started, the clew goes forward again, and the sheeting point that was right for close-hauled sailing is too far aft. In addition to moving the sheeting point forward, it is also necessary to increase the 10-degree horizontal angle for reaching and running. An outrigger would be needed for that, but it's generally not worth the trouble. The boat will go along well reaching and running even with the sail poorly sheeted.

Again, due to sheeting restrictions, boomless sails have to be tall relative to the length of the boat to get area. The limit on height is the head angle. Twenty-three degrees is close to the minimum that allows the sailmaker to work some shape into the top of the sail. Other things being equal, the bigger the head angle, the better.


23°
76
LEACH CLOSE-HAULED
10°
10°

A small sail of this type can be furled by wrapping it around the mast, or by rolling the sail in to the mast by twisting it up from the clew with a wringing motion, ending with the sail in a snug roll with the leech inside. The leech has to be kept stretched out tight while the rolling is done, and there's always a small, loose flap left at the top, but the furl is quite secure with a single tie near the foot. This is practical with a mast small enough to be routinely unstepped when the boat is put to bed, and it eliminates the need to slide the sail up and down the mast. The mast can be very slender at the top without a halyard pulling on it; the weight and expense of a sheave at the masthead are saved, as are the weight and expense of a track, slot, hoops, or lacing for the luff. The halyard itself is eliminated. It's always good to be able to do away with any line that leads aloft on account of wind resistance. Listen to them in any marina on a windy day!

Without a halyard, the sail can't be reefed in the usual way. It can be done by unstepping the mast and relashing the head of the sail at a lower point, but usually rigs like this are used only in small sizes that don't need reefing in any weather that's fit for sailing. In some such rigs, brails have been used to pull a panel of the luff in to the mast, but this calls for several lines leading aloft, and the shape of the reefed sail is poor unless the grommets for the brails are more cleverly located than you have any right to expect.

Sails of this type, but with a halyard, have been used more for storm sails in larger boats than for any other purpose. So used, they're called trysails because they originally replaced four-sided gaff sails that had booms too long to be manageable in heavy weather.

RIG 2 Leg-o'-mutton with club

The club in this case is used to extend the clew of the sail farther aft than the available sheeting angle would allow if the sheet came off the clew.

The sail is sheeted with exactly the same geometry as a boomless sail without a club. The sheet lead is parallel in all planes to a sheet from the clew. If the attachment of the sheet to the club is exactly right, the sail will set with almost the same shape as if the club were not there and the sheet led from the clew to a point farther aft and farther outboard. The best attachment point is usually just slightly abaft the midpoint of the club, but it has to be perfected by trial and error. The three-dimensional shape of the sail affects it, so it's not precisely predictable.

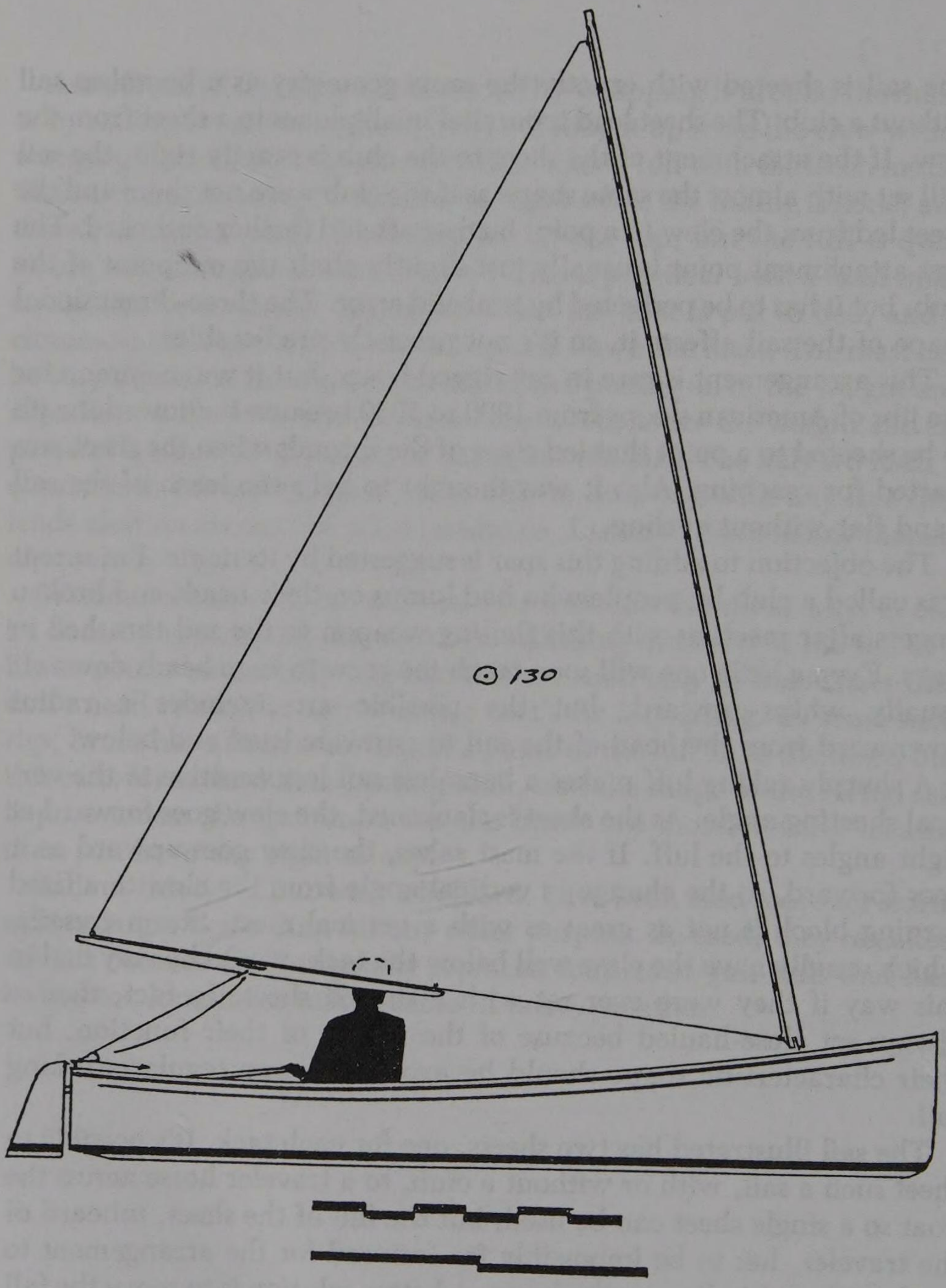
This arrangement is rare in cat-rigged boats, but it was common for the jibs of American sloops from 1900 to 1930 because it allowed the jib to be sheeted to a point that led clear of the shrouds when the sheet was started for reaching. Also it was thought to help the leech of the sail stand flat without curling.

The objection to adding this spar is suggested by its name. I'm sure it was called a club by people who had lumps on their heads and broken fingers after meeting with this flailing weapon as the sail thrashed in stays. Even a little one will soon teach the crew to keep heads down. It usually whips upward, but the possible arc includes a radius downward from the head of the sail to gunwale level and below.

A sharply raking luff makes a boomless sail less sensitive to the vertical sheeting angle. As the sheet is slackened, the clew goes forward at right angles to the luff. If the mast rakes, the clew goes upward as it goes forward, so the change in vertical angle from the clew to a fixed turning block is not as great as with a vertical mast. Storm trysails, which usually have the clew well below the tack, would be very bad in this way if they were ever set with a started sheet. In fact, they're always set close-hauled because of the nature of their function, but their characteristic shape should be avoided in any regular working sail.

The sail illustrated has two sheets, one for each tack. It's possible to sheet such a sail, with or without a club, to a traveler horse across the boat so a single sheet can be used, but the fall of the sheet, inboard of the traveler, has to be impossibly far forward for the arrangement to work without binding on the horse. A better solution is to move the fall over to a cleat or pin on the lee side for each tack.

In these boomless rigs, all the force that drives the boat is delivered along the line of the sheet. The effect is as though the boat were being towed by a tug with the towline attached at the sheet block. Such a towline would tend to swing the boat around. When towed by the sheet to the sail, the turning effect produces weather helm. The pull of



the luff of the sail on the mast is to leeward and somewhat aft. This partly compensates for the off-center towline, but boats setting boomless sails will normally carry more weather helm than boats with booms and should have their rigs stepped farther ahead on the hull.

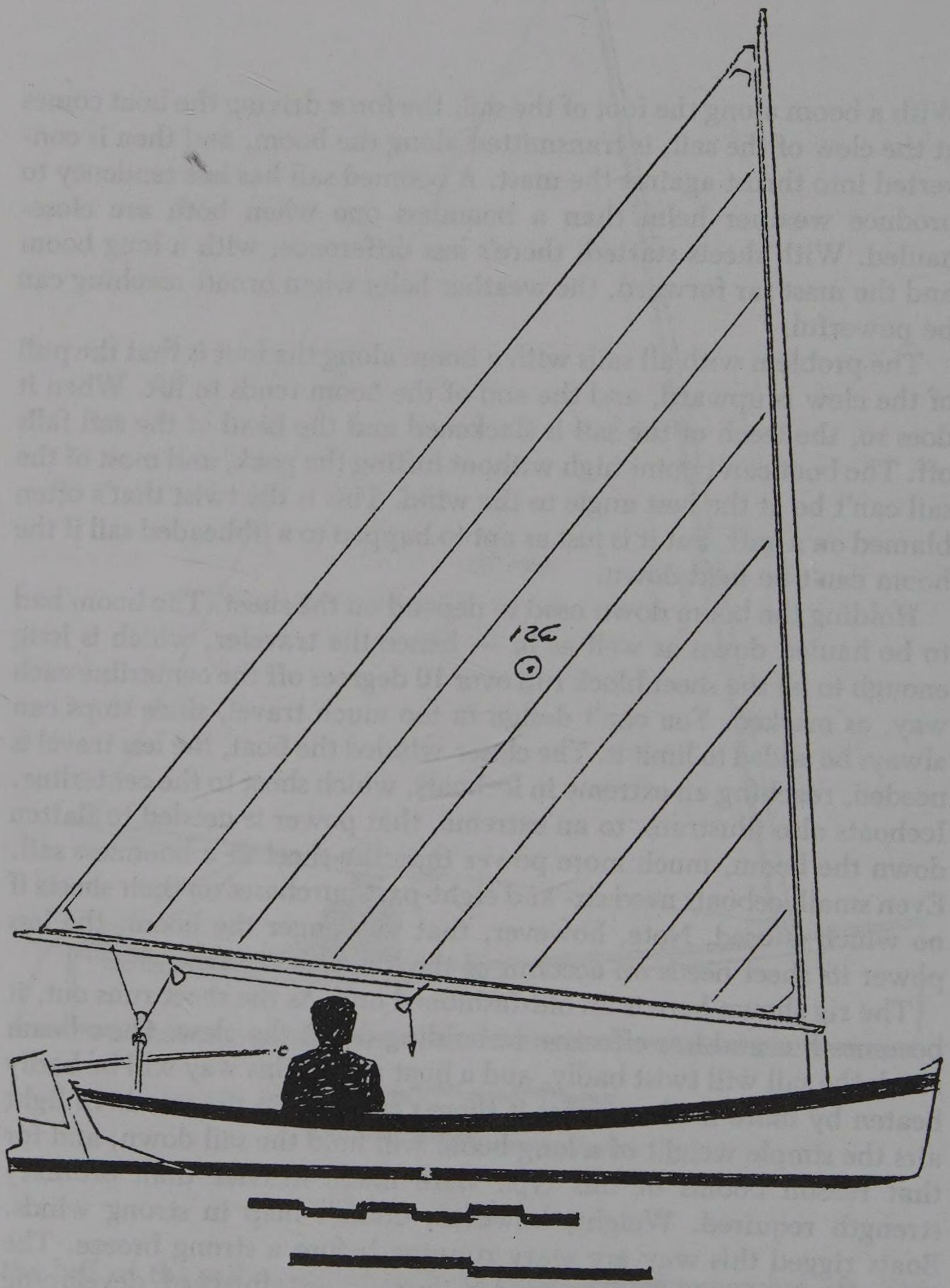
RIG 3 Leg-o'-mutton with boom

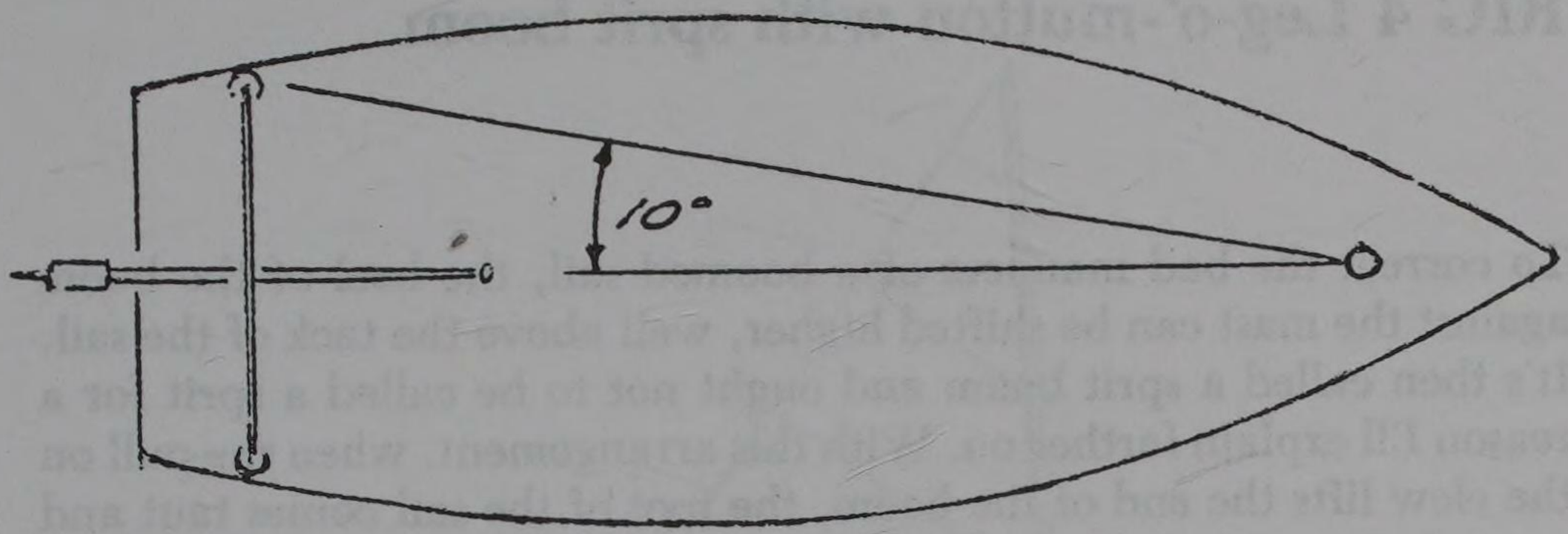
With a boom along the foot of the sail, the force driving the boat comes at the clew of the sail, is transmitted along the boom, and then is converted into thrust against the mast. A boomed sail has less tendency to produce weather helm than a boomless one when both are close-hauled. With sheets started, there's less difference; with a long boom and the mast far forward, the weather helm when broad-reaching can be powerful.

The problem with all sails with a boom along the foot is that the pull of the clew is upward, and the end of the boom tends to lift. When it does so, the leech of the sail is slackened and the head of the sail falls off. The boat can't point high without luffing the peak, and most of the sail can't be at the best angle to the wind. This is the twist that's often blamed on a gaff, but it is just as apt to happen to a jibheaded sail if the boom can't be held down.

Holding the boom down used to depend on the sheet. The boom had to be hauled down as well as in — hence the traveler, which is long enough to let the sheet block run over 10 degrees off the centerline each way, as marked. You can't design in too much travel, since stops can always be added to limit it. The closer-winded the boat, the less travel is needed, reaching an extreme in iceboats, which sheet to the centerline. Iceboats also illustrate, to an extreme, that power is needed to flatten down the boom, much more power than the sheet of a boomless sail. Even small iceboats need six- and eight-part purchases on their sheets if no winch is used. Note, however, that the longer the boom, the less power its sheet needs on account of the longer lever arm.

The rig shown here is an old-fashioned one. As the sheet runs out, it becomes less and less effective in holding down the clew. On a beam reach the sail will twist badly, and a boat rigged this way will be badly beaten by more modern types if there's strength in the wind. In light airs the simple weight of a long boom will hold the sail down, and for that reason booms of this type were made heavier than ordinary strength required. Weight, however, doesn't help in strong winds. Boats rigged this way are scary running before a strong breeze. The boom swings up wildly. The head of the sail twists forward, developing lateral forces that start the boat rolling. The rolling makes her yaw, the rudder movements to correct the yaw make the roll worse, and in the end the boat is plain out of control.





A long boom is a bad device for strong winds and rough water in another way. It can drag in the water when the boat heels sharply. The boat gets a knockdown. The sheet is slacked out to ease her, but the boom goes in the water instead of swinging out. Slacking the sheet more only produces bights of line dragging in the water. The bights, and the drag of the boom itself, slow the boat down and prevent her from luffing as she loses steerageway. The correct reaction is to haul in on the sheet, but that is against the programming of anybody brought up in small boats. To minimize such situations it used to be customary to give the mast a sharp rake in rigs with long booms. This would swing the boom up as it went out, clearing the water at sharper angles of heel. The penalty of such geometry is that in light airs the boom swings back toward the centerline of its own weight and has to be guyed out to make it draw before the wind. For seagoing rigs, it's a good rule of thumb not to have a boom longer than about twice the breadth of the boat.

The cut of the sail shown, parallel to the leech, was the standard method up to the late 1890s when Nathanael Herreshoff began producing sails with the seams at right angles to the leech, "crosscut." The crosscut sail has slightly less wind drag and could be built with a bigger roach in its leech, allowing extra area on the spars and a bigger head angle. A sail cut "up and down," parallel to the leech, is stronger because the stress comes mostly along the seams instead of across them, and the failure of a seam doesn't disable the sail to the same extent that it does in a crosscut sail, if the foot is secured to a boom. With modern sailmaking methods there's no real problem with the strength of a crosscut sail, and most sailcloth is woven on the assumption that the sails will be crosscut. I like the look of an up-and-down cut myself, and it is less apt to develop a curled leech without battens, but nowadays it's really an affectation.

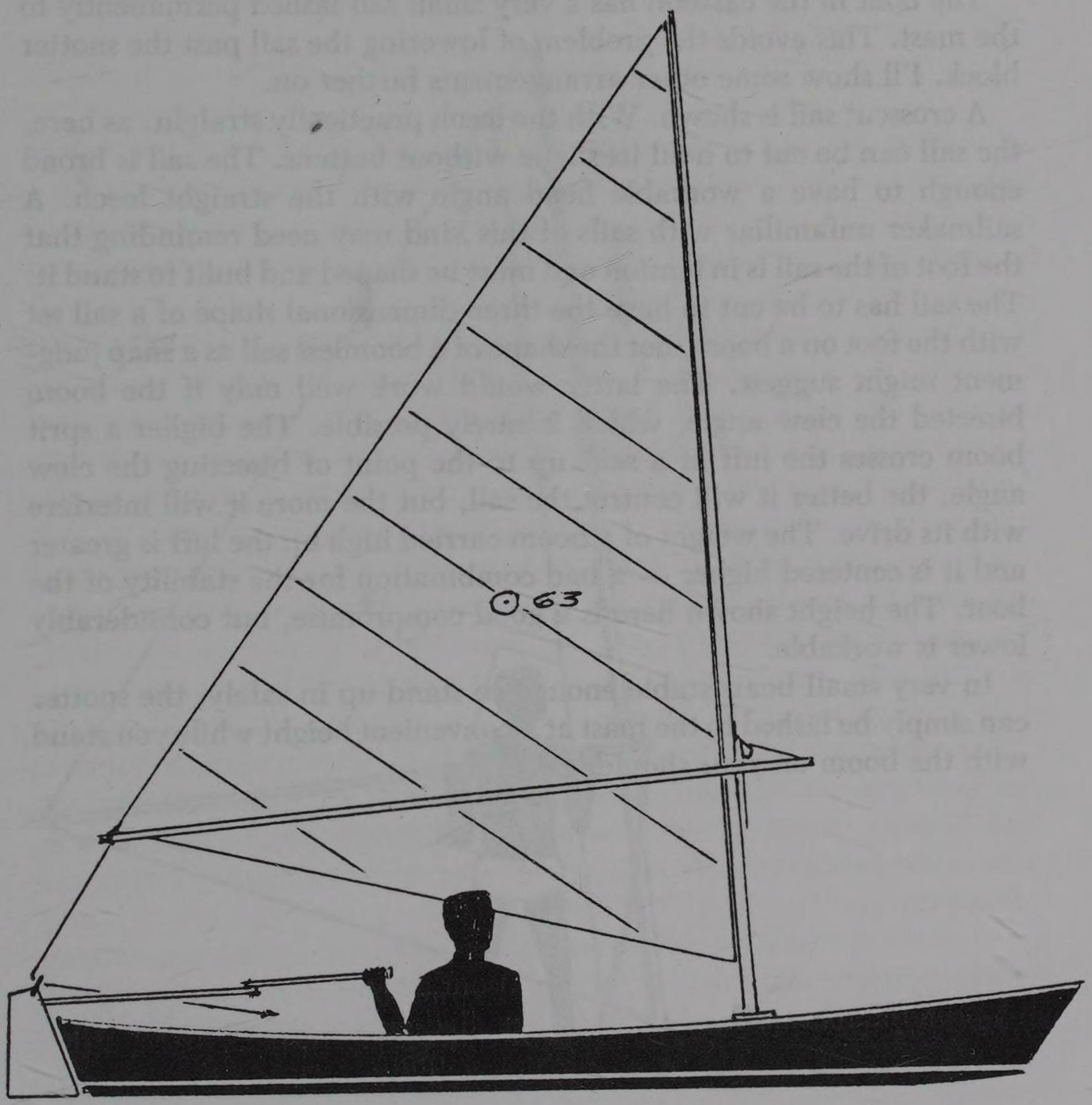
RIG 4 Leg-o'-mutton with sprit boom

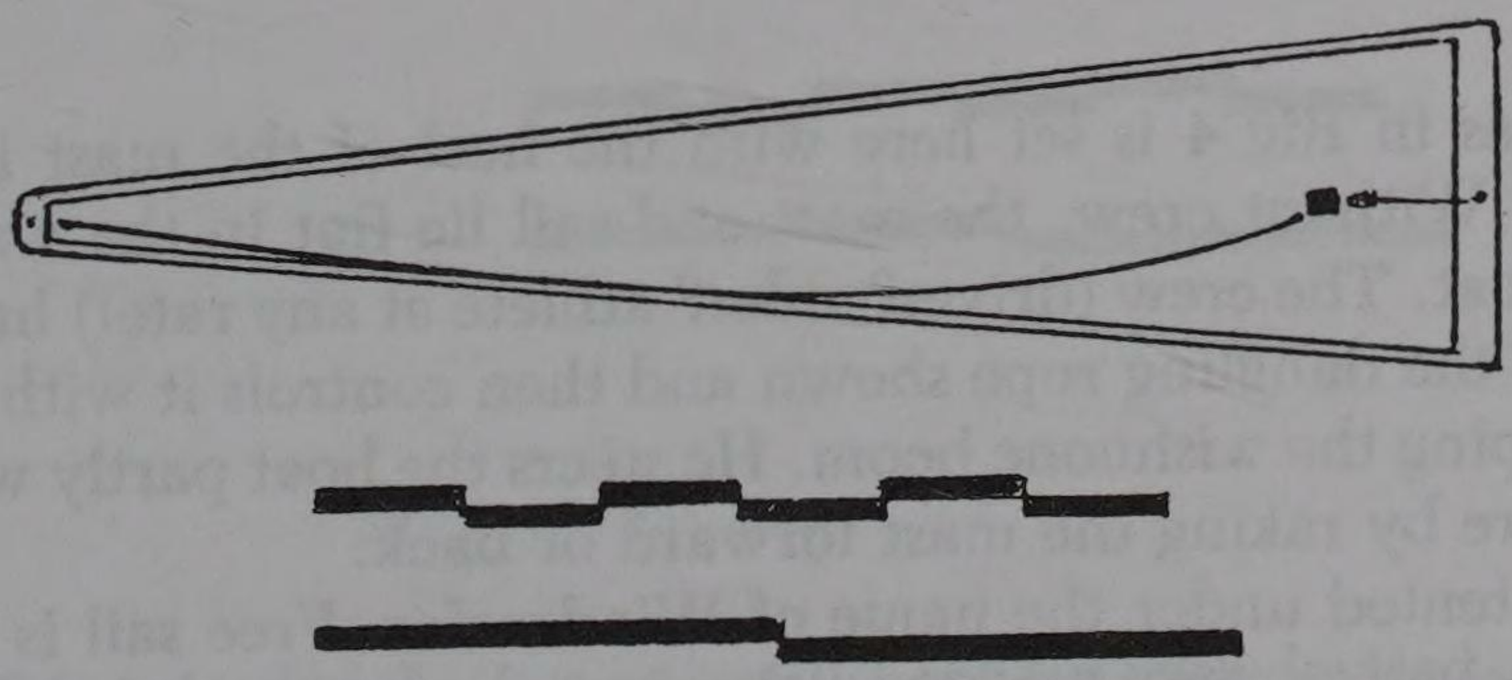
To correct the bad manners of a boomed sail, the heel of the boom against the mast can be shifted higher, well above the tack of the sail. It's then called a sprit boom and ought not to be called a sprit for a reason I'll explain farther on. With this arrangement, when the pull on the clew lifts the end of the boom, the foot of the sail comes taut and stops the lift. A sail rigged this way is docile on all points of sailing. It's also light to sheet because no effort is devoted to holding the boom down. With a long sprit boom, sails up to 150 square feet can be sheeted without any mechanical advantage. The point to which the sheet leads is not very important either, though it's best if the sheet leads well aft and no more downward than necessary.

A great many methods of holding the forward ends of sprit booms have been used. The cartoon here shows one form of wishbone boom. The clew of the sail is fast at the outboard end. Tension on the sail is adjusted with a snotter, a line led from the heel of the boom in to the mast, then down to the deck.

The simplest form of sprit boom looks the same in profile: a straight spar passing against the mast with the standing end of the snotter on its heel. The drawback of such a boom is that it cuts into the sail on one tack, possibly chafing the sail and reducing its power slightly. The advantage of the straight sprit boom, besides its simplicity, is that if there are shrouds, it can be squared out much farther. Wishbone booms and standing rigging don't marry happily; for instance, there was a case of a sizable yacht that was dismasted with a spectacular crash when the mainsheet broke and the wishbone boom crashed around against the shrouds.

It's possible to use only half of a wishbone boom. The result looks like an arm bent at the elbow with the snotter held in the fist. Such a boom has to be supported by a lift at the elbow to some point higher on the mast. I've usually had a wire bridle on the end of the lift to support the boom at both wrist and elbow. With such an arrangement, the draft of the sail can be adjusted delicately for different wind strengths, but in a heavy sea the snotter has to be kept tight or the boom will swing on the lift and slam against the mast. With that problem and the chafe problem, sprit booms aren't usually a good choice for a long-distance cruiser in spite of the apparent advantage in downwind manners. They're at their best in small and casual daysailers.


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The boat in the cartoon has a very small sail lashed permanently to the mast. This avoids the problem of lowering the sail past the snotter block. I'll show some other arrangements farther on.

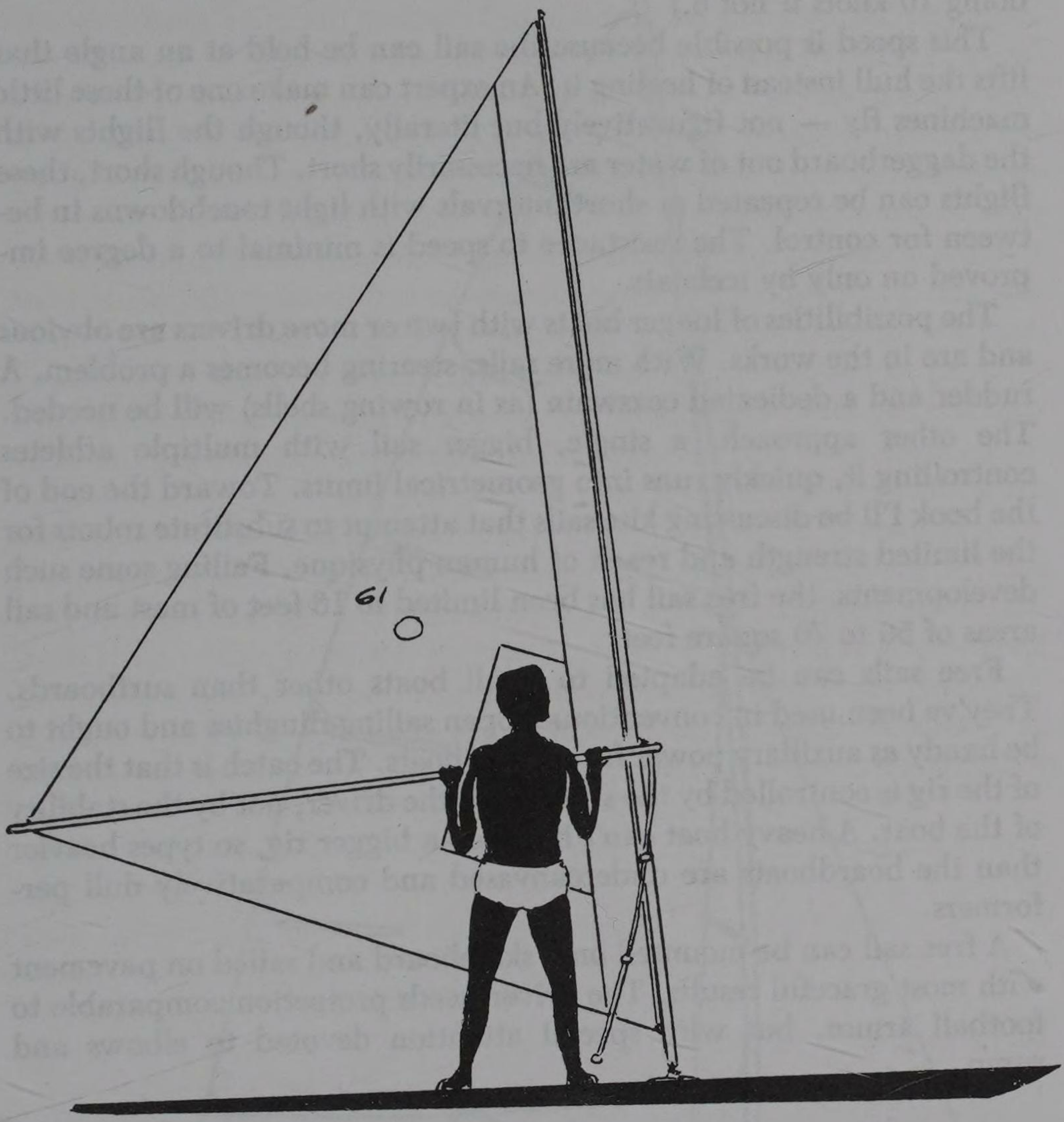
A crosscut sail is shown. With the leech practically straight, as here, the sail can be cut to hold its shape without battens. The sail is broad enough to have a workable head angle with the straight leech. A sailmaker unfamiliar with sails of this kind may need reminding that the foot of the sail is in tension and must be shaped and built to stand it. The sail has to be cut to have the three-dimensional shape of a sail set with the foot on a boom, not the shape of a boomless sail as a snap judgment might suggest. The latter would work well only if the boom bisected the clew angle, which is rarely possible. The higher a sprit boom crosses the luff of a sail, up to the point of bisecting the clew angle, the better it will control the sail, but the more it will interfere with its drive. The weight of a boom carried high up the luff is greater and it is centered higher — a bad combination for the stability of the boat. The height shown here is a good compromise, but considerably lower is workable.

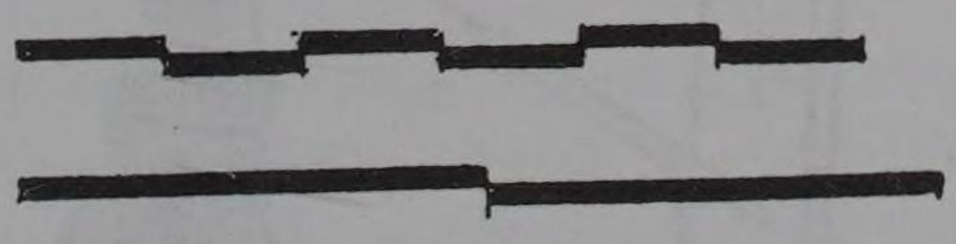
In very small boats stable enough to stand up in safely, the snotter can simply be lashed to the mast at a convenient height while you stand with the boom on your shoulder.

RIG 5 Free sail

The same sail as in Rig 4 is set here with the heel of the mast in a universal joint. Without crew, the mast and sail lie flat in the water alongside the boat. The crew (driver? rider? athlete at any rate!) hauls the rig up with the dangling rope shown and then controls it with his two hands gripping the wishbone boom. He steers the boat partly with his feet but more by raking the mast forward or back.

The rig is patented under the name of Windsurfer. Free sail is the generic name, covering some variations that may or may not evade the patent depending on the outcome, eons hence, of interminable litigation.





This is by far the fastest small-boat rig ever devised. Speeds of more than 20 knots have been reliably measured, not merely imagined, as has been common before. (Excusably, a lot of good sailing dinghies feel

as though they are doing 20 knots, but when measured turn out to be doing 10 knots if not 6.)

This speed is possible because the sail can be held at an angle that lifts the hull instead of heeling it. An expert can make one of these little machines fly — not figuratively but literally, though the flights with the daggerboard out of water are necessarily short. Though short, these flights can be repeated at short intervals with light touchdowns in between for control. The resistance to speed is minimal to a degree improved on only by iceboats.

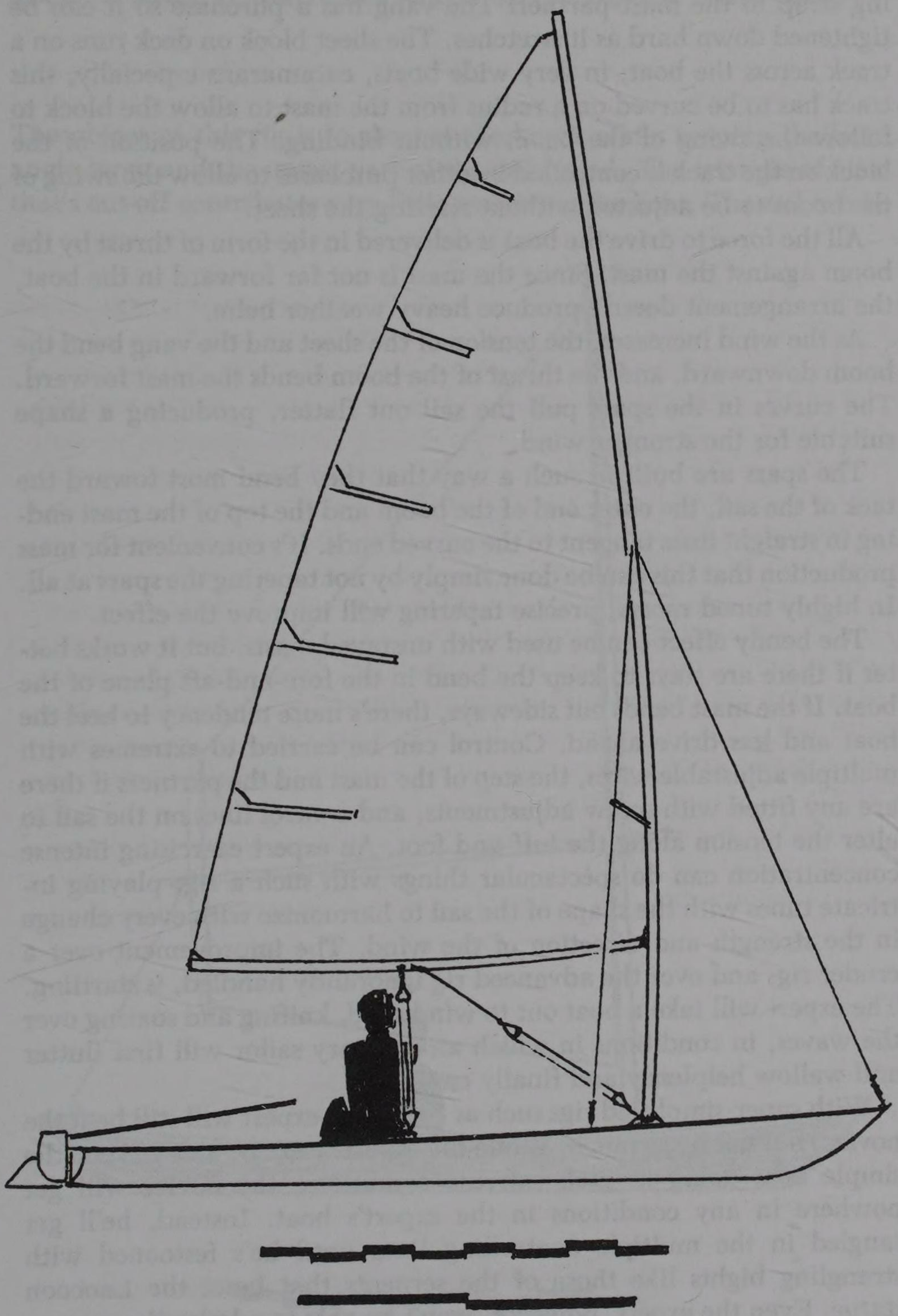
The possibilities of longer boats with two or more drivers are obvious and are in the works. With more sails, steering becomes a problem. A rudder and a dedicated coxswain (as in rowing shells) will be needed. The other approach, a single, bigger sail with multiple athletes controlling it, quickly runs into geometrical limits. Toward the end of the book I'll be discussing kite sails that attempt to substitute robots for the limited strength and reach of human physique. Failing some such developments, the free sail has been limited to 16 feet of mast and sail areas of 50 to 70 square feet.

Free sails can be adapted to small boats other than surfboards. They've been used in conventional, open sailing dinghies and ought to be handy as auxiliary power for rowing boats. The catch is that the size of the rig is controlled by the strength of the driver, not by the stability of the boat. A heavy boat can't be given a bigger rig, so types heavier than the boardboats are undercanvased and comparatively dull performers.

A free sail can be mounted on a skateboard and sailed on pavement with most graceful results. The driver needs protection comparable to football armor, but with special attention devoted to elbows and rump.

RIG 6 Leg-o'-mutton with bendy spars

In this rig the sail is caught in slots along the mast and boom, and cut very full; that is, with a deep three-dimensional curve. A sail so shaped is powerful in gentle winds. The boom is held down by a vang or kick-



ing strap to the mast partner. The vang has a purchase so it can be tightened down hard as it stretches. The sheet block on deck runs on a track across the boat; in very wide boats, catamarans especially, this track has to be curved on a radius from the mast to allow the block to follow the swing of the boom without binding. The position of the block on the track is controlled by other purchases to allow the swing of the boom to be adjusted without starting the sheet.

All the force to drive the boat is delivered in the form of thrust by the boom against the mast. Since the mast is not far forward in the boat, the arrangement doesn't produce heavy weather helm.

As the wind increases, the tension of the sheet and the vang bend the boom downward, and the thrust of the boom bends the mast forward. The curves in the spars pull the sail out flatter, producing a shape suitable for the stronger wind.

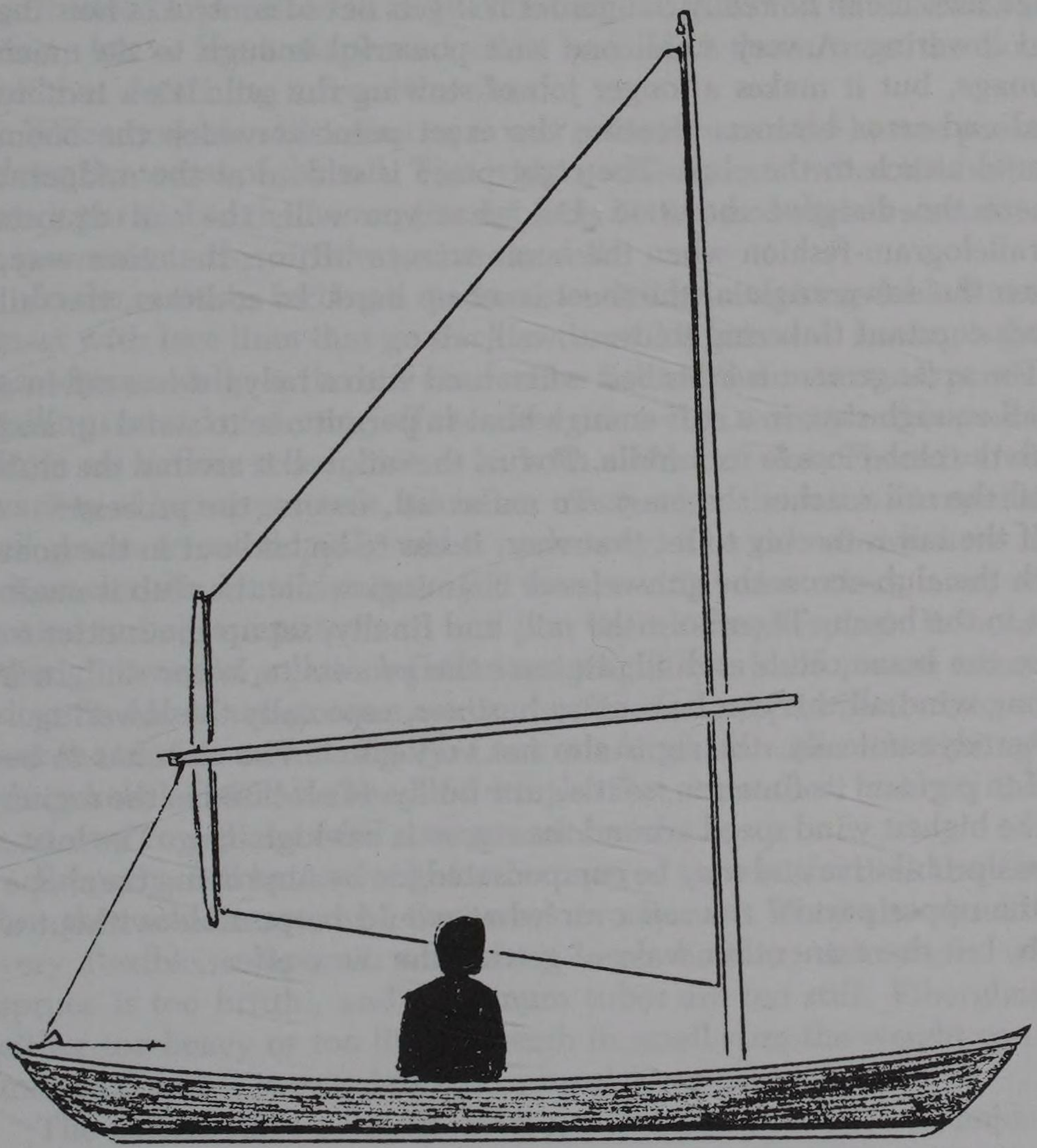
The spars are built in such a way that they bend most toward the tack of the sail, the outer end of the boom and the top of the mast ending in straight lines tangent to the curved ends. It's convenient for mass production that this can be done simply by not tapering the spars at all. In highly tuned racers, precise tapering will improve the effect.

The bendy effect can be used with unstayed masts, but it works better if there are stays to keep the bend in the fore-and-aft plane of the boat. If the mast bends out sideways, there's more tendency to heel the boat and less drive ahead. Control can be carried to extremes with multiple adjustable wires, the step of the mast and the partners if there are any fitted with screw adjustments, and control lines on the sail to alter the tension along the luff and foot. An expert exercising intense concentration can do spectacular things with such a rig, playing intricate tunes with the shape of the sail to harmonize with every change in the strength and direction of the wind. The improvement over a cruder rig, and over the advanced rig ignorantly handled, is startling. The expert will take a boat out to windward, knifing and soaring over the waves, in conditions in which an ordinary sailor will first flutter and wallow helplessly and finally capsize.

With super-simplified rigs such as Rig 4, the expert will still beat the novice, but not by so much. While the expert won't be able to keep the simple boat going in such extreme conditions, the novice will get nowhere in any conditions in the expert's boat. Instead, he'll get tangled in the multiple controlling lines until he's festooned with strangling bights like those of the serpents that beset the Laocoon statue. Even the expert, however, won't be able to admire the scenery much while he's making his rig work.

RIG 7 Leg-o'-mutton with sprit boom and club

The object of this rig is to shorten the boom while keeping the head angle large and the upper part of the sail broad. The triangle of clew that's cut off contributes very little to driving the boat. The sail can be





built stronger and will hold its shape better because the tension to the outhaul and thence to the mast isn't concentrated at a pointed clew.

The club doesn't have to be parallel to the mast. It can cut across the clew at any angle down to parallel with the foot, as in Rig 2. It could also cant the other way, with the lower end tailing out aft, though I have never seen such a shape and can't think of a reason for it.

This arrangement has never been widely popular. Old-time sailmakers liked it for the reasons given, but the club is a nuisance. In large sizes it can be really dangerous if it gets out of control in hoisting and lowering. A very small one isn't powerful enough to do much damage, but it makes a longer job of stowing the sail. It's a tedious trial-and-error business locating the exact point at which the boom should attach to the club. The right place is seldom at the midpoint where the designer shows it. Do what you will, the sail distorts parallelogram-fashion when the boom tries to lift, or, the other way, when the down angle of the sheet is set up hard. In addition, the sail needs constant tinkering to draw well.

The arrangement is at its best when used with a halyard-less sail in a small enough size, in a stiff enough boat to permit one to stand up and grab the club close to its middle. To furl the sail, roll it around the club until the roll reaches the mast. To make sail, reverse the process.

If the sail is too big to set that way, it has to be laid out in the boat with the club across the gunwales or coamings while the club is made fast to the boom. Then hoist the sail, and finally, set up the snotter to raise the boom, club and all. Reverse the process to lower sail. In a strong wind all this can be a noisy business, especially the lowering.

Aerodynamically, the rig is also not very good. The club has to be stiff to perform its function, so it's quite bulky. It's located in the region of the highest wind speed around the rig, so it has high drag. The losses aren't prohibitive and may be compensated for by improving the shape of the upper part of the sail over what would be possible without a club, but there are other ways of getting the same effect.

RIG 8 Jibheaded with full battens

These sails used to be called batwings. The name had the bad effect of suggesting to designers that the battens ought to splay out like a bat's finger bones. Such a layout of battens was further promoted by the tendency to think of the sail as a gaff rig with the triangle above the gaff filled in. A sail built in that fashion, with its luff attached to the mast, has a fixed shape and can't be folded down onto the boom without detaching it from the mast.

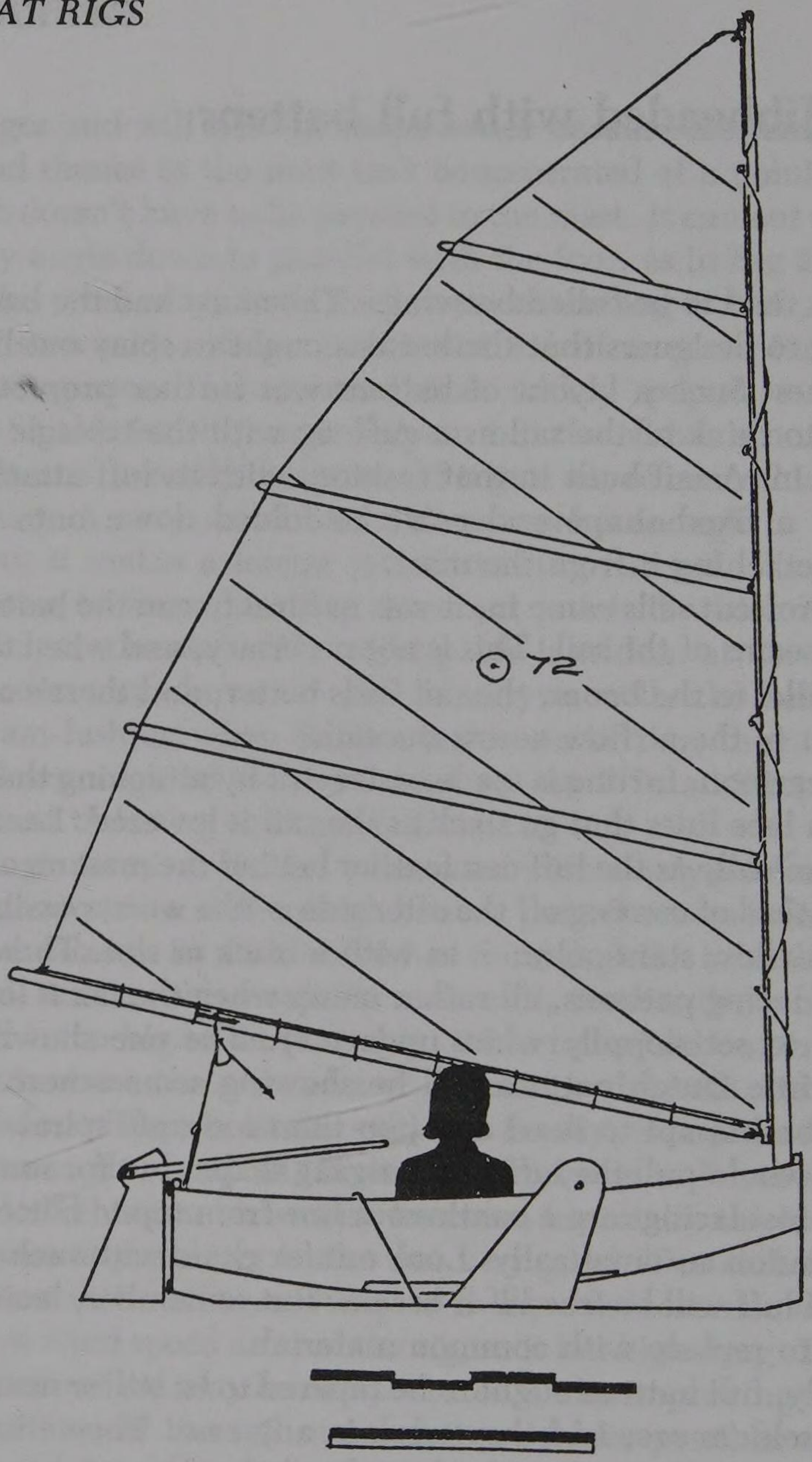
When crosscut sails came in, it was natural to run the batten pockets along the seams of the sail. This is not necessary, and when the battens work parallel to the boom, the sail furls better, and there's a small improvement in the airflow across the sail.

In the cartoon, furling is made easier still by attaching the luff to the mast with lace lines that go slack as the sail is lowered. Lacing is good aerodynamically as the luff can feather behind the mast on all points of sailing instead of coming off the after side — the worst possible position from an airflow standpoint — as with a track or slot. There is a wide variety of lacing patterns, all rather messy when the sail is lowered and all prone to set sloppily when underway. The one shown here is a characteristic Dutch pattern (I'll be showing some others later) supposed to be less apt to snarl and jam than a simple spiral. It looks as though it would pull the luff into a zigzag shape, but for some reason it doesn't. Most lacings are a continuous line from top to bottom, to even out the tension automatically. Look out for chafe with such a lacing — the whole luff will be freed if it breaks. But remember, lacing is cheap and easy to replace with common materials.

Properly, full battens ought to be tapered to be stiffer near the leech, but they seldom are, and they work in any case. They also should be very flexible compared with short leech battens. Ash works well, spruce is too brittle, and aluminum tubes are too stiff. Fiberglass is either too heavy or too limp, though in small sizes the weight can be tolerated and it is even less apt to break than ash.

The battens serve a double or treble function. The first is to hold out the heavily rounded leech. A large area can be set on a comparatively short mast and boom, and the sail is a compact shape, powerful for its area. The ineffective narrow triangles at head and clew are eliminated.

The second function is to suppress slatting when the sail is luffed. When a sail flutters, its wind resistance is increased a lot. A small boat



can be capsized by this drag even if the boom is slacked out till the whole sail weathervanes. The battens reduce the fluttering, more or less according to how close together they are.

The third function is to control the draft of the sail, to increase or decrease its three-dimensional curves. This isn't done much any more but was an art in some types of racing boats at one time, especially in Germany and Austria. The battens projected out of their pockets, more than shown here, and could be forced in and out to vary the tension.

The result was the same as described with Rig 6 but was accomplished much more clumsily. It does have the advantage of being easier on the spars than the bendy rig, but neither would be used where that was an important consideration.

The rig shown, with the boom on the foot, has the same off-the-wind vices as Rig 3, unless the battens are so stiff that the sail can't fall into a reasonably deep draft. They can be helped some in a tiny boat like this one by bringing the fall of the sheet down on the lee side each tack. A vang or kicking strap on the boom would be desirable. Full-batten sails with sprit or wishbone booms are most unhandy to furl.

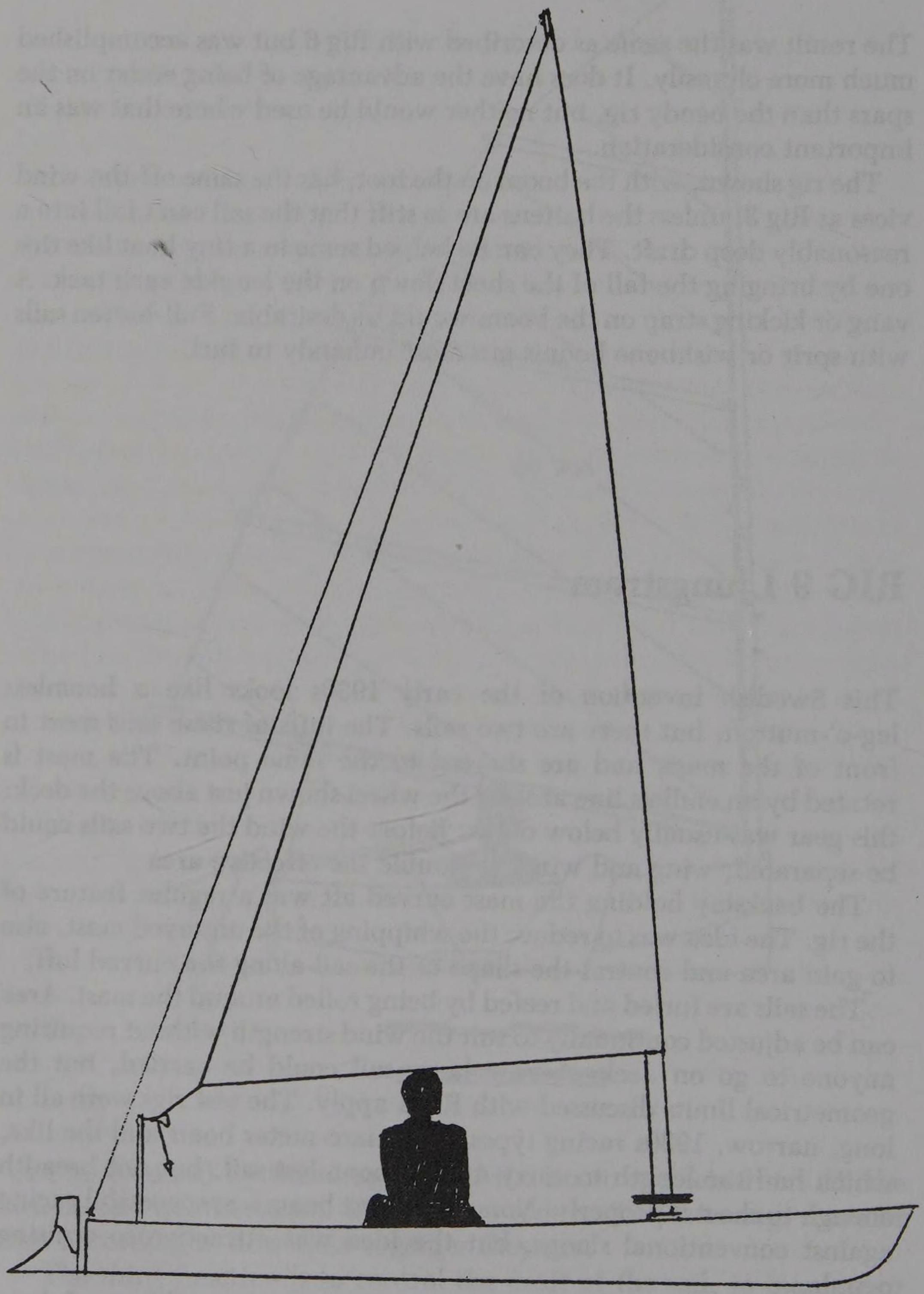
RIG 9 Ljungstrom

This Swedish invention of the early 1930s looks like a boomless leg-o'-mutton, but there are two sails. The luffs of these sails meet in front of the mast, and are sheeted to the same point. The mast is rotated by an endless line around the wheel shown just above the deck: this gear was usually below decks. Before the wind the two sails could be separated, wing and wing, to double the effective area.

The backstay holding the mast curved aft was a regular feature of the rig. The idea was to reduce the whipping of the unstayed mast, also to gain area and control the shape of the sail along the curved luff.

The sails are furled and reefed by being rolled around the mast. Area can be adjusted continually to suit the wind strength without requiring anyone to go on deck. A very large sail could be carried, but the geometrical limits discussed with Rig 1 apply. The test rigs were all in long, narrow, 1930s racing types, 22-square-meter boats and the like, which had the length to carry a large boomless sail, but not breadth enough to sheet it properly. None of the test boats was successful racing against conventional sloops, but the idea was attractive to cruising people.

The drawbacks are numerous. First, there are the problems of sheet angle, described with Rig 1, that show up in more extreme form as the sail is reduced by rolling it in to the mast. It's hard, if not impossible, to build a sail that retains a good shape in its exposed part after being

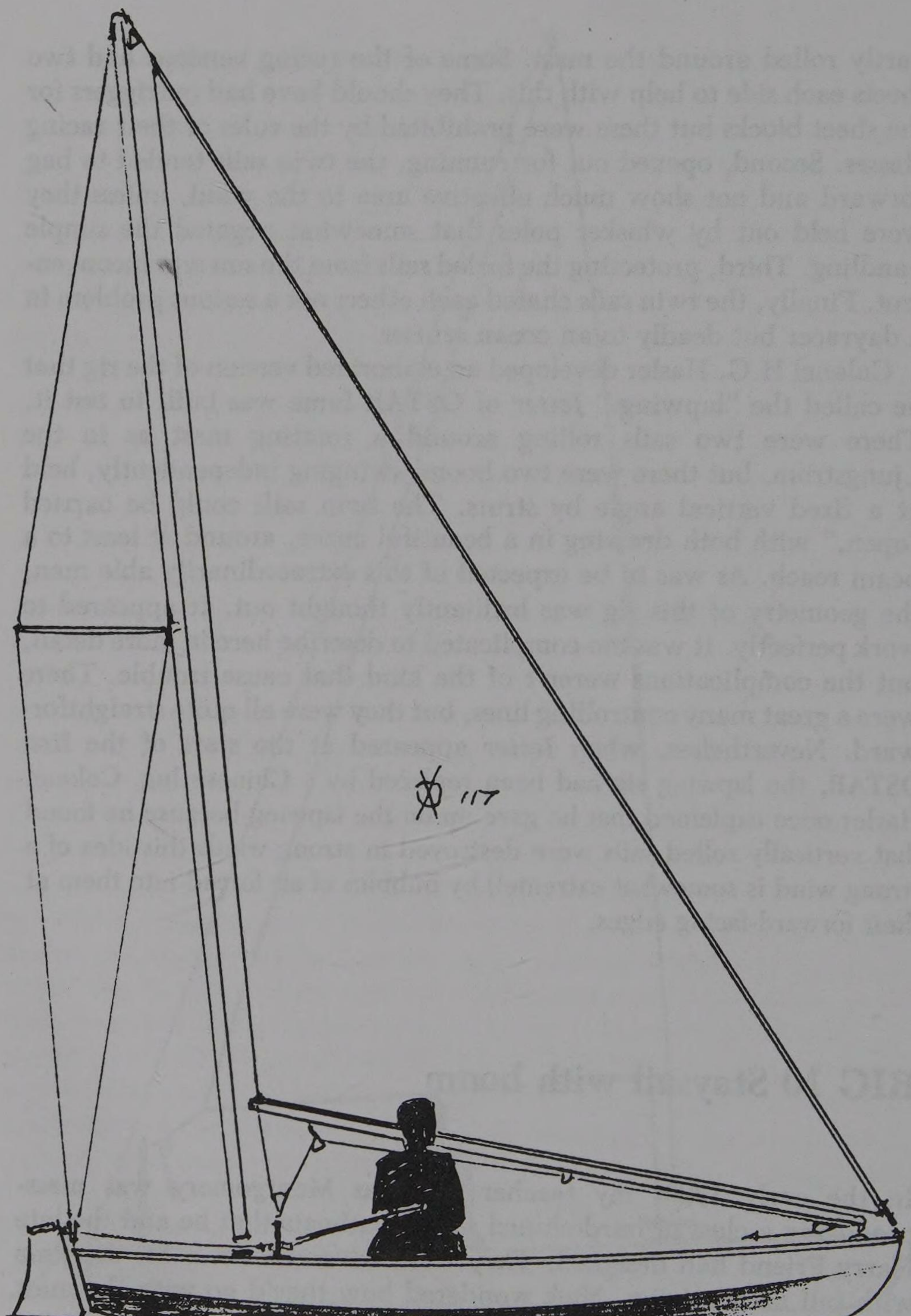


partly rolled around the mast. Some of the racing versions had two sheets each side to help with this. They should have had outriggers for the sheet blocks but these were prohibited by the rules of their racing classes. Second, opened out for running, the twin sails tended to bag forward and not show much effective area to the wind, unless they were held out by whisker poles that somewhat negated the simple handling. Third, protecting the furled sails from the sun was inconvenient. Finally, the twin sails chafed each other; not a serious problem in a dayracer but deadly to an ocean cruiser.

Colonel H.G. Hasler developed an elaborated version of the rig that he called the "lapwing." *Jester* of OSTAR fame was built to test it. There were two sails rolling around a rotating mast as in the Ljungstrom, but there were two booms swinging independently, held at a fixed vertical angle by struts. The twin sails could be carried "open," with both drawing in a beautiful curve, around at least to a beam reach. As was to be expected of this extraordinarily able man, the geometry of this rig was brilliantly thought out. It appeared to work perfectly. It was too complicated to describe here in more detail, but the complications weren't of the kind that cause trouble. There were a great many controlling lines, but they were all quite straightforward. Nevertheless, when *Jester* appeared at the start of the first OSTAR, the lapwing rig had been replaced by a Chinese lug. Colonel Hasler once explained that he gave up on the lapwing because he found that vertically rolled sails were destroyed in strong winds (his idea of a strong wind is somewhat extreme!) by bubbles of air forced into them at their forward-facing edges.

RIG 10 Staysail with boom

In the early 1920s my teacher Nicholas Montgomery was mass-producing a class of hard-chined racing catboats that he and the late Harry Friend had designed. They were advanced boats for the time with tall marconi rigs. Nick wondered how they'd go with the mast stepped in the stern, and he pulled one off the finishing line and tried it. The test rig looked about like this cartoon. The mast was the standard one. The boom was shortened. The rigging components were from the production boats, but were more effective because the wide



stern gave a better spread for the shrouds. The sail had less area than the standard ones, but a longer luff.

As he told it many years afterward, the experimental boat was dramatically faster than the standard boats in gentle sailing breezes. The testing wasn't carried any further, probably because it had too much potential to confuse the promotion of the standard boats.

Probably the improvement was due mostly to relieving the bow of the boat of the mast's weight, or rather, of its inertia. The light bow would be quicker to lift to a wave; hence, it would have less resistance in a chop.

The sail itself would have been a much better airfoil with no mast in front of it to start the air eddying, but this would have been canceled out by a sagging luff spoiling the shape of the sail. With 1920 techniques and materials, there was no way to build the rig stiff enough to hold the long headstay straight. The boat, however, was more suitable for the experiment than most boats of her time. The rig geometry was potentially stiff if they'd had good terminals in place of the spliced loops actually used. The hull construction was (is — they're still being built) unusually rigid as wooden boats go, with sawn frames and a deep girder in the sides. But I doubt it would be possible to build a wooden boat with mechanical fastenings that would stand the rigging tensions needed to make a sail like this hold its shape in strong winds.

If it could be made to stand high tensions, this rig has huge advantages, especially in bad conditions. Getting the weight of the mast out of the bow would make the boat not only faster, but also drier and easier to control in rough water. Moving the air resistance of the mast and rigging to the stern would make her ride steadily to an anchor and maybe even heave-to without one. The high clew, relative to the luff, would prevent the sail from twisting as much as the regular, near-right-triangle shape when the sheet was slacked. With the boom squared out, it swings so high that there's no fear of tripping it in a wave crest even in a severe knockdown. The corollary is that the boom has a strong tendency to center itself by its own weight, a problem before the wind in light airs.

If you chase down the forces generated by this rig, you find a strong upward component tending to lift the boat instead of heeling her. The effect is not in the same class with that mentioned in Rig 5, but it's noticeable and no conventional rig has as much of it as this one.

Conclusion: This is a heavy-weather rig and a seaworthy rig in principle, but it won't work without a tremendous tension to hold the luff of the sail against sagging. The high tension means that all the com-

ponents of hull and rig have to be very strong, so they're either heavy or brittle and usually both. The whole thing will blow up in your face if one turnbuckle pin gives way, or one swage pulls out.

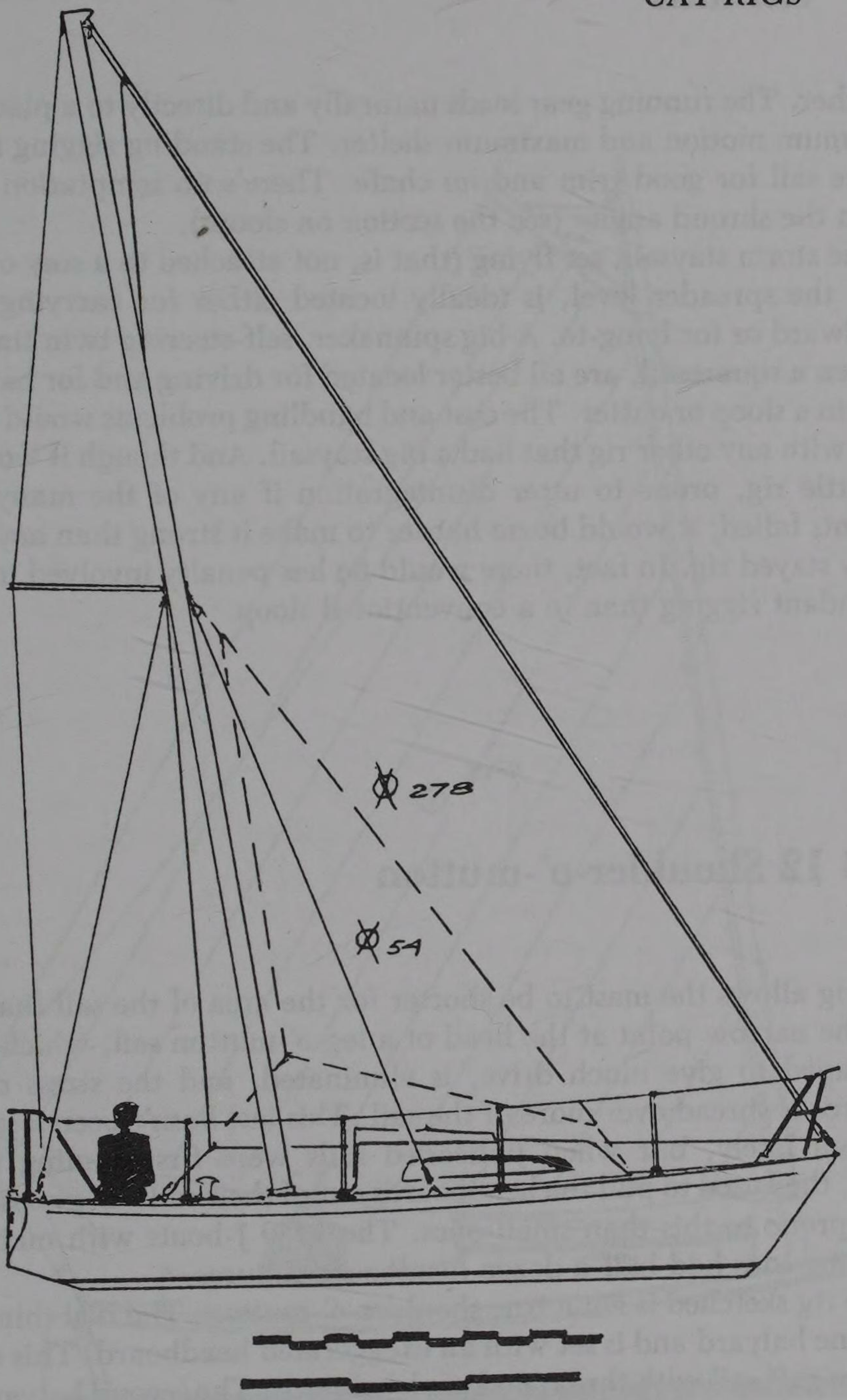
It's also an expensive rig. The cartoon shows a sail of 117 square feet, needing 10 sophisticated terminals, 5 turnbuckles, and a couple of hundred feet of 1 x 19 wire to stand. The mast has to be a high-compression strut. An equivalent sail of the type of Rig 3 would stand quite well and be more reliable, lashed to a stolen cedar tree with drugstore twine.

RIG 11 Staysail, boomless

Forty years after Nick Montgomery's experiment, racing gear had become stiff enough to make tightening the long luff of a masthead staysail routine. All the ocean racers were carrying masthead jibs bigger than their mainsails. It was noticed that such jibs did more to drive the boats than the mainsails, for the reasons given above. Crafty skippers began to reduce their ratings by using smaller mainsails with headboards well below the mastheads.

A.E. Luders, Jr., didn't approve of this and thought there should be a rule against it. To illustrate his point, he had his sloop, *Storm*, measured without her mainsail. With a huge overlapping jib set, very good handling, and some luck on the weather, he won a major event on the resulting handicap. The rule was changed as he intended; racers were required to carry mainsails the full height of the mast. Nothing was done about the width of the sails, however, so there was a trend to short booms and narrow ribbon mainsails.

Suppose the authorities had decided not to make racers carry mainsails; small cruiser-racers might have come to look something like this cartoon. This boat would have a rather wide stern. There are two upper backstays led over V-spreaders to give lateral support to the top of the mast. The components needed to make this rig work are all readily available. It's all fiendishly expensive but there's nothing people haven't been accustomed to buying.



For reasons to be discussed when I get to sloop rigs, it's likely that rigs like this wouldn't have had long popularity in racing. Big mainsails with important drive came back into fashion. But for a cruising boat there's something to be said for this rig. The weight and windage of the mast and its staying are beautifully located to ease the boat in heavy

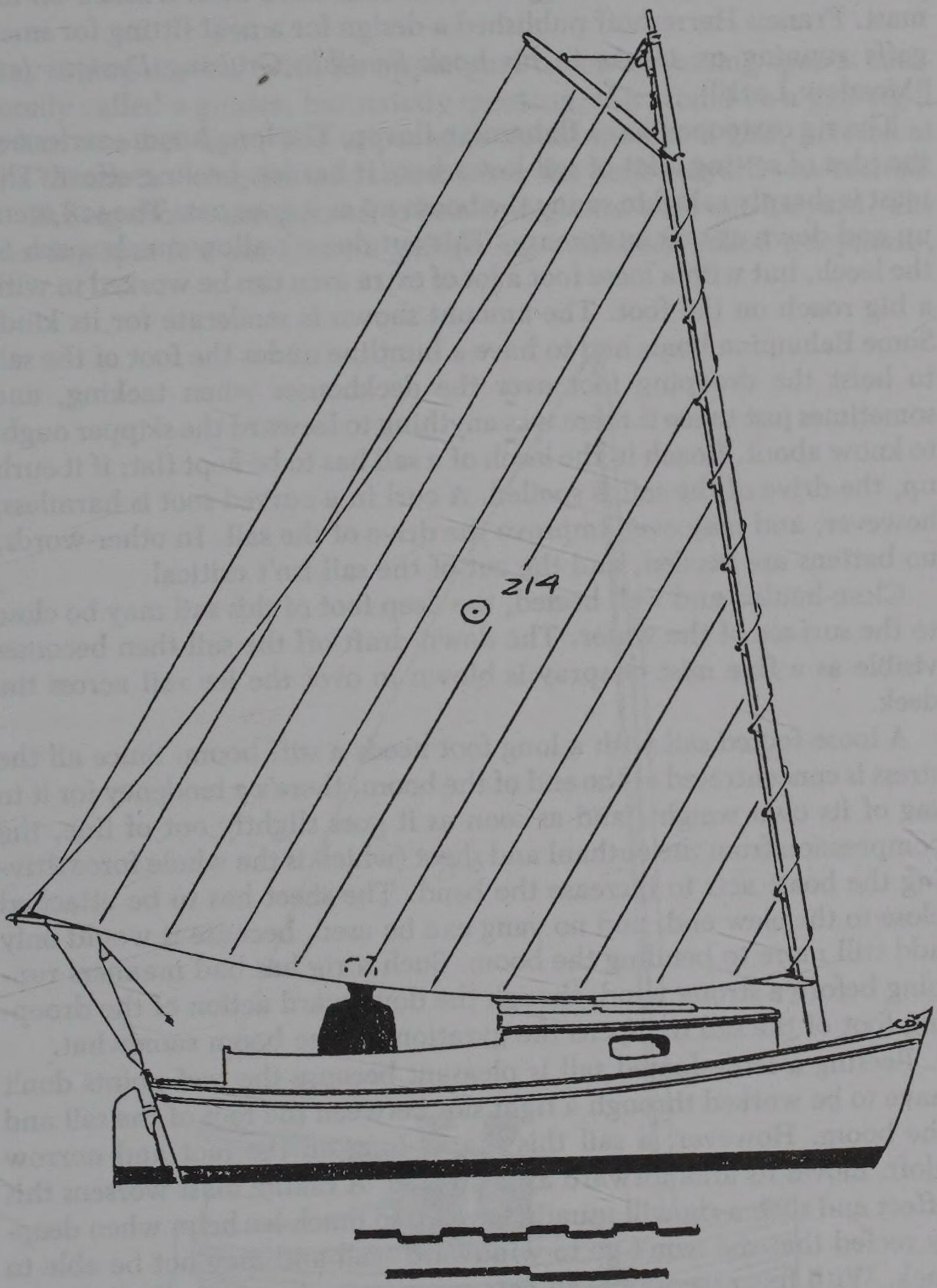
weather. The running gear leads naturally and directly to a place with minimum motion and maximum shelter. The standing rigging is clear of the sail for good trim and no chafe. There's no temptation to cut down the shroud angles (see the section on sloops).

The storm staysail, set flying (that is, not attached to a stay or spar) from the spreader level, is ideally located either for carrying on to windward or for lying-to. A big spinnaker, self-steering twin staysails, or even a squaresail, are all better located for driving and for handling than in a sloop or cutter. The cost and handling problems would be less than with any other rig that had a big staysail. And though it would be a brittle rig, prone to utter disintegration if any of the many components failed, it would be no harder to make it strong than any other stiffly stayed rig. In fact, there would be less penalty involved in some redundant rigging than in a conventional sloop.

RIG 12 Shoulder-o'-mutton

This rig allows the mast to be shorter for the area of the sail than Rig 11. The narrow point at the head of a leg-o'-mutton sail, which can't be shaped to give much drive, is eliminated, and the stress of the halyards is spread over more of the sail. This last hasn't been a serious problem lately, but when jibheaded sails were first coming in on racers, they used to pull the headboards out of their sails. Big ones were more prone to this than small ones. The 1930 J-boats with mainsails weighing tons had half a dozen headboard failures.

The rig sketched is not a true shoulder-o'-mutton. The real thing has only one halyard and is set with an exaggerated headboard. This one is really a gaff sail with throat and peak halyards. The second halyard increases wind resistance and needs an extra block or two, adding to the expense, but it's no more trouble to handle, because the two halyards can be gripped together to hoist and lower. The advantage of having two is that the set of the sail can be adjusted easily and quickly by peaking the gaff more or less. With one halyard, this has to be done by shifting the point of attachment of the halyard to the gaff-cum-headboard (sometimes called headstick).


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In the cartoon, the gaff has jaws and the luff or hoist is attached to the mast with a spiral lacing, but such sails have been tracked on the mast. Francis Herreshoff published a design for a neat fitting for small gaffs running on tracks in his book *Sensible Cruising Designs* (see "Meadow Lark").

The rig cartooned has a Bahamian flavor. The long boom carries out the idea of setting a lot of sail low where it has less heeling effect. The mast is sharply raked to swing the boom up as it goes out. The sail is cut up and down as was customary. This cut doesn't allow much roach to the leech, but with a loose foot a lot of extra area can be worked in with a big roach on the foot. The amount shown is moderate for its kind. Some Bahamian boats had to have a buntline under the foot of the sail to hoist the drooping foot over the deckhouses when tacking, and sometimes just to see if there was anything to leeward the skipper ought to know about. Roach in the leech of a sail has to be kept flat; if it curls up, the drive of the sail is spoiled. A curl in a curved foot is harmless, however, and may even improve the drive of the sail. In other words, no battens are needed, and the cut of the sail isn't critical.

Close-hauled and well heeled, the deep foot of this sail may be close to the surface of the water. The down-draft off the sail then becomes visible as a fine mist of spray is blown in over the lee rail across the deck.

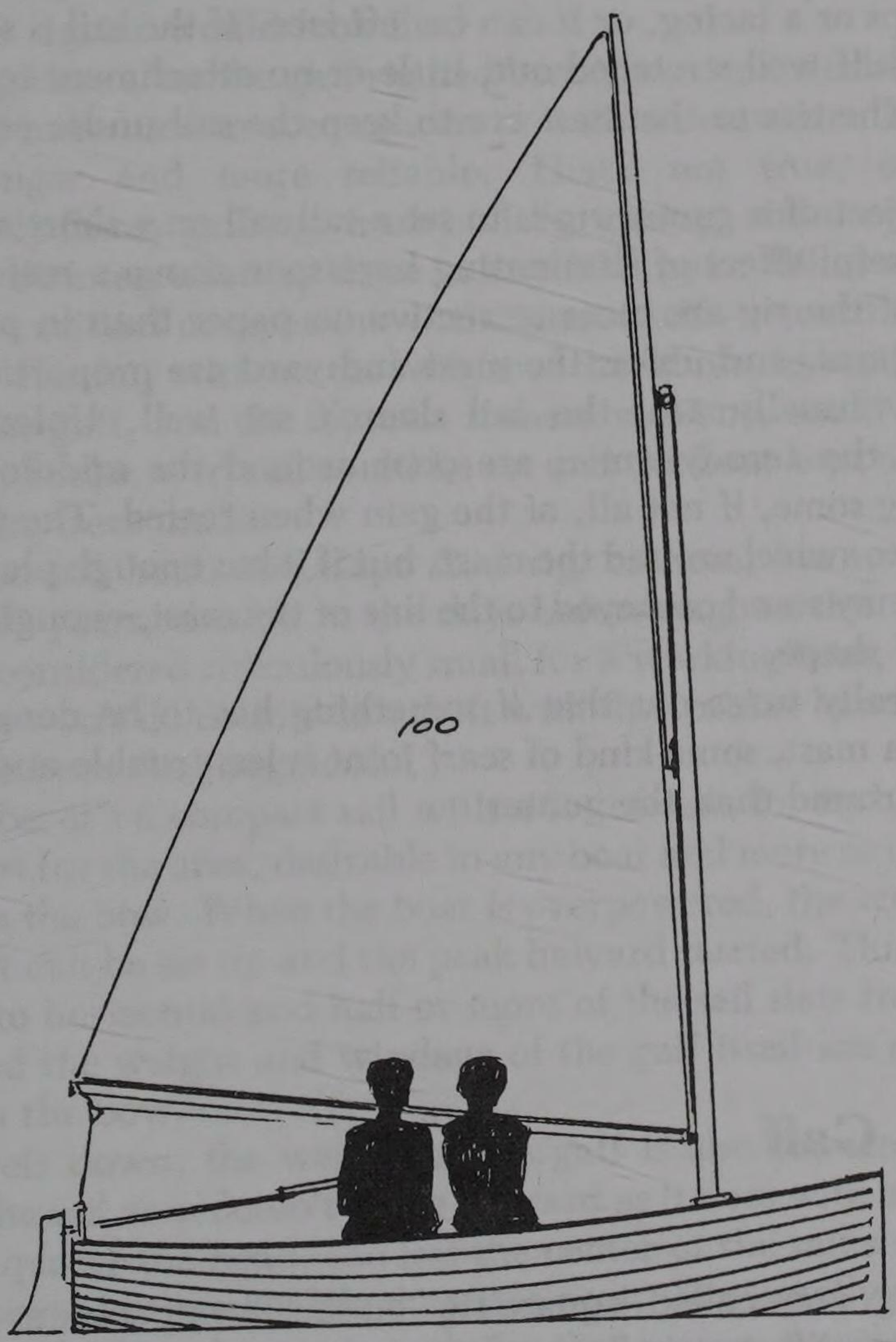
A loose-footed sail with a long foot needs a stiff boom. Since all the stress is concentrated at the end of the boom, there's a tendency for it to sag of its own weight, and as soon as it goes slightly out of line, the compression from the outhaul and sheet (which is the whole force driving the boat) acts to increase the bend. The sheet has to be attached close to the clew end, and no vang can be used, because it would only add still more to bending the boom. Such a rig has bad manners running before a strong wind, though the downward action of the drooping foot of the sail dampens the gyrations of the boom somewhat.

Reefing a loose-footed sail is pleasant because the reef points don't have to be worked through a tight slot between the foot of the sail and the boom. However, a sail this shape, long on the foot and narrow aloft, moves its area forward as it's reefed. A raking mast worsens this effect and such a rig will usually develop so much lee helm when deeply reefed that she won't go to windward well and may not be able to tack. With few exceptions, all cats are more or less prone to this vice.

RIG 13 Gunter

Any triangular sail with its upper part set on a running spar is commonly called a gunter, but strictly speaking, this would be a gaff rig if it had two halyards. The upper spar would then be a gaff, pivoted at the throat to swing out and down when the peak halyard was started.

The rig shown is supposed to be a true gunter with one halyard. The moving spar is a yard, not a gaff (it has even been called a topmast),



and it always stands parallel with the mast. Here it slides up and down on a track, but it is often attached by hoops or collars around the mast. The overlapping part can be much shorter than this one, but the shorter it is, the more likely it is to bind when it ought to slide.

In a sail as small as this one, the head of the sail would be lashed or pinned at the head of the yard. To furl the sail, the yard would be lowered as far as it will go, and the rig would be unstepped, mast and all. A bigger one would have a peak outhaul equivalent to a halyard, with the upper luff sliding on a track or in a slot in the yard. The sail would be set by first hoisting it up the yard, then raising the yard itself. The luff below the yard can be held to the mast with slides to a track, with hoops or a lacing, or it can be left free. If the sail is set properly, with the luff well stretched out, little or no attachment to the mast is needed. The ties to the mast are to keep the sail under control as it's lowered.

The object of a gunter rig is to set a tall sail on a short mast. It also has the useful effect of eliminating bare spar above a reefed sail. The benefits of the rig are more attractive on paper than in practice. It's prone to jams, and unless the mast and yard are proportioned better than they usually are, the sail doesn't set well. Unless the mast oscillates, the aerodynamics are poor around the middle and lower luff, losing some, if not all, of the gain when reefed. The yard can be arranged to swivel around the mast, but if it has enough play to do that freely, it may stand cockeyed to the line of the mast, enough to pull the sail out of shape.

It generally turns out that if something has to be done about the length of a mast, some kind of scarf joint is less trouble and more efficient all around than the gunter.

RIG 14 Gaff

The gaff rig, once called "square rig" on the Chesapeake, as opposed to leg-o'-mutton "sharp rig," was the usual rig in yachts for a couple of hundred years. Around 1915 the gaff-rigged racers began to be outclassed by new boats with marconi rigs, and since then a mythology

has developed that boats with gaff rigs are always slow and never close-winded. The gaff sags, it's said. Sometimes it does, just as the upper part of a leg-o'-mutton sail does, and for the same reason.

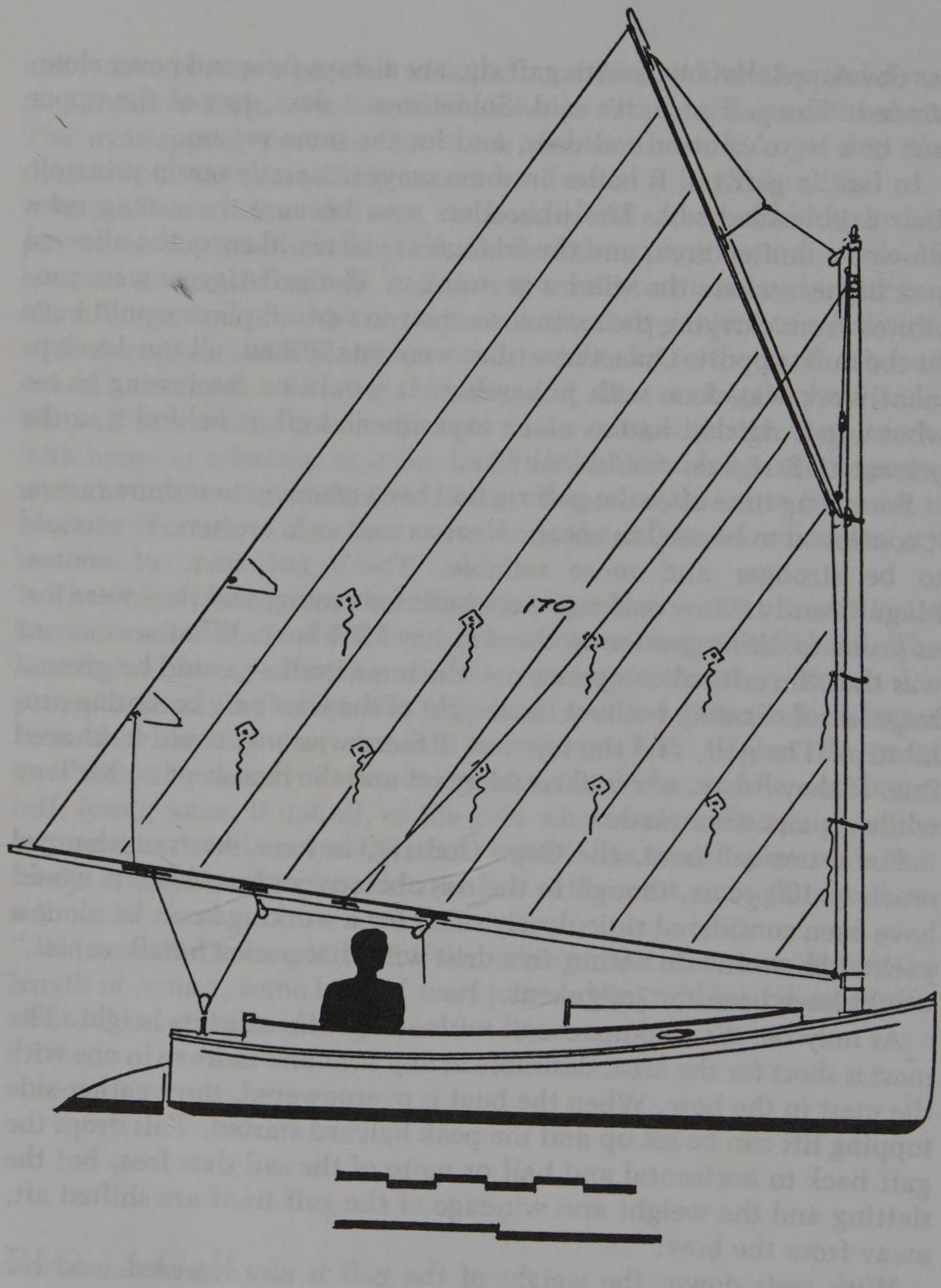
In fact, a gaff sail is better in some ways in aerodynamic principle than a jibheaded sail. The jibheaders won because the racing rules allowed a limited area, and the triangular sail could carry the allowed area higher, where the wind was stronger. The gaff-riggers were prohibited from carrying the extra area their lower sail plans would have let the hull support. Once these rules were established, all the development work was done with jibheaders. It would be interesting to see what a gaff rig that had as much experimental effort behind it as the present IOR rigs do would look like.

For a long time after the gaff rig had been given up in inshore racers, it continued to be used in ocean racers as well as in cruisers. It was said to be stronger and more reliable. That's not true, of course. Magnificently flimsy gaff rigs were built for racing, and they were just as prone to disintegration as those in any IOR boat. What was meant was that the critical component — the mast itself — could be given a huge factor of safety without the weight of the whole rig becoming prohibitive. The gaff, and the topmast if there was one, could be shaved fine. If they broke, a trysail could be set and the boat kept on her way while repairs were made.

For a one-sail boat, the Cape Cod rig, as here, has not changed much in 100 years, though in the days before engines this one would have been considered ridiculously small for a working boat, let alone a yacht. "She won't do nothin' in a drift with that pocket handkerchief," would have been the judgment.

As may be, it's a compact sail with a lot of area for its height. The mast is short for the area, desirable in any boat and more so in one with the mast in the bow. When the boat is overpowered, the weather-side topping lift can be set up and the peak halyard started. This drops the gaff back to horizontal and half or more of the sail slats free, but the slatting and the weight and windage of the gaff itself are shifted aft, away from the bow.

With reefs down, the weight of the gaff is also lowered, and the center of the sail area doesn't move forward as it does with a triangular sail. The squarer the head, the less the center of the sail shifts. When reefing was more a way of life than it is now, they usually didn't peak their gaffs as high as this one, partly for that reason. Another reason is that the squarer the head, the more area can be set on a given length of spars.



The advantage of a high-peaked gaff is the improved lead of the peak halyard. A good rule is that the peak halyard block should be placed where a perpendicular line off the midpoint of the gaff will intersect the mast. If it's lower, as it has to be if the gaff is at a flat angle, the stress on the peak halyard will be increased. Apart from being hard

on the gaff and the masthead, both of which have to be heavier to take it, the halyard is likely to stretch. The stretch lets the peak drop. A ridge appears in the sail from throat to clew, and the upper and after part of the sail falls off. The boat will then neither point high nor foot fast. A good part of the bad reputation of the gaff rig is due to giving them too little masthead, above the jaws, for the peak angle.

Many yachts had the gaff and the hoist run on a track on the mast; they used wooden tracks before there were metal ones. This saved chafing the mast, but the sail gives a little more drive when set with hoops. With a metal mast, the spun street-lamp poles that have come in so handy lately (though they're unpleasantly heavy at the top due to the way they're manufactured), there need be no hesitation about using hoops and jaws. A lot of hoops aren't needed; their important function is to keep the sail under control as it's lowered, and for that, their spacing doesn't need to be less than the breadth of the boat just abaft the mast. Too many hoops make a tall heap that spoils the nice furl otherwise possible with the four-sided sail.

There's also a tendency to use more reef points than there's any need for, though in that case there's some real relief of stress on the sail. The number shown here is conservative for a small sail. In fact, a modern sail this size will easily hold without any points tied in.

The gaff here has a metal saddle, sheathed with leather, instead of jaws on the gaff. A saddle can be constructed to take eccentric stresses that often break jaws. It's also quieter and has less tendency to chafe the mast. But it's hard to design a saddle that doesn't get jammed around with an edge or back against the mast. It's often not appreciated that unless the gaff is set at a flat angle to a too-short masthead, the gaff is not thrusting against the mast at all when the sail is full and drawing. The action of the sail tends to pull the gaff away from the mast, and a saddle has to be proportioned to ride loosely without getting trapped at the wrong angle.

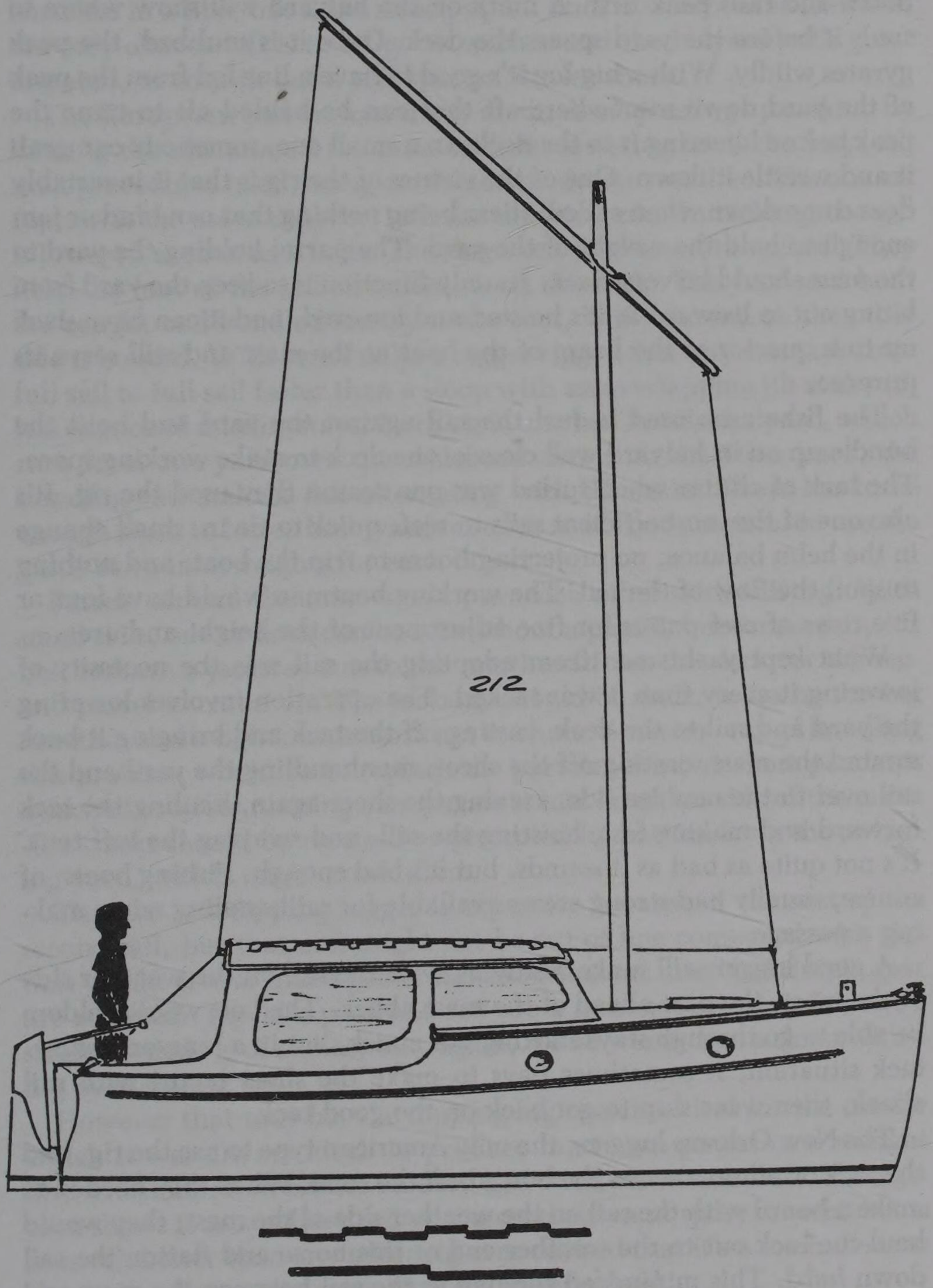
This sail would have the vice of lifting at the clew before the wind. Sprit booms are possible, but the snotter lead is clumsy and the boom hard to control for reefing. There's no room here for a vang. Nathanael Herreshoff sometimes set a strut diagonally across the tack to hold the boom down, but he had trouble making his customers use it. A long, heavy boom suppresses the problem in moderate weather, but the harder the wind, the less effective the weight; hence, the bad behavior of cats when driven hard off the wind. It's surprising how well the "hard-mouthed cat" will steer if you can hold her boom down where it belongs.

RIG 15 Dipping lug

All through the 19th century the dipping lug was the characteristic sail of the British Isles and the west coast of France, between the squaresails of Scandinavia and the lateeners of Spain. Even in its homeland it wasn't used for pleasure boats, but swarms of fishermen, surfmen, and pilots used it until they could get engines. Then it died, leaving a formidable legend behind it. It was the most powerful windward sail possible with primitive technology. It wasn't improved on until the advent of 1 x 19 wire and reliable swaged terminals made it possible for big staysails to stand close-hauled. And although a lugger can't go to windward with a space-age sloop, the sloop can't match the lugger for low first cost, easy maintenance, little wind resistance with sails lowered, and low bridge clearance.

A dipping lug is essentially a big jib with the top cut off, set flying. The luff is kept taut by the weight of the long, upper part of the yard. For this action to be effective, the luff shouldn't be too long relative to the length of the yard. This one is about as tall as is workable, and most were broader for their height. The longer the luff relative to the length of the yard, the farther below the midpoint of the yard the halyard should be attached; one-third to two-fifths of the overall length of the yard is the normal range. The tack pendant forms a straight extension of the line of the luff to the deck and should be as short as possible. A long tack pendant allows the tension along the foot of the sail to pull the tack aft; hence, the clew will rise, the sheet angle will become too low, and the flow of the sail will be distorted.

It's sheeted in the same fashion as any boomless sail, but it's easier to get good sheeting geometry if, as in the cartoon, the tack is well back from the stem. The sheeting angle is measured from a line parallel with the boat centerline, but taken from the tack of the sail, not from the mast. In a lugger like this one, the tack can be hauled out to a point to windward of the centerline and so can be sheeted to a point farther inboard at the clew end. The effect can't be carried to extremes because the yard is pivoting on the mast and the sail has to go around the lee side of the mast in a minimum close-hauled sweep, but it can be helpful. Before the wind, the tack can be brought down to the weather rail abreast of the mast, allowing more of the sail to draw than is usual with boomless sails. The tack does need a solid anchorage. If it isn't held hard, the peak of the yard will sag and the sail will go out of shape.


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When the halyard is slacked to lower the sail, the yard turns upside down and falls peak first. A mark on the halyard will show where to snub it before the yard spears the deck. Once it is snubbed, the peak gyrates wildly. With a big lug it's good to have a line led from the peak of the yard down somewhere aft that can be hauled aft to tame the peak before lowering it to the deck. In a small one, somebody can grab it and wrestle it down. One of the virtues of the rig is that it invariably does come down when called, there being nothing that can bind or jam enough to hold the weight of the yard. The parrel holding the yard to the mast should be very slack. Its only function is to keep the yard from kiting out to leeward as it's hoisted and lowered, and it can have slack up to a quarter of the beam of the boat at the mast and still serve its purpose.

The fishermen used to furl the sail against the yard and hoist the bundle up on its halyard well clear of the deck to make working space. The lack of clutter when furled was one reason they used the rig. It's also one of the most efficient sails to reef: quick to tie in, small change in the helm balance, no projecting boom to trip the boat, and nothing to spoil the flow of the sail. The working boatmen would have four or five rows of reef points for fine adjustment of the height and area.

What kept yachtsmen from adopting the sail was the necessity of lowering it every time it was tacked. The operation involves lowering the yard and sail to the deck, casting off the tack and bringing it back around the mast, casting off the sheet, manhandling the yard and the sail over to the new lee side, reeving the sheet again, hauling the tack forward and making fast, hoisting the sail, and swaying the luff taut. It's not quite as bad as it sounds, but it's bad enough. Fishing boats, of course, usually had strong crews available for sailhandling when making a passage.

A good lugger will make headway with the sail on the weather side of the mast, the part ahead of the mast aback. The best would seldom be able to go through stays starting sail aback, but in a long-and-short-tack situation, it sometimes pays to make the short board with sail aback, then wear ship to get back on the good tack.

The New Orleans luggers, the only American type to use the rig, had the tack on a horse across the bow abaft the stem. When they needed to make a board with the sail on the weather side of the mast, they would haul the tack out to the weather end of this horse and flatten the sail down hard. This minimized the bag in the sail between the mast and the luff as long as no overpowering squall struck. If caught by a squall in this condition, the maneuver is to up helm and pay off before the

wind as fast as possible. The dipping lug is docile before the wind and harmless in a jibe, but if the strong squall finds no searoom to leeward, the only chance left is to let go an anchor and the halyard with great dispatch, or to pick out a soft spot on the lee shore.

The Europeans had various tricky methods of speeding up tacking by hauling the sail around the mast without lowering it all the way. All such procedures need strong crews and moderate weather. The one exception is the use of separate sails for the two tacks. In tacking, the sail is lowered as soon as it luffs. The sheet and tack are not touched. They hold the foot of the sail stretched along the deck. The yard and bunt are caught and bundled loosely to the foot, while the sail on the other side is hoisted. With small sails, a lugger rigged this way can tack from full sail to full sail faster than a sloop with an overlapping jib and with less chance of missing stays. Nothing is touched but the halyard, which runs from one yard over the masthead sheave to the other yard, the standing end and the fall alternating with the tacks. There has to be enough slack to lower both yards at once so it's not practical to use the yards as counterweights for each other.

Parrels around the mast won't pass each other with this rig. With small sails, one or both can be set without a parrel, but for security it's best to have a jackstay run to the masthead from the deck for the second parrel to travel on. The jackstay should be slack; it has no staying function and a tight one is more apt to chafe. A neater way of handling this problem would be to replace the parrels with two short pendants attached to slides running on separate tracks on either side of the mast. The tracks should be recessed or protected by battens from the swinging yard, which might crush them.

The two-sail dipping lugger is expensive because of the cost of the second sail, but that cost might not be out of line compared with rigs that would give as much performance. The short mast and simple gear are retained. The idle yard and sail are a nuisance on deck. It's not a singlehanded rig of choice, but, again, it's no worse than a sloop with a big overlapping jib.

However that may be, the dipping lug remains ideal for the use for which it was always ideal: to produce maximum power in a straight line with minimum clutter on deck and wind resistance aloft. The cartoon shows it as auxiliary sail on a motorboat, a purpose for which it is so much better than any other rig ever devised that it's a monument to the rarity of common sense that it's so little used.

RIG 16 Standing lug

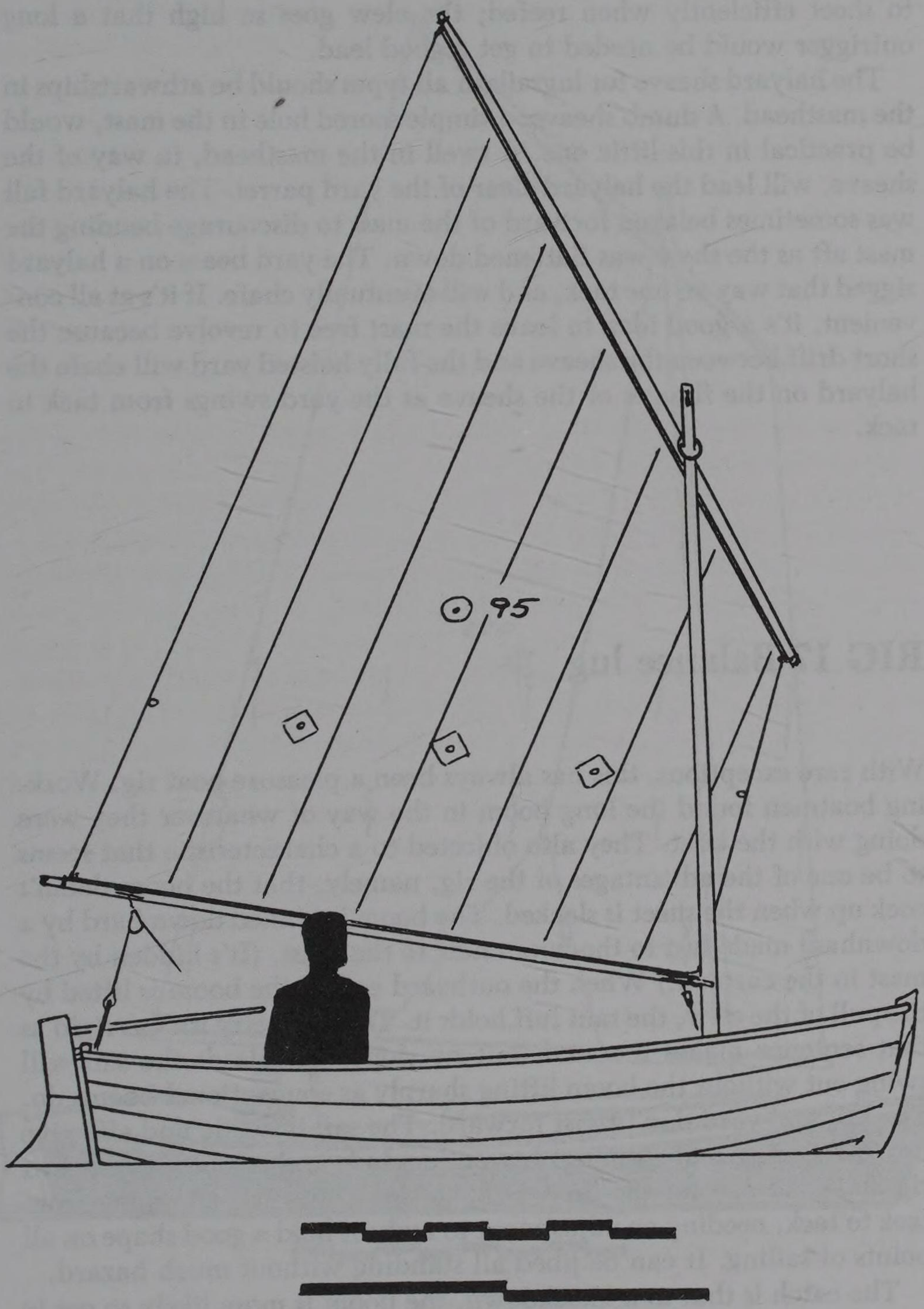
Sometimes when the crew of a dipping lug grew aged and decrepit, they would rerig the boat as a standing lug. Then they would fish closer to home, tacking more but not sailing as fast or as far. Because this sail stands closer to the mast, which spoils the airflow, especially when the sail is on the weather side of the mast, it doesn't develop the driving power of the dipping lug. If the areas are similar, the mast of a standing lug will be farther forward, and the weight and windage there will make the boat slower in rough water and generally less seaworthy.

A standing lug is at least as effective as a gaff sail, and its gear is simpler. The sail and yard can be detached quickly from the mast. The corollary is that the lug is more likely to get out of control in hoisting and lowering. The yard turns over and hangs peak down when the halyard is let go. The rig was a common choice for yacht tenders with rigs small enough to be manhandled casually. There was never much interest among pleasure boatmen in imitating a Manx nobby fishing boat with a 35-foot yard on her standing lug, even though the nobby might have been converted from a nickie with a dipping lug to make her easier to handle. A big standing lug is a docile sail when it's fully set, but it needs good judgment and quick reflexes to set and take in, in heavy weather.

The small ones were popular for dinghies because all the spars could be short enough to stow inside the boat. The cartoon represents a 13½-foot dinghy with a 95-square-foot sail. Her longest spar is the 12½-foot mast. The equivalent gaff sail would need a much longer mast, to say nothing about the requirements of jibheaded sails. The yard is 12 feet long, and the shape of the sail allows a neat furl with yard and boom attached ready for use. Two people can rig a boat like this in seconds, from everything below the gunwale to sail full and drawing.

Standing lugs can be boomless, loose-footed on a boom, bent to a boom as in the cartoon, or fitted with a sprit boom. The latter is set on the opposite side of the mast from the yard and sail, and interferes less with the set of the sail than a sprit boom on a gaff or a leg-o'-mutton sail, but the snotter and usually a heel lift as well spoil the simplicity that is the main advantage of the rig.

Standing lugs are easy and quick to reef. When the reef tack pendant is hauled down, the yard is peaked more than with full sail. This in turn cocks the boom up, which is desirable in heavy weather but usual-


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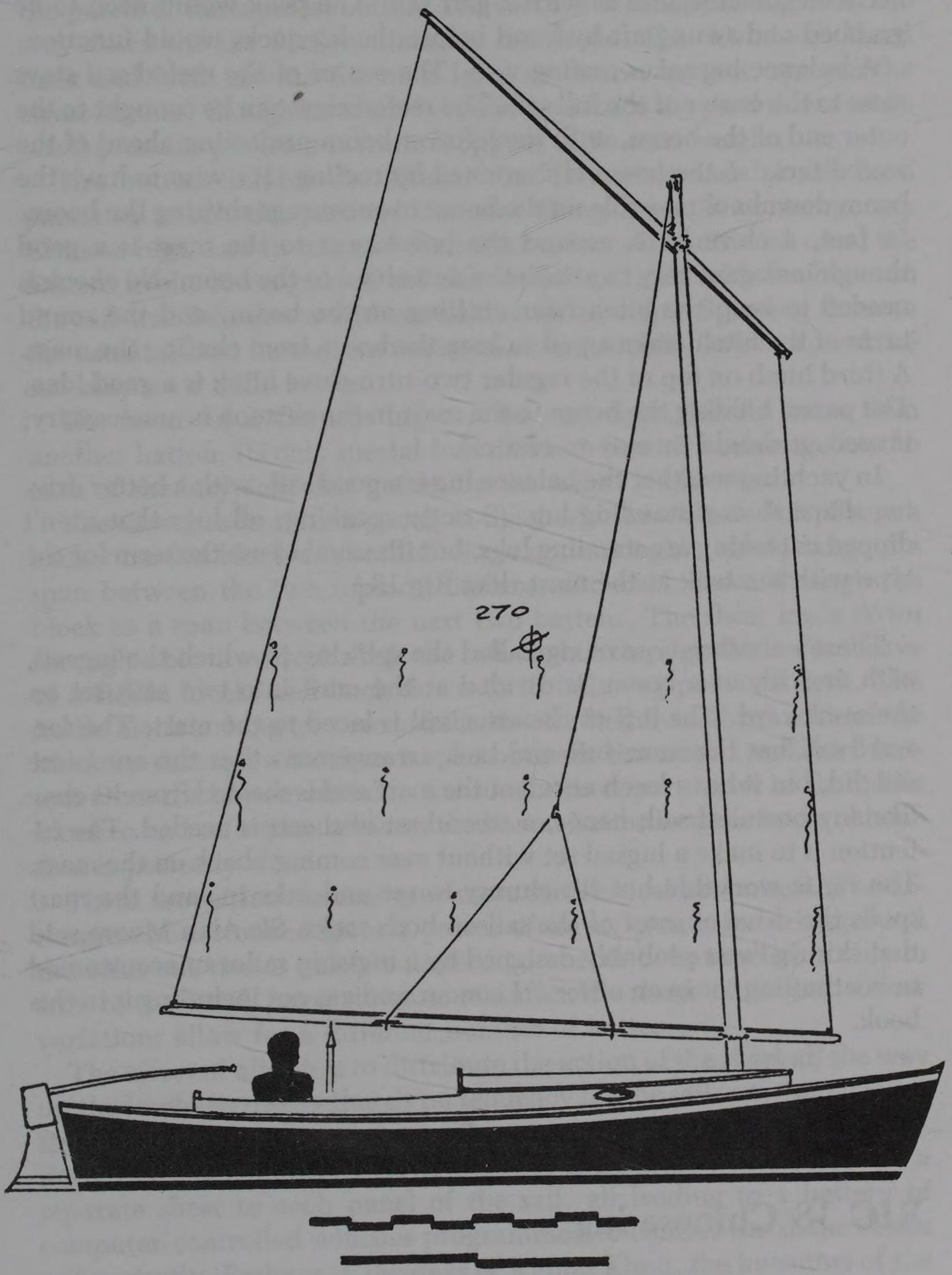
ly hurts the set of the sail more or less. A boomless standing lug is hard to sheet efficiently when reefed; the clew goes so high that a long outrigger would be needed to get a good lead.

The halyard sheave for lugsails of all types should be athwartships in the masthead. A dumb sheave, a simple scored hole in the mast, would be practical in this little one. A swell in the masthead, in way of the sheave, will lead the halyard clear of the yard parrel. The halyard fall was sometimes belayed forward of the mast to discourage bending the mast aft as the sheet was flattened down. The yard bears on a halyard rigged that way on one tack, and will eventually chafe. If it's at all convenient, it's a good idea to leave the mast free to revolve because the short drift between the sheave and the fully hoisted yard will chafe the halyard on the flanges of the sheave as the yard swings from tack to tack.

RIG 17 Balance lug

With rare exceptions, this has always been a pleasure boat rig. Working boatmen found the long boom in the way of whatever they were doing with the boat. They also objected to a characteristic that seems to be one of the advantages of the rig, namely, that the boom doesn't cock up when the sheet is slacked. The boom is pinned down hard by a downhaul made fast to the boom next to the mast. (It's hidden by the mast in the cartoon.) When the outboard end of the boom is lifted by the pull of the clew, the taut luff holds it. The geometry isn't as rigid as that sentence makes it sound, but by sloppy standards the sail will swing out without the boom lifting sharply as conventional booms do. The sail and yard don't twist forward. The sail is docile and effective broad-reaching and running. In gentle winds and smooth water, this rig is a good one for the lazy; light to sheet, and self-trimming from tack to tack, needing no adjustment to make it hold a good shape on all points of sailing. It can be jibed all standing without much hazard.

The catch is that in a knockdown, the boom is more likely to get in the water and trip the boat. Also, in lowering, the yard comes down on end as with other lugsails. The cartoon shows lazyjacks on the sail to


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gather up the bunt, but in fact the yard won't come down naturally between the lazyjacks as with a gaff sail. The peak would need to be grabbed and swung aft by hand before the lazyjacks would function.

A balance lug takes reefing well. The center of the reefed sail stays close to the center of the full sail. The reefed clew can be brought to the outer end of the boom, with the leftover boom projecting ahead of the reefed tack, so the boom is shortened by reefing. It's wise to have the boom downhaul movable on the boom to encourage shifting the boom. In fact, a clove hitch around the boom next to the mast is a good though inelegant way to attach the downhaul to the boom. No chock is needed to keep the hitch from shifting on the boom, and the round turns of the hitch make a pad to keep the boom from chafing the mast. A third hitch on top of the regular two-turn clove hitch is a good idea. The parrel holding the boom to the mast in the cartoon is unnecessary; if used, it should be easy to cast off.

In yachting weather the balance lug is a good sail, with a better driving shape than a standing lug. (Strictly speaking, all lugs that aren't dipped in tacking are standing lugs, but it's usual to use the term for the type with the tack at the mast, like Rig 16.)

There's another type of rig called the split lug in which the lugsail, with or without a boom, is divided at the mast into two sails set on the same yard. The luff of the after sail is laced to the mast. The forward sail has the same luff and tack arrangement that the one-piece sail did, but it has a leech ahead of the mast and is sheeted from its clew like any boomless sail; hence, a second set of sheets is needed. The intention is to make a lugsail set without ever coming aback on the mast. The rig is workable but it's clumsy to set and take in, and the mast spoils the drive of most of the sail on both tacks. Sir Alan Moore said that this rig "was probably designed by a big-ship sailor unaccustomed to boat sailing, or in an office." I concur and am not including it in this book.

RIG 18 Chinese lug

This rig is designed to control all the parts that get away in other lugsails. The yard is not peaked by tension the full length of the luff as

in other lugs. It's held up by the fabric between the foot of the yard and the parrel of the topmost batten. The successive similar triangles all the way down the sail further maintain the shape. The downhaul, laced back and forth around the mast from successive battens, spreads the stress further, though its main function is to force the yard down when wind pressure prevents it from dropping of its own weight.

The battens inhibit the fabric from fluttering and furnish hard points to attach the parts of the controlling lines. In contemporary Chinese lugs, and in some of the wide variety of traditional ones, the battens in the lower part of the sail are run parallel with the boom so the sail will fold down without distorting its shape. Splaying them to the extent shown here doesn't seem to cause trouble, however, and the sail may set a trifle better.

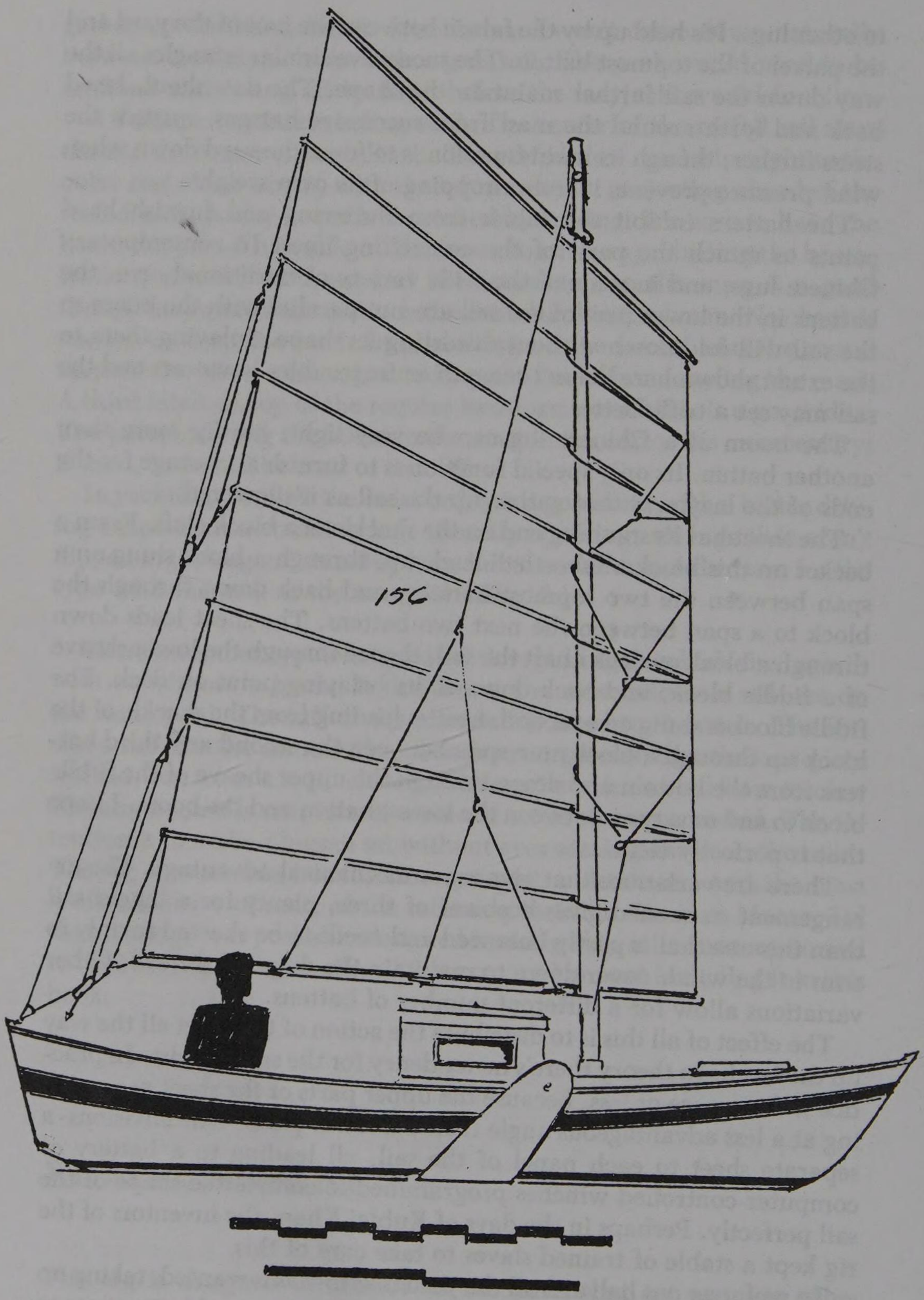
The boom of a Chinese lug can be very light, hardly more than another batten. Its only special function is to furnish anchorage for the ends of the lazyjacks that gather up the sail as it's lowered.

The sheet has its standing end on the shackle of a block aloft. From a becket on this block a "sheetlet" leads up, through a block slung on a span between the two topmost battens, and back down through the block to a span between the next two battens. The sheet leads down through a block on deck abaft the sail, thence through the lower sheave of a fiddle block, and back down to its belaying point on deck. The fiddle block is slung on a second sheetlet leading from the shackle of the block up through a block on a span between the second and third battens from the bottom and down through the upper sheave of the fiddle block to end on a span between the lowest batten and the boom. I hope that is perfectly clear . . . .

There are variations that give more mechanical advantage. The arrangement cartooned gives a power of three, plenty for a bigger sail than this one that is partly balanced and needs to be sheeted in only to trim to the wind, never down to maintain the shape of the sail. Other variations allow for a different number of battens.

The effect of all this is to distribute the action of the sheet all the way up the leech. In theory there's no tendency for the sail to twist. In practice it does more or less, because the upper parts of the sheet are working at a less advantageous angle than the lower parts. One envisions a separate sheet to each panel of the sail, all leading to a battery of computer-controlled winches programmed to control the shape of the sail perfectly. Perhaps in the days of Kublai Khan, the inventors of the rig kept a stable of trained slaves to take care of this.

To reef, pay out halyard till the yard is as low as is wanted, taking up on the downhaul if necessary to pull the yard down, and in any case to


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hold it down. The sheet will go slack as the sail comes down. Take up on it till the fiddle block is brought up against the deck block; then catch a turn to hold it and take up on the lower sheetlet. In a big lug this would be part of the sheet proper and the hauling down would be a continuous operation, but in a small sail, there would be so many parts in the sheet that its length would be intolerable. If the deck block can be placed far enough abaft the sail, the sheetlet adjustment can be eliminated, but usually there isn't room. A far-aft deck block also improves the control of the upper panels of the sail.

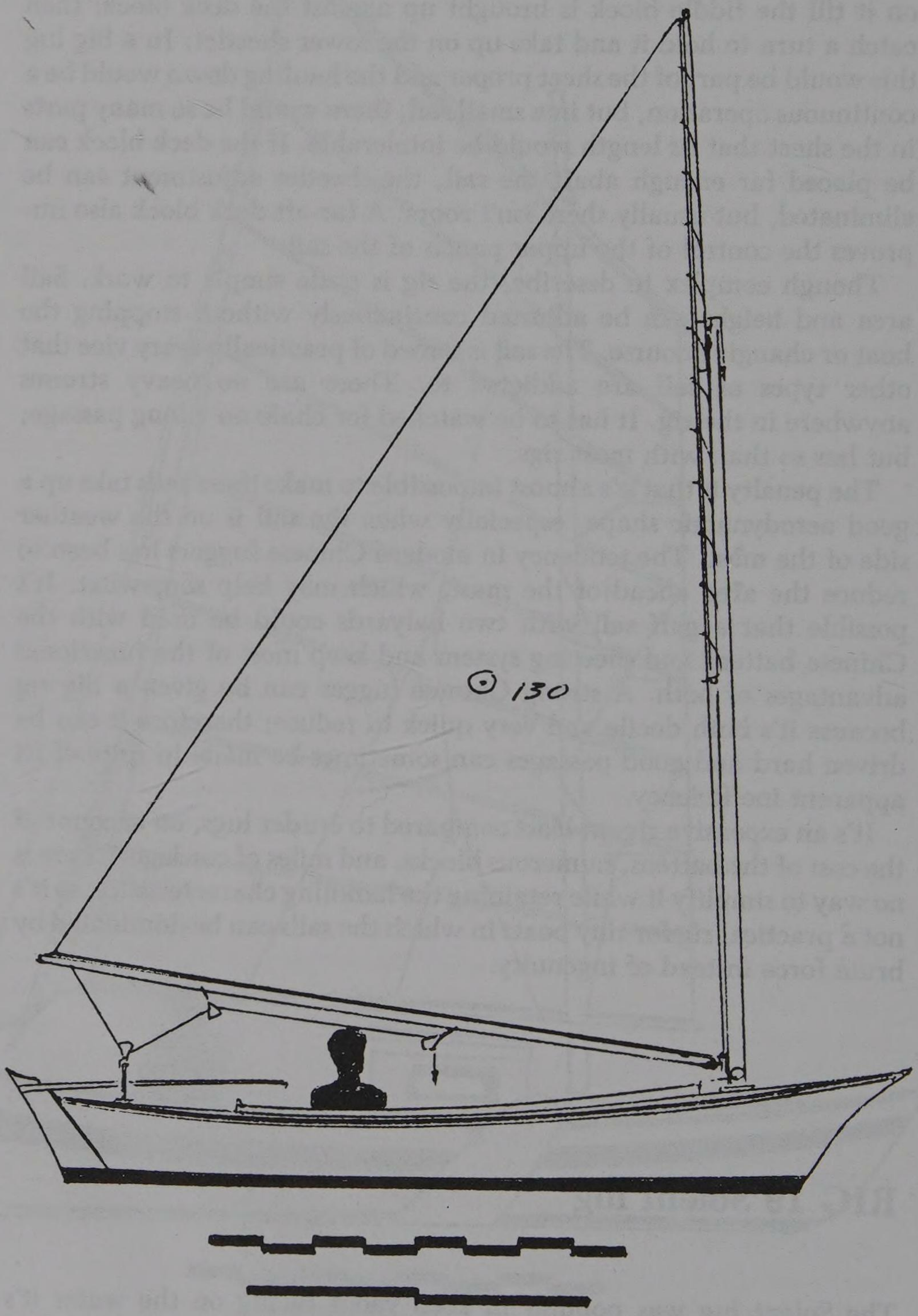
Though complex to describe, the rig is quite simple to work. Sail area and height can be adjusted continuously without stopping the boat or changing course. The sail is tamed of practically every vice that other types of sail are addicted to. There are no heavy stresses anywhere in the rig. It has to be watched for chafe on a long passage, but less so than with most rigs.

The penalty is that it's almost impossible to make these sails take up a good aerodynamic shape, especially when the sail is on the weather side of the mast. The tendency in modern Chinese luggers has been to reduce the area ahead of the mast, which may help somewhat. It's possible that a gaff sail with two halyards could be used with the Chinese battens and sheeting system and keep most of the functional advantages of both. A strong Chinese lugger can be given a big rig because it's both docile and very quick to reduce; therefore it can be driven hard and good passages can sometimes be made in spite of its apparent inefficiency.

It's an expensive rig, at least compared to cruder lugs, on account of the cost of the battens, numerous blocks, and miles of cordage. There is no way to simplify it while retaining the handling characteristics, so it's not a practical rig for tiny boats in which the sails can be dominated by brute force instead of ingenuity.

RIG 19 Solent lug

The Solent lug was popular in keen yacht racing on the water it's named for. It competed on at least even terms with highly developed


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gaff rigs and with a few primitive marconi rigs in the last years of the 19th century.

It looks like a gunter at first glance, but it's a true lug with one halyard and no attachment of the luff of the sail to the mast. It differs from other lugs in having the yard slung above its center of gravity. The yard hangs vertically regardless of tension on the luff of the sail. No parrel is used. To hoist, the heel of the yard is held at the tack until the yard has been raised enough to hang clear above the boom. Then it's released and the yard hoisted vertically up snug against the masthead sheave.

The yard can be very long, the mast correspondingly short. The limit on the length of yard is the depth of reef, which is the length of luff below the foot of the yard when the sail is fully hoisted. A yard two-thirds of the total hoist with full sail is average. To reef, the yard has to be lowered all the way down flat and the halyard shifted to a higher point on the yard. With maximum reefs there is no free luff, and the peak of the yard is almost level with the masthead, an efficient arrangement except that the yard is likely to bow aft as the luff (properly the head, but since the true luff and the head of the sail are one straight line, the distinction is more confusing than useful) pulls aft on it. If the yard bows, it will throw more draft into the sail just when it should have been flattened to suit the strong wind that induced the reef. While the yard can be held with a running bight of light line around the mast made fast at the full-sail halyard attachment point, it's simpler to make sure the yard is stiff. This isn't a rig that benefits by flexible spars in any case, and it suffers less than most from overweight spars.

The rig has the same defects for cat-rigged boats as the leg-o'-mutton. The sail is high or the boom long, or both, for the possible area, and when it's reefed, the remaining sail is too far forward.

It is the only lugsail that works well on a stayed mast, since the vertically moving yard works clear of shrouds and stays. For this reason it was used mostly in sloops rather than cats.

A sprit boom could be used more simply with this rig than in most lugs because there's no yard parrel traveling on the mast. The attachment for the boom or its snotter can be fixed permanently on the mast, as high as is wanted. The gear for the boom is as simple as with the rigs that have no halyard or that run the sail on a track, and there's no need to protect a track from being crushed by the boom. A little care is needed in lowering to make sure the heel of the yard doesn't hook the boom as it comes down.

If a conventional boom on the foot of the sail is used as in the cartoon, it needs some vertical adjustment to set the luff of the sail up taut, since the halyard has to be kept hoisted as far as it will go. In the cartoon there's supposed to be a short slide for the gooseneck. Jaws are usually better but need a round or nearly round mast.

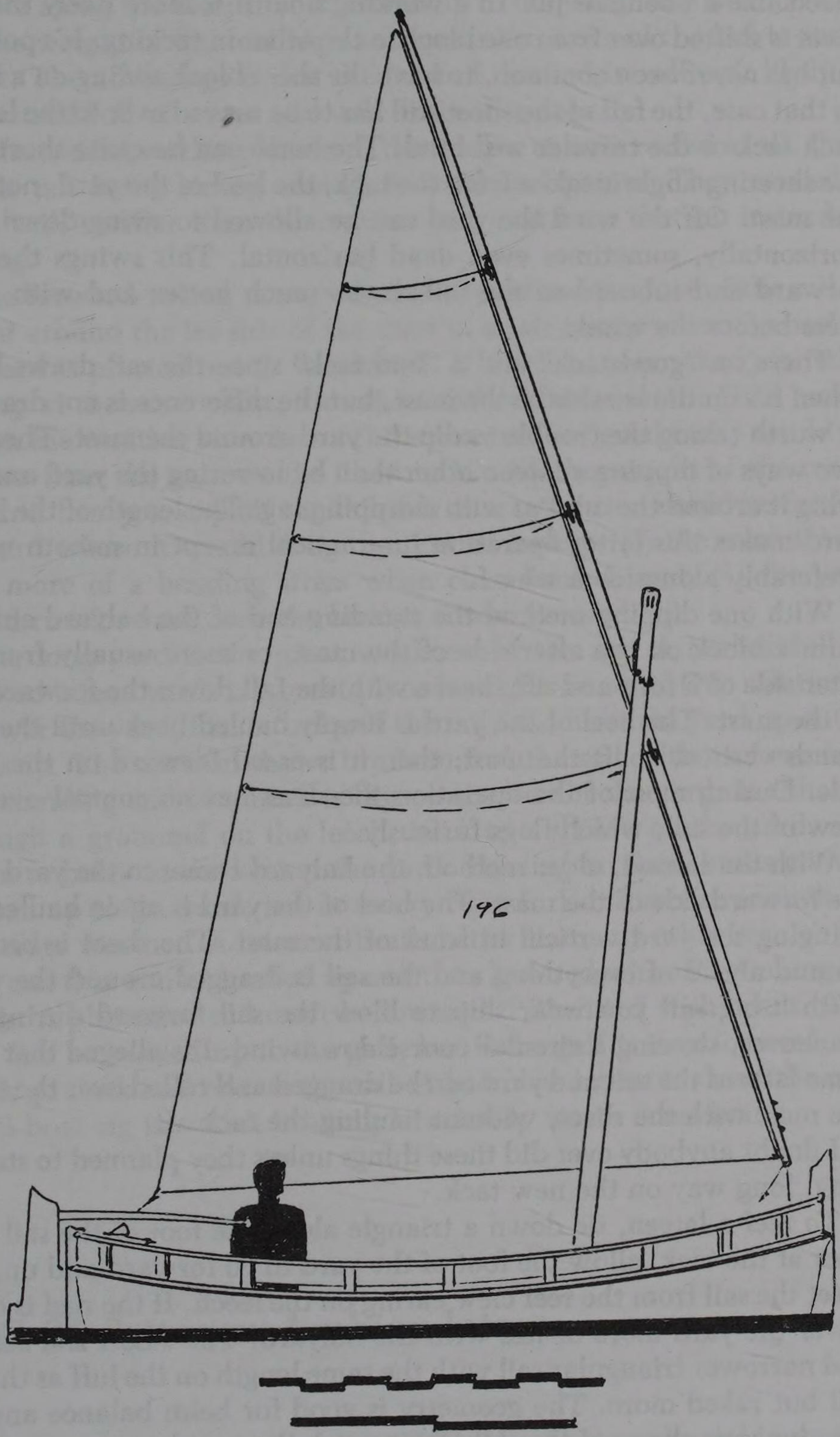
RIG 20 Lateen

The classical lateen is the most graceful of all rigs. It's the lightest and simplest of the very tall rigs. Its yard is considerably shorter and lighter than a mast setting a boomless leg-o'-mutton sail, since it's supported at one-third of its length instead of at the lower end. The head of the yard can be slender because there's no stress from a halyard, so the narrow head of the sail has more driving power than one set on a thicker mast.

The yard can be very flexible since the bend works to flatten the sail in the right way for a strengthening wind. There is some fail-safe quality in any case. A broken lateen yard doesn't leave the boat as helpless as a broken mast does in a jibheader. Some makeshift device can be contrived to hoist on the stubby mast, which never breaks. It's customary to abuse this characteristic, so, historically, a great many lateen yards have been broken.

The sail is easier to sheet efficiently than most boomless sails as the tack can be pivoted out to windward. Traditional lateeners use two or more guys to position the yard, shifting them when tacking and for different points of sailing. The yard is slung at about a third of its length. Some special types had it much lower, but if this is done, there's generally a counterweight on the foot of the yard. The lower the yard is slung, the shorter the mast can be — say, to go under a bridge — but the one-third position is best to get the right shape of bend to flatten the sail. The foot of the yard can be guyed back to the mast to make it pivot around the mast in one plane without adjustment, but this was never done in workboats. There was usually some gear in the way, and working boatmen didn't worry as much about chores like shifting the heel guys as yachtsmen do.

The boat in the cartoon has a sheet block on each quarter and two


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sheets like a boomless jib. In a working boat it is more likely that one sheet is shifted over from one block to the other in tacking. It's possible, but has never been common, to have the sheet block sliding on a horse. In that case, the fall of the sheet still has to be moved over to the lee side each tack or the traveler will bind. The horse can be quite short since the sheeting angle is taken from the tack, the heel of the yard, not from the mast. Off the wind the yard can be allowed to swing down more horizontally, sometimes even dead horizontal. This swings the clew forward and inboard so the sail draws much better and with fewer vices before the wind.

There's a "good tack" and a "bad tack" since the sail draws better when it's on the lee side of the mast, but the difference is not dramatic or worth taking the trouble to dip the yard around the mast. There are two ways of dipping a lateen other than by lowering the yard and carrying it around the mast as with a dipping lug. The length of the lateen yard makes this latter operation impractical except in smooth water, preferably alongside a wharf.

With one dipping method the standing end of the halyard emerges from a block on the after side of the mast, or more usually from the after side of a fore-and-aft sheave with the fall down the forward side of the mast. The heel of the yard is simply hauled back until the yard stands vertical abaft the mast; then it is eased forward on the other side. During most of the operation the sheet has no control over the clew of the sail, which flogs furiously.

With the second, older method, the halyard comes to the yard from the forward side of the mast. The heel of the yard is again hauled aft, bringing the yard vertical in front of the mast. The sheet is brought around ahead of everything and the sail is dragged around the yard. With a big sail you wear ship to blow the sail forward during this maneuver, steering a circular course downwind. It's alleged that with some lateens the sail and yard can be dragged and rolled over the top of the mast with the sheet, without hauling the tack aft.

I doubt anybody ever did these things unless they planned to stand a long, long way on the new tack.

To reef a lateen, tie down a triangle along the foot of the sail with apex at the tack, allow the foot of the yard to go forward and up, and sheet the sail from the reef clew earing on the leech. If the reef is deep, lower the yard more or less with the halyard. The result is a smaller and narrower triangular sail with the same length on the luff as the full sail but raked more. The geometry is good for helm balance and the aerodynamic shape of the sail is not much degraded.

Working lateeners usually are reefed in a triangle along the yard in-

stead of along the foot; that is, reefed up to the yard. This method carries the weight of the reef high and spoils the drive of the sail to some extent. The advantage is that the bunt of the tied-in reef isn't likely to scoop itself full of water and will drain if it does so.

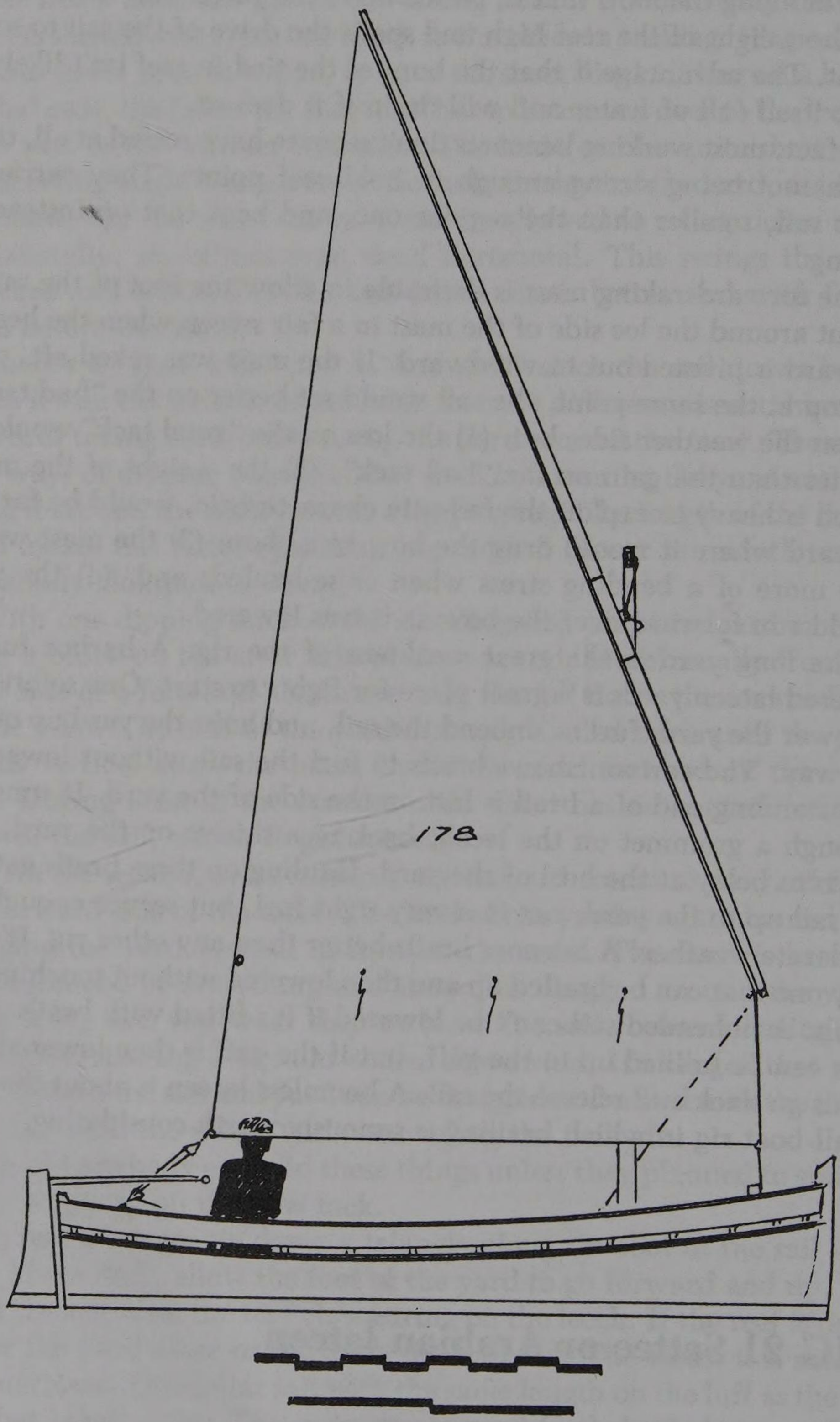
In fact, most working lateeners don't seem to have reefed at all, their canvas not being strong enough to hold reef points. They carried a spare sail, smaller than the regular one, and bent that on instead of reefing.

The forward-raking mast is desirable to allow the foot of the sail to go out around the lee side of the mast in a fair sweep when the heel of the yard is pivoted out to windward. If the mast was raked aft, with the top at the same point, the sail would set better on the "bad tack," sail on the weather side, but: (1) the loss on the "good tack" would be greater than the gain on the "bad tack"; (2) the weight of the mast, which is heavy to exploit the fail-safe characteristic, would be farther forward where it would drug the bow in a chop; (3) the mast would take more of a bending stress when close-hauled; and, (4) the yard would run forward over the bow as it was lowered.

The long yard is the great weakness of the rig. A harbor full of lowered lateen yards is a great place for fights to start. One solution is to lower the yard, furl or unbend the sail, and hoist the yard up out of the way. The cartoon shows brails to furl the sail without lowering. The standing end of a brail is fast on the side of the yard. It runs out through a grommet on the leech, back to a sheave on the yard, and down to belay at the heel of the yard. Hauling on these brails gathers the sail up to the yard, not in a very tight furl, but secure enough for moderate weather. A lateener brails better than any other rig. It's the only one that can be brailed up and then lowered without touching the brails. A jibheaded sail can't be lowered if it's fitted with brails. Gaff sails can be brailed up to the gaff, but if the gaff is then lowered, the brails go slack and release the sail. A boomless lateen is about the only small-boat rig in which brailing is seriously worth considering.

RIG 21 Settee or Arabian lateen

Exactly when a settee with a long luff and a short yard would turn into a dipping lug with a long yard and a short luff defies precise definition.


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The distinction ought to be that the settee retains the guys on the heel of the yard, controlling the peak angle and swing, but modern, perhaps decadent, settee rigs often don't have guys and control the yard from the tack of the sail. In fact, historically the luff has always been so short that there's no confusion.

The yard is shorter and lighter than that of a full lateen. It's easier to dip around the mast but is rarely dipped since it sets fairly well on the bad tack. It works best in full-bowed boats in which the tack can be moved out to windward of the boat's centerline on the bad tack, or on both tacks if there's any problem getting a good sheeting angle to the quarters.

This sail is faster than the full lateen due to the good airflow past the free luff, and to the fact that the yard can be a little lighter and slimmer. The difference doesn't amount to much.

The settee is potentially a good reefing sail, with good helm balance and minimum wind resistance. The working types don't have reef points, however, because the sailcloth available isn't strong enough to stand the stress. A sail can be badly strained by unevenly tied reef points, the extreme case being the single forgotten point that rips the sail as it's hoisted after turning out a reef. Racing boats favored reef lacing partly because it was self-evening, though mostly because it could be cut to make more sail quickly.

The cartoon shows a sail about as high, narrow, and peaked-up as is practical. A triangle as acute at the head as this one is hard for sailmakers to build a good draft into at the top. Some of the weight and resistance of the narrow head is wasted, at least when working to windward.

RIG 22 Lateen with boom

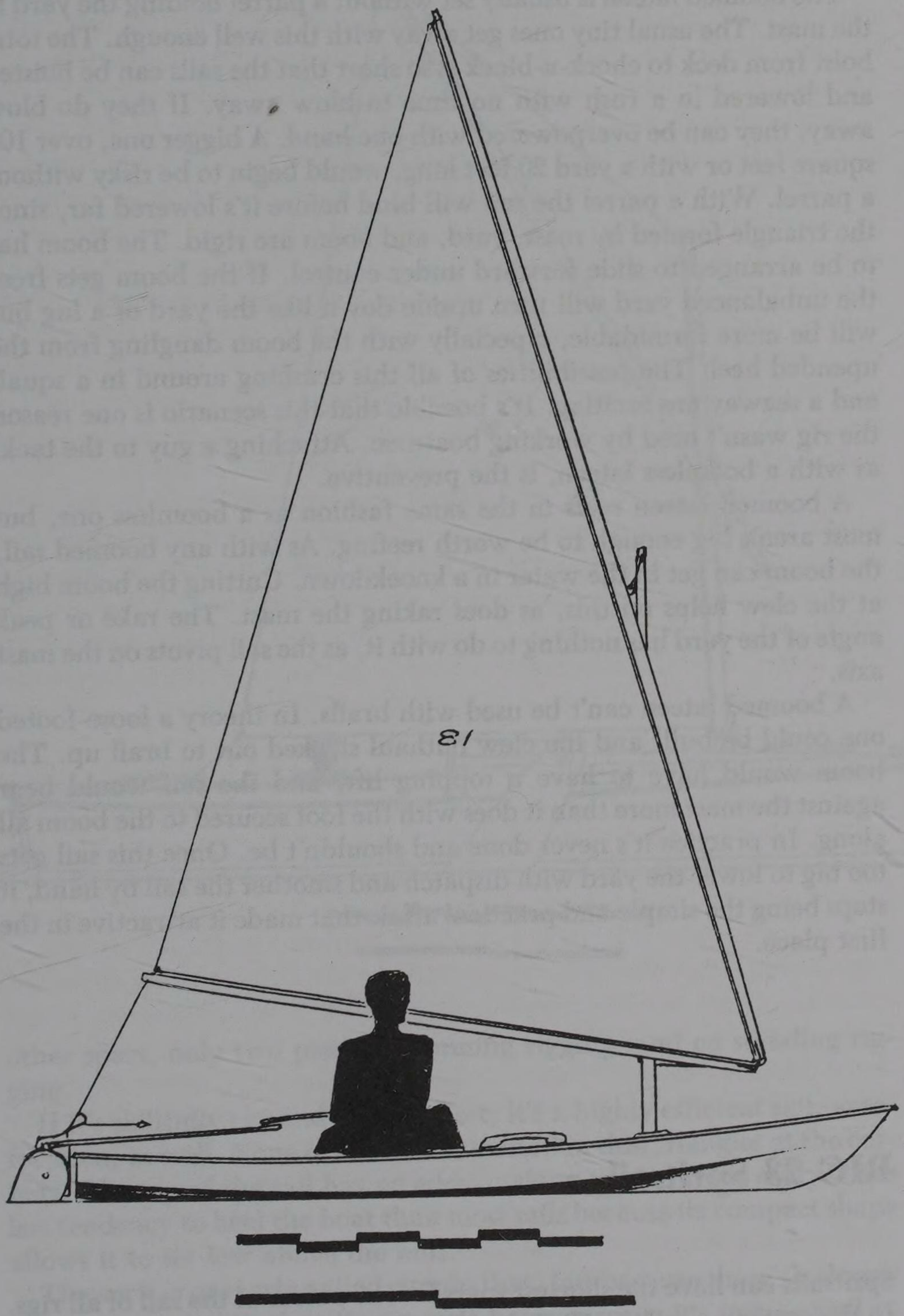
This has always been a pleasure-boat rig and a rare one in the past. It was most visible in iceboats, in which, often slung on a bipod mast, it competed with gaff sloops. Anybody thinking of using it with a bipod should look carefully at the geometry of squaring it out. An iceboat is always close-hauled, but a bipod lateen designed to sail with the wind free is either heavy or complex.

Working boatmen had no use for a boom they could get along without. But after World War II the Alcort Company adopted the boomed lateen for their phenomenally successful sailing surfboard. Their reason was that it combined short spars with quick and foolproof rigging and setting. The cartoon shows the sheet turned through a block on the rudder, but the rig works perfectly with the sheet run straight from the boom to the hand. If the boom is clamped to the mast or otherwise held down at the mast, the attachment at the tack holds the forward end of the boom up and the after end down. The downhaul or clamp at the mast acts as a kicking strap. The sheet is used only to trim the sail, with no extra force used to flatten it down. The sail, being partly balanced as well, is the lightest on a sheet of all common sails. It is, however, hard to sail a boat with the sheet leading directly from hand to boom without frequently jerking the sail; bad for performance though harmless for casual amusement.

The longer the boom, the more area can be handled without mechanical advantage, up to diminishing returns at a length where the sheet comes off the boom into the boat at an acute angle. Boomed lateen sails up to 150 square feet can be sheeted this way if their booms are 12 or 14 feet long and there's a pin or cleat to hook the sheet under to ease the stress. The friction-maker is good to damp out the jerks even in small sails.

This sail suffers from having been used mostly in mass-production boats intended for users who aren't expected to be critical. A sail of this type, carefully cut by a skilled sailmaker, is rare. A lot of them have no built-in shape at all, but are simply flat sheets. A sail like that will drive a boat, but the difference in windward performance between a sail built flat and one with a calculated three-dimensional shape is dramatic. There's no type of sail where this doesn't apply.

A boomed lateen would be easy to adapt to all the tricks of adjusting the draft of the sail by bending the spars. It would be easier, much easier, to make the yard assume the optimum curve to suit the sail shape than the mast of a leg-o'-mutton cat. A highly refined boomed lateen would not be competitive racing with a jibheader because she would lose aerodynamic efficiency from the eddies off the mast when it was on the lee side of the sail. The difference would be seconds per mile. On short courses with lots of maneuvering, the lateen might get it back because her gear would be simpler and not distract the helmsman from tactics. The very best sailors, who thrive on distractions, would still win with the jibheader. The second-raters, who would do better with the lateen, would rather follow the leaders, so there won't be any refined lateeners.


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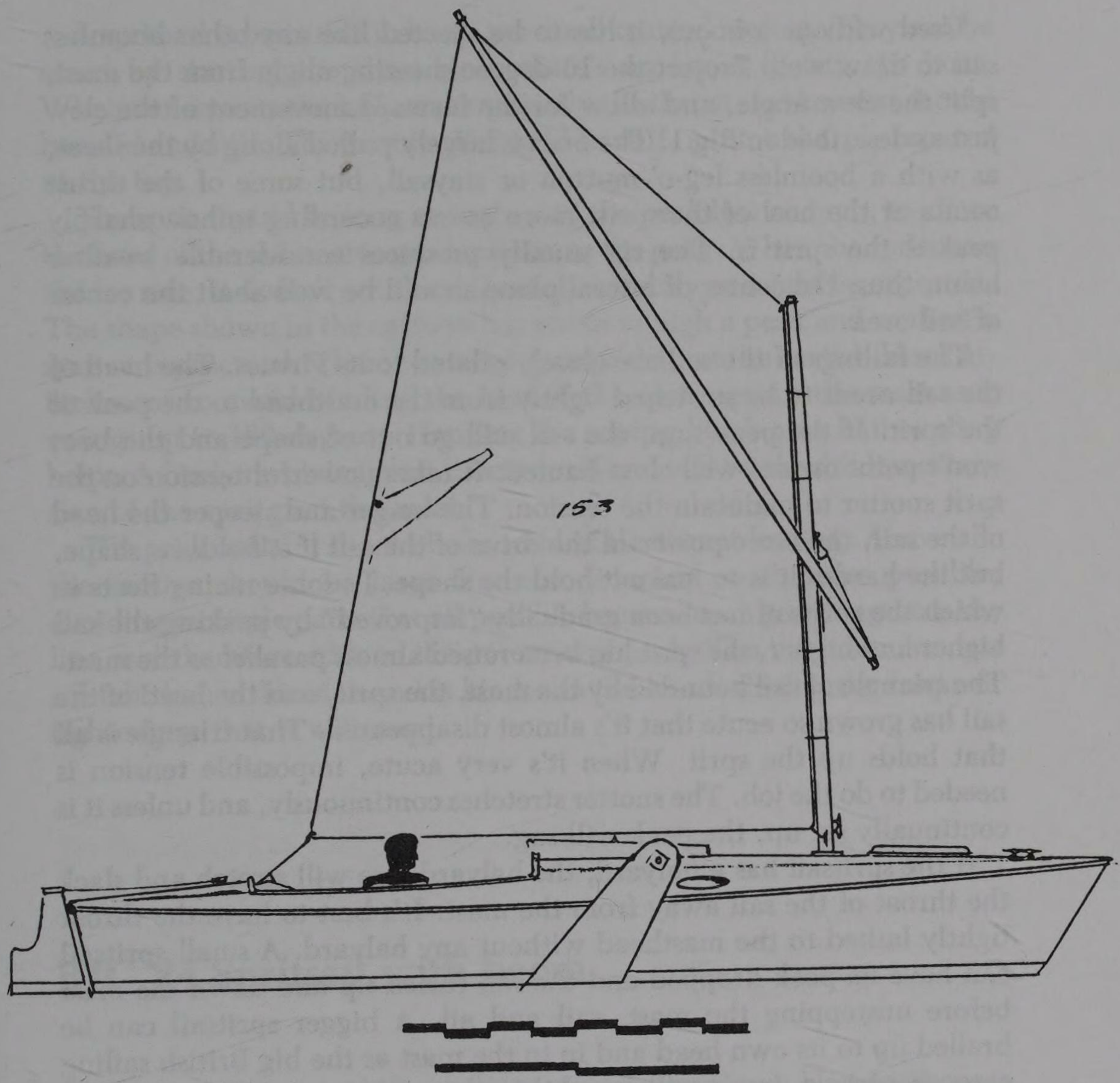
The boomed lateen is usually set without a parrel holding the yard to the mast. The usual tiny ones get away with this well enough. The total hoist from deck to chock-a-block is so short that the sails can be hoisted and lowered in a rush with no time to blow away. If they do blow away, they can be overpowered with one hand. A bigger one, over 100 square feet or with a yard 20 feet long, would begin to be risky without a parrel. With a parrel the sail will bind before it's lowered far, since the triangle formed by mast, yard, and boom are rigid. The boom has to be arranged to slide forward under control. If the boom gets free, the unbalanced yard will turn upside down like the yard of a lug but will be more formidable, especially with the boom dangling from the upended heel. The possibilities of all this crashing around in a squall and a seaway are exciting. It's possible that this scenario is one reason the rig wasn't used by working boatmen. Attaching a guy to the tack, as with a boomless lateen, is the preventive.

A boomed lateen reefs in the same fashion as a boomless one, but most aren't big enough to be worth reefing. As with any boomed sail, the boom can get in the water in a knockdown. Cutting the boom high at the clew helps on this, as does raking the mast. The rake or peak angle of the yard has nothing to do with it, as the sail pivots on the mast axis.

A boomed lateen can't be used with brails. In theory a loose-footed one could be built and the clew outhaul slacked out to brail up. The boom would have to have a topping lift, and the sail would bear against the mast more than it does with the foot secured to the boom all along. In practice it's never done and shouldn't be. Once this sail gets too big to lower the yard with dispatch and smother the sail by hand, it stops being the simple and practical affair that made it attractive in the first place.

RIG 23 Spritsail

Spritsails can have the shortest spars for the power of the sail of all rigs. In the cartoon a sail of 150 square feet is set on a mast only 16 feet long overall including the bury, with a sprit only 18 feet long. There are no



other spars, only two pieces of running rigging, and no standing rigging.

If it's skillfully cut and correctly set, it's a highly efficient sail, area-for-area, as well. None of the area is wasted in thin triangles at the corners. The top of the sail has no eddy-making spar in front of it. It has less tendency to heel the boat than most sails because its compact shape allows it to set low above the hull.

The sprit is properly called simply that, but because there's a sloppy but common habit of calling a sprit boom a sprit, it's just as well to specify a peak sprit.

Used without a boom, it has to be sheeted like any other boomless sail to draw well. Project the 10-degree sheeting angle from the mast, split the clew angle, and allow for the forward movement of the clew just as described in Rig 1. The boat is largely pulled along by the sheet, as with a boomless leg-o'-mutton or staysail, but some of the thrust comes at the heel of the sprit, more or less according to how sharply peaked the sprit is. The rig usually produces considerable weather helm; thus, the center of lateral plane should be well abaft the center of sail area.

The failings of the sail are closely related to its virtues. The head of the sail needs to be stretched tightly from the masthead to the peak of the sprit. If the peak sags, the sail will go out of shape and the boat won't point or foot well close-hauled. It takes powerful tension on the sprit snotter to maintain the tension. The longer and steeper the head of the sail, the more powerful the drive of the sail if it holds its shape, but the harder it is to make it hold the shape. In some racing fleets in which the spritsail has been gradually "improved" by peaking the sail higher and higher, the sprit has been raised almost parallel to the mast. The triangle of sail bounded by the mast, the sprit, and the head of the sail has grown so acute that it's almost disappeared. That triangle is all that holds up the sprit. When it's very acute, impossible tension is needed to do the job. The snotter stretches continuously, and unless it is continually set up, the peak will sag.

If the spritsail has a halyard, the halyard also will stretch and slack the throat of the sail away from the mast. It's best to have the throat tightly lashed to the masthead without any halyard. A small spritsail can have its peak dropped and the sail furled up and down the mast before unstepping the mast, sail and all. A bigger spritsail can be brailed up to its own head and in to the mast as the big British sailing cargo barges do, but a sail rigged this way can't be reefed, so it has to be a small part of the vessel's total sailplan. The furls by brails are dangerously loose as well. The rig is not seaworthy in large sizes.

A small spritsail can be reefed by placing a heavily reinforced grommet on the leech where the cartoon shows it. To reef, the peak is pulled down and the peak sprit outhaul pendant transferred to the grommet. If everything is proportioned correctly, the result is a sail with its head on the line from the masthead to the leech grommet. The area above that line is doubled down, with the original head of the sail stretched snugly down the mast, held in place by downward tension on the original peak. The sprit stands horizontal. Such a reef is none too secure, and the geometry is poor for windward work, but it does make an effective reduction in the heeling force of the sail.

A spritsail is best used in boats too small to need reefing. They can be eased by starting the sheet since there's no boom to trip the boat. Whatever secures the luff, and especially the throat, to the mast should be solid and stiff. The mast itself should be stiff, not too sharply tapered at the top.

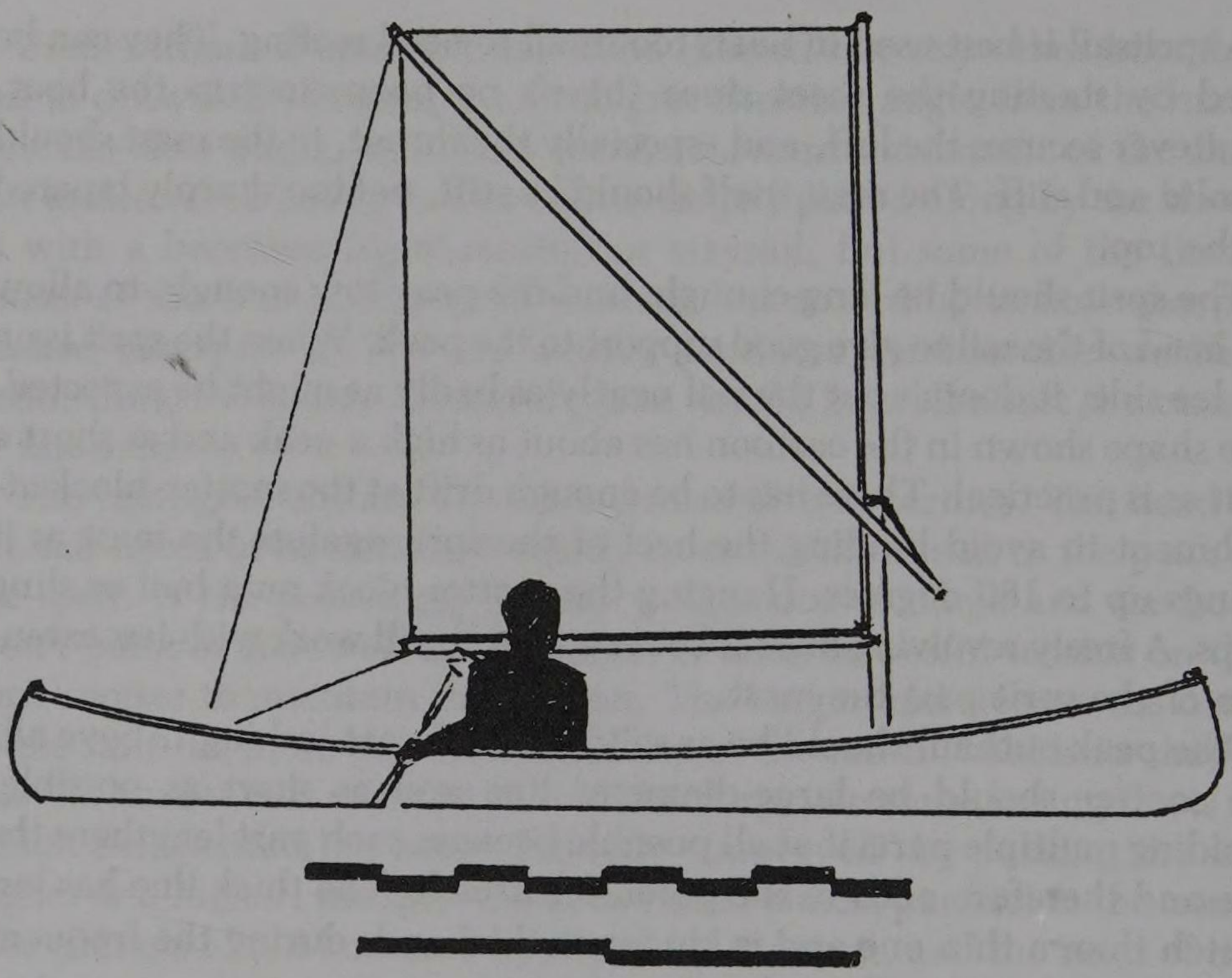
The sprit should be long enough, and the peak low enough, to allow the head of the sail to give good support to the peak. When the sprit is on the lee side, it doesn't cut the sail nearly as badly as might be expected. The shape shown in the cartoon has about as high a peak and as short a sprit as is practical. There has to be enough drift at the snotter-block attachment to avoid binding the heel of the sprit against the mast as it swings up to 180 degrees. Hanging the snotter block on a bail or sling helps. A freely revolving mast is better still and will work with less extension of the sprit past the mast.

The peak outhaul should be as solid as the throat lashing. Above all, the snotter should be large-diameter line and as short as possible, avoiding multiple parts if at all possible because each part lengthens the line and therefore adds to the potential stretch. The thick line has less stretch than a thin one and is kinder to the hands during the frequent tightenings that it will need.

RIG 24 Spritsail with boom

This cartoon, a makeshift auxiliary rig used by Down East Indians, is lifted from Adney and Chapelle's *The Bark Canoes and Skin Boats of North America*. A sail on this plan can be made out of a discount-store bedsheet, a couple of 11-foot poles or tubes, and some clothesline. It seems to be a natural human impulse to want to put a sailing rig into any nice rowing boat. It's almost equally common to expect the sailing rig to be free, or at least to be startled at the cost of sail, spars, cordage, rudder, and centerboard.

The cartoon shows a rig that can, in fact, cost almost nothing. Something like this is worth doing just to see what you're getting for your money in a conventional rig. The bedsheet-and-scrounged-poles rig will move the boat in a gentle wind, sometimes surprisingly well. A paddle or an oar over the side takes the place of rudder and leeboard.



The boat may even be able to make something good to windward.

In more than a zephyr the bedsheet shows its weakness, stretching till it tears. If reinforced with tape along the edges, the middle will stretch out into a shapeless bag. A glimpse is vouchsafed of what the Vikings were up against trying to use sails made of homespun wool. They're said to have tried to stiffen their sails with double-diagonal bands of leather. Perhaps the same could be done with tape now, but it's easier to go to an awning-maker. The sail he makes will be strong enough, and an education in the difference between a sail and a flat piece of fabric masquerading as a sail.

Finally, a sailmaker can make a very good sail with this outline, if he's a real craftsman rather than a robot programmed to assemble one kind of sail, which, naturally, isn't this kind.

The skilled sailmaker's product will drive a suitable boat most respectably, including to windward, if it's sheeted effectively and the peak can be kept from sagging. As to the sheeting, the Quoddy canoe has a long bight of light line between the peak of the sprit and the end of the boom. It serves as a vang for the peak as well as a sheet. To make this arrangement work, it's treated as two separate parts. It can *be* two

separate parts if you think you can keep hold of them both. The vang from the peak is held as far aft as possible, where it will keep the peak from falling off and forward with the least tendency to pull it down. The sheet part is made fast, or more likely merely caught under a pin or cleat, well forward, to hold the boom down. If the boom is merely sheeted in, it will lift. The vang holds the peak, but the leech below the peak will belly out, with poor consequences for the shape of the sail. Putting a kicking strap on the boom of a sail like this seems an incongruity, but perhaps one of these elaborate purchases they sell at their weight in gold for racing dinghies would make a conversation piece. At any rate, it would work. Then get another one for the peak snotter.

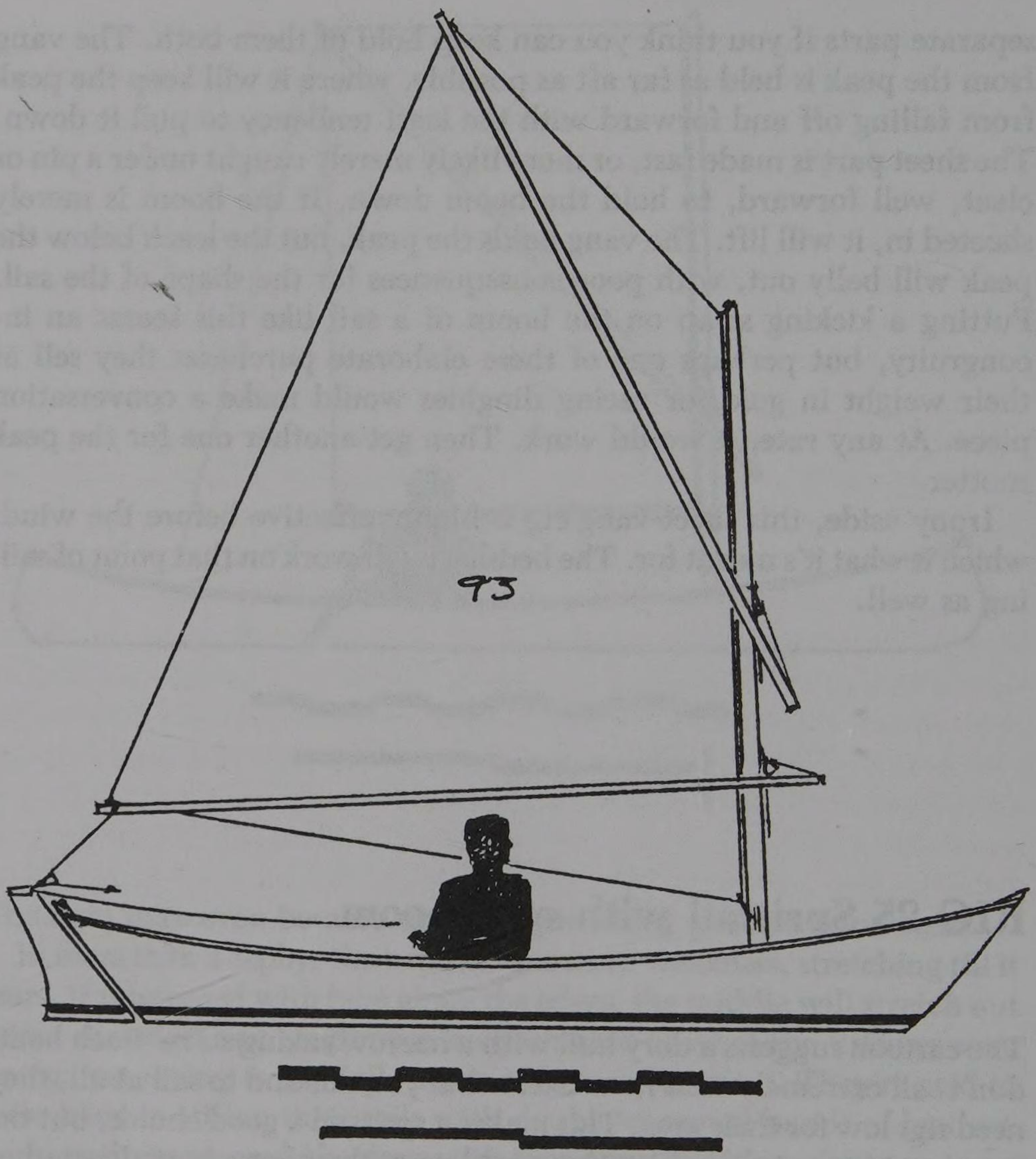
Irony aside, this sheet-vang rig is highly effective before the wind, which is what it's meant for. The bedsheet will work on that point of sailing as well.

RIG 25 Spritsail with sprit boom

The cartoon suggests a dory hull with a narrow raking stern. Such boats don't sail extremely well no matter what you do, and to sail at all, they need rigs low for their area. This makes a spritsail a good choice, but the narrow stern presents a sheeting problem with either a boomless sail or one with a boom on the foot. The available sheeting base isn't wide enough at the stern for either.

The sprit boom obviates this problem and incidentally gets the boom up somewhat clear of heads. With the usual reservation that keeping the peak up where it belongs takes planning and attention, this is an effective sail, 93 square feet of it set on a mast 12 feet long with a 13-foot sprit, with a respectable performance on all points. The spars will not only stow inside the boat but will do so off the centerline to leave space to row, or just to step into the tiddly dory where she won't stagger under your weight.

There are two drawbacks. The obvious one is that the rig needs two extra pieces of gear, the boom snotter and boom clew outhaul pendant.



Both are somewhat mean to get set up if the sail is slatting around hard, though they're docile enough once they're fast.

The other is the defect of its virtue. As with all sprit booms, the foot of the sail holds it down as it swings out. If the boom is long and the boat tender, as in this example, the boom will go into the water in a knockdown even more readily than a boom that's less efficiently controlled in the vertical plane. It's advisable to observe strictly the rule of twice the beam of the boat for the length of such booms, even if the rig becomes higher, or smaller in area, as a consequence.

Both types of boomed sails drive the boat by thrust against the mast

and have less weather-helm tendency than boomless sails. It's usually wise to use no lead on the center of the sail area ahead of the quarter-chord of the lateral plane, at least if the lateral plane is a well-defined fin like a centerboard or leeboard.

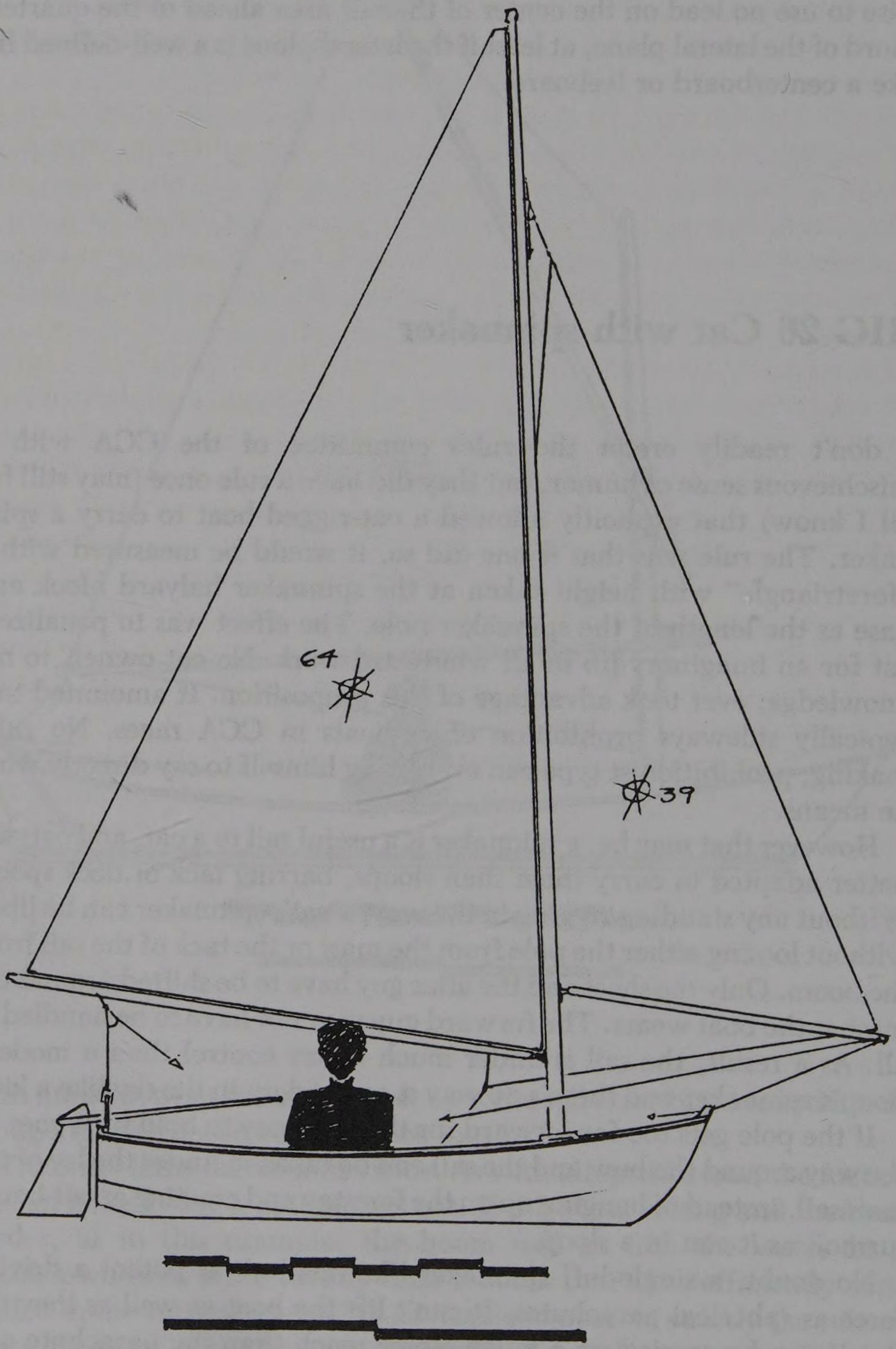
RIG 26 Cat with spinnaker

I don't readily credit the rules committee of the CCA with a mischievous sense of humor, but they did have a rule once (may still for all I know) that explicitly allowed a cat-rigged boat to carry a spinnaker. The rule was that if one did so, it would be measured with a "foretriangle" with height taken at the spinnaker halyard block and base as the length of the spinnaker pole. The effect was to penalize a cat for an imaginary jib in all windward work. No cat owner, to my knowledge, ever took advantage of this proposition. It amounted to a typically sideways prohibition of catboats in CCA races. No rule-making, prohibitionist type can ever bring himself to say directly what he means.

However that may be, a spinnaker is a useful sail to a cat, and cats are better adapted to carry them than sloops, barring lack of deck space. Without any standing rigging in the way, a cat's spinnaker can be jibed without loosing either the pole from the mast or the tack of the sail from the boom. Only the sheet and the after guy have to be shifted around the mast as the boat wears. The forward guy may not have to be handled at all. As a result, the sail is under much better control than a modern sloop's spinnaker and there's no way it can end up in the sky like a kite.

If the pole gets too far forward for the after guy to hold it, it goes all the way around the bow and the sail can be taken in under the lee of the mainsail, instead of hanging up on the forestay and creating an all-hands turmoil as it can in a sloop.

No doubt, a single-luff spinnaker like this isn't as potent a driving force as spherical parachutes. It can't lift the boat as well as they do. But it can be carried on a much closer reach than the parachute and still do more good than harm. Such a sail should be cut like a reaching jib and sheeted like one. On a close reach the pole is guyed out until the


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clew is brought around the mast at an angle that doesn't backwind the mainsail. The flow off it will, in fact, smooth out the eddies from a cat's big mast, "reattach the flow," and so make her mainsail drive better, over and above the drive of the spinnaker itself.

A sail like this can't be carried close-hauled, because in light airs it would produce lee helm, always fatal to good windward work, while in a breeze of wind the cat rig isn't stayed stiffly enough to allow the spinnaker luff to be kept stretched tight. When it sags, the fullness of the sail is increased just when it ought to be decreased. On any point up to a close reach, the extra fullness can be allowed for by a knowledgeable sailmaker.

For a cruiser, this rig has some qualities worth thinking about. I often remark that I never had any trouble getting a boat to go downwind, meaning that improved performance in that direction isn't especially valuable. But it's not quite true. I recall one or two occasions when a capability to run faster would have been welcome, either to get in somewhere before a threat arrived, or to get through a bottleneck against a stream. I have one particular memory of overtaking a boat in a bottleneck passage. We had just enough speed to make headway over the bottom. She didn't have quite enough. We got through and went on about our business, while she stopped just short of the strongest part of the stream and stayed there till we were out of sight.

There have been many times when I would have liked to be able to leave the tiller when running. With this rig and no standing rigging, the mainsail can be eased forward of the beam on one side and the spinnaker guyed forward on the other. This creates considerable self-steering effect, usually enough to take care of itself for a few minutes, even without hooking up the sails to the tiller.

RIG 27 Cat with jib (cat-sloop)

This was a racing rig used only in pleasure boats. In the 1900s they had generous ideas about sail area and expected to do lots of reefing. A cat

like the one cartooned would have had five rows of points in her sail, and she would have been considered moderately sparred and canvased.

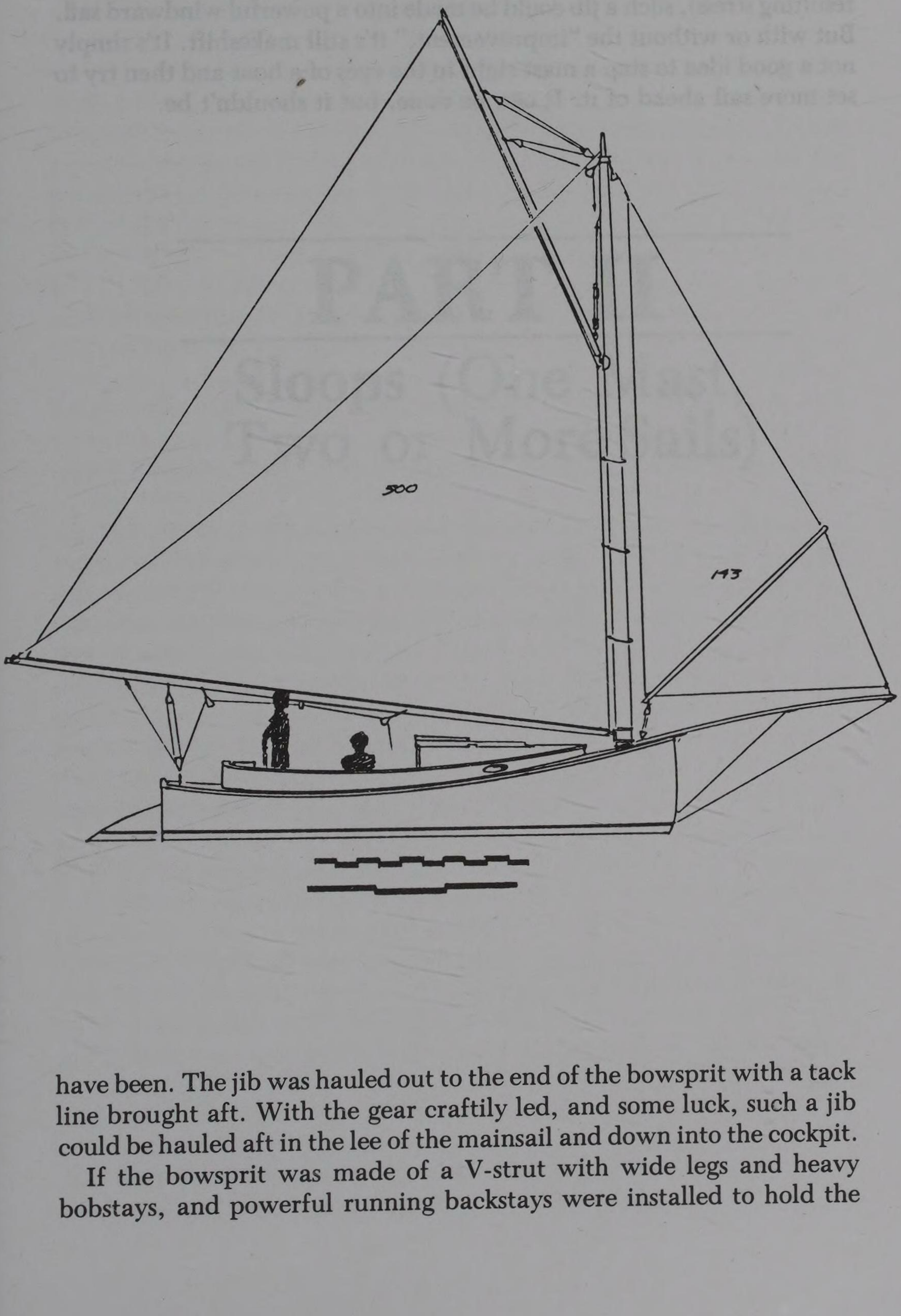
Increasing the rig of a cat has two ways to go: up in the air or out over the stern. They did both with exuberance. But going up creates the problem that the sheer weight of a tall mast will make a boat tender, reefed or not. Extending the boom too far makes the boat hard-mouthed, especially reaching, and especially when the rules of the class prohibit deep rudders. So a makeshift bowsprit is shipped, and a makeshift jib set. The jib may or may not have been an advantage close-hauled, but it allowed the boat to carry a longer main boom and still steer. On Massachusetts Bay all the Quincy Cats, the hot racing association, had jibs. On Barnegat Bay they were prohibited, and, possibly by no coincidence, the racing of catboats lasted longer in New Jersey.

At the time these jibs on catboats flourished, boomless jibs weren't fashionable. There's no deck breadth to install a traveler horse forward of the mast, so a boomed jib had lifting-clew problems. A common treatment was the sprit boom shown, sometimes in the form of a heavy batten or two battens, one on each side of the sail and bolted together through eyes in the sail. This kept the clew down and made a docile sail, but there were several drawbacks. A regular sprit boom cut into the sail on one tack at a more damaging angle than such a boom on a mainsail. The battens, supposed to be flexible, had to be too stiff for light airs or too limber in a breeze. The thrust of the boom against the luff distorted the sail, more or less, as indicated in the cartoon.

Incidentally, a spar like this can be risky if it bears against a stay. The jib shown is set flying with a patch of reinforcement and a grommet on the luff to take the heel of the boom, but a wire stay can be kinked until it breaks in fatigue by anything that pushes against it or pulls on it at a point. If a sprit boom is used on a staysail, the bearing on the stay should be rounded on a long, smooth radius. Radius or no radius, it's bad practice in a seagoing boat.

The sprit boom is possibly some use in taking some of the sag out of the luff of the jib. The luff will sag because any unstayed mast bends more or less, and in a cat it's almost impossible to get the bowsprit held stiffly. The jib still sags above and below the boom, but the total effect may be mitigated.

About all that can be said for this sail is that they actually did get them to stand surprisingly well in the racing cats. They were usable hard on the wind as even a flat single-luff spinnaker was not. They were also easier to set and take in, with no foredeck to speak of, than a spinnaker would



have been. The jib was hauled out to the end of the bowsprit with a tack line brought aft. With the gear craftily led, and some luck, such a jib could be hauled aft in the lee of the mainsail and down into the cockpit.

If the bowsprit was made of a V-strut with wide legs and heavy bobstays, and powerful running backstays were installed to hold the

masthead (and the mast and mast step proportioned to stand the resulting stress), such a jib could be made into a powerful windward sail. But with or without the "improvement," it's still makeshift. It's simply not a good idea to step a mast right in the eyes of a boat and then try to set more sail ahead of it. It can be done, but it shouldn't be.

PART II

Sloops (One Mast, Two or More Sails)

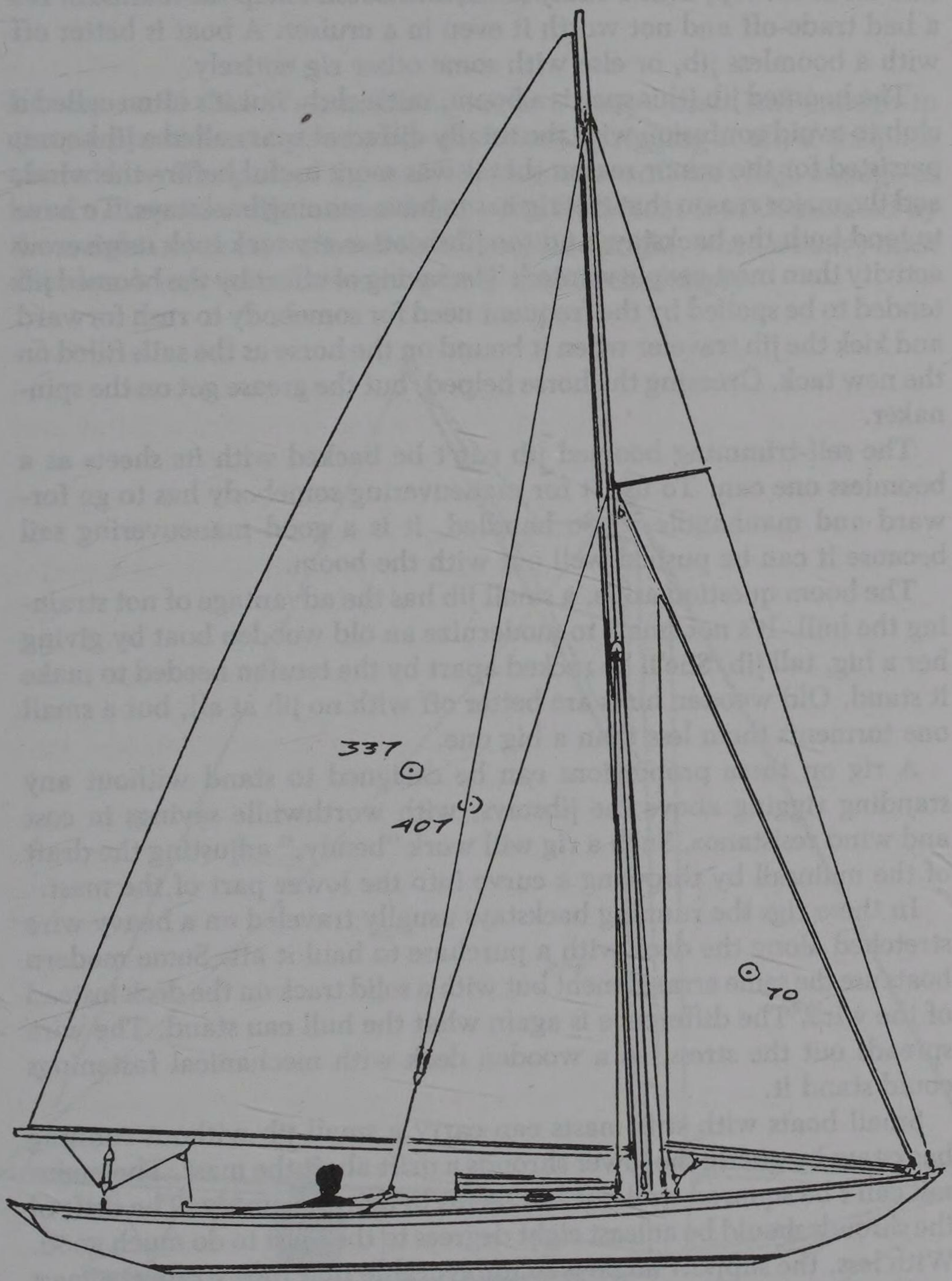
RIG 28 Jibheader with low foretriangle

This was the characteristic rig of the 1920s. It was developed when the racing boats all changed over to the marconi rig as it was then called. Rigging materials had developed enough to make the tall masts stand, but not enough to build the really rigid rigs that allow big jibs to be set up with luffs taut. The standing backstay was unheard of. It can't be used with a gaff rig, and for a long time the only way to get a large sail area was to use a big mainsail with a long boom.

In their old age some of these boats had their booms docked two or three feet so standing backstays could be installed. This always resulted in their being outsailed by the unaltered boats simply because they had less sail area. Apparently some people expected them to sail even, on the theory that "it's the luff that drives the boat." No doubt the boats would have suffered more if their masts had been shortened than they did by having their booms shortened, but the penalty of loss of area at the clew was quite noticeable.

A small, low jib like this can be made to stand well with moderate backstay tension. It's a good windward sail in its own right, but an important part of its usefulness is the effect on the mainsail. The era of this rig was an era of low booms, to get extra sail area where it didn't heel the boat. It was common for the boom to touch the companionway slide when it was flattened down hard. With no space for a kicking strap under the boom, there was always some twist in the sail, meaning that to keep it from luffing aloft, it had to be too flat at the tack. This produced turbulence over the lower part of the sail on the lee side, which the draft from the jib tended to smooth out. This was called "feeding the vacuum" at the time — not a useful phrasing. The small sail forms something like what aircraft people call a leading-edge slat.

Such a jib will work better without a boom than with one, and with simpler sheeting. A boomed jib like this has to have a traveler and horse, and the fall of the sheet has to lead forward to a turning block close to the tack. It's tempting to sheet it with the standing end of the sheet on a deck padeye to one side, up through a block on the boom, down to a turning block across the deck from the standing end, and so aft. The leads are simplified a lot and the number of jams from kinks in the line are reduced. The bights of the sheet don't hang up on the mooring cleat, as they do exasperatingly when rigged as shown. A good many cruising boats were, and some still are, rigged that way. No racer ever was, because the arrangement doesn't hold the boom down. The sail twists,


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falls off at the top, draws badly itself, and doesn't help the mainsail. It's a bad trade-off and not worth it even in a cruiser. A boat is better off with a boomless jib, or else with some other rig entirely.

The boomed jib (this spar is a boom, not a club, but it's often called a club to avoid confusion with the totally different spar called a jibboom) persisted for the minor reason that it was more useful before the wind, and the major reason that this rig has to have running backstays. To have to tend both the backstays and the jibsheets every tack took more crew activity than most people wanted. The saving of effort by the boomed jib tended to be spoiled by the frequent need for somebody to rush forward and kick the jib traveler when it bound on the horse as the sails filled on the new tack. Greasing the horse helped, but the grease got on the spinnaker.

The self-trimming boomed jib can't be backed with its sheets as a boomless one can. To use it for maneuvering somebody has to go forward and manhandle it. So handled, it is a good maneuvering sail because it can be pushed well out with the boom.

The boom question aside, a small jib has the advantage of not straining the hull. It's not smart to modernize an old wooden boat by giving her a big, tall jib. She'll be racked apart by the tension needed to make it stand. Old wooden hulls are better off with no jib at all, but a small one torments them less than a big one.

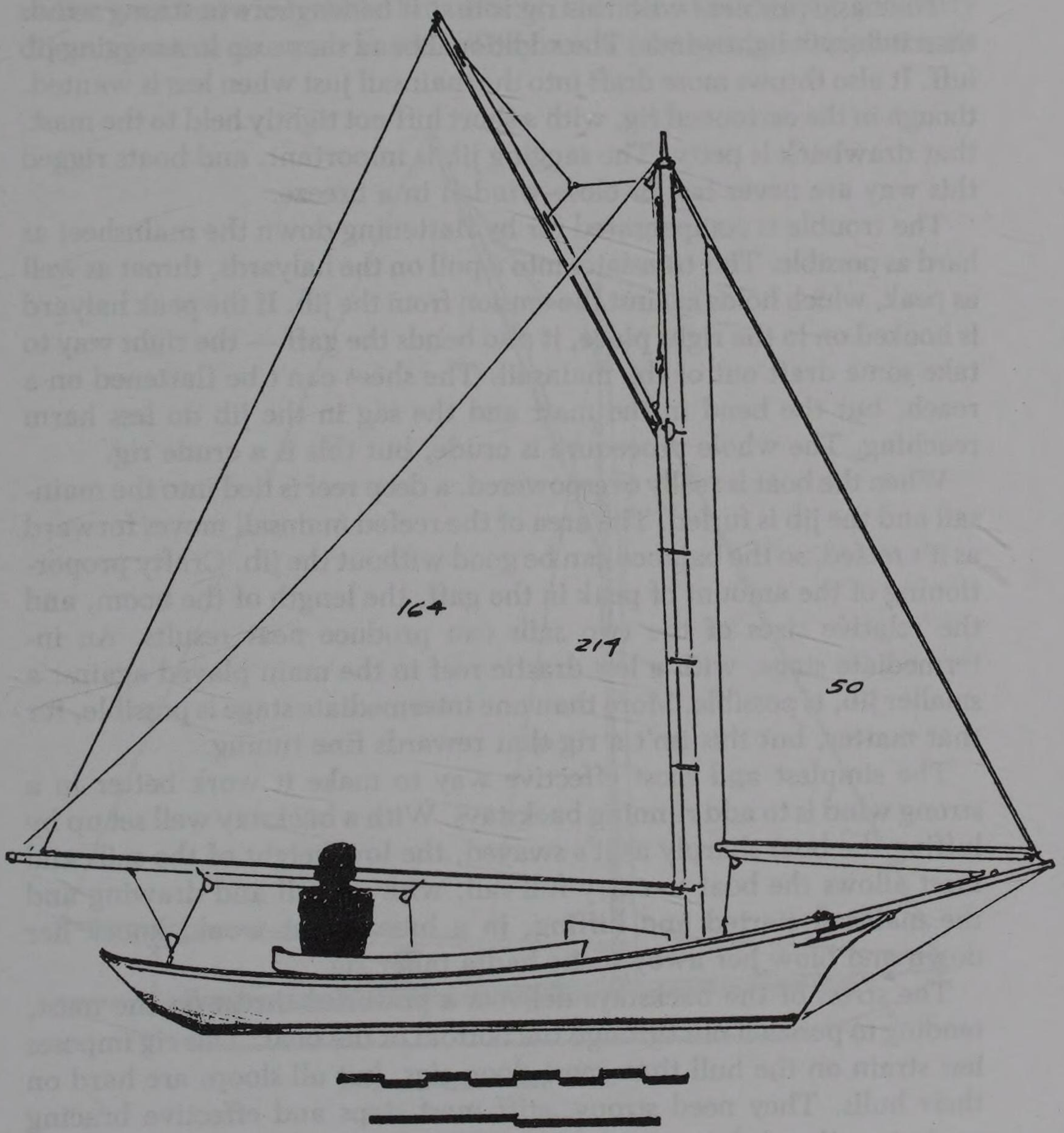
A rig on these proportions can be designed to stand without any standing rigging above the jibstays, with worthwhile savings in cost and wind resistance. Such a rig will work "bendy," adjusting the draft of the mainsail by throwing a curve into the lower part of the mast.

In these rigs the running backstays usually traveled on a heavy wire stretched along the deck with a purchase to haul it aft. Some modern boats use the same arrangement but with a solid track on the deck instead of the wire. The difference is again what the hull can stand. The wire spreads out the stress, so a wooden deck with mechanical fastenings could stand it.

Small boats with stiff masts can carry a small jib without running backstays by giving the lower shrouds a drift abaft the mast. The mainsail can't be squared well out but seems to drive tolerably. The drift of the shrouds should be at least eight degrees to the mast to do much good. With less, the support angle is so unfavorable that they strain the mast more in compression than they help hold it against bending. At best, standing shrouds made to do double duty as backstays are hard on a hull for that reason.

RIG 29 Gaff with boomed jib

In very small sizes it's possible to make a sloop's mast stiff enough to carry a jib without backstays or any standing rigging at all, if the jib is carried low. The part of the mast that has to be stiff isn't high enough to have a disastrous effect on stability. The little boat is so dominated by the weight of her crew that she can be sailed upright, when a heavy mast does less harm than it does in a boat that heels sharply.



The mast will be bent forward at the top by the forestay, or by the jib halyard if the sail is set flying. This will put initial tension on the luff of the jib. The mast is drawn straight in the cartoon, which is customary since it's built straight, but the designer has to look at the effects of the bending on the actual positions of the sails in action with the mast bent. In some rigs the sheet angles are different enough to be taken into account in locating deck leads. In the cartoon there's nothing that needs to be done. The sailmaker should be warned about it if he hasn't had appropriate experience, for the curve of the mast can be enough to be worth taking into account as he shapes the luff of the sail.

The basic problem with this rig is that it bends more in strong winds than it does in light winds. The additional bend shows up in a sagging jib luff. It also throws more draft into the mainsail just when less is wanted, though in the cartooned rig, with a short luff not tightly held to the mast, that drawback is petty. The sagging jib is important, and boats rigged this way are never fast or close-winded in a breeze.

The trouble is compensated for by flattening down the mainsheet as hard as possible. This translates into a pull on the halyards, throat as well as peak, which holds against the tension from the jib. If the peak halyard is hooked on in the right place, it also bends the gaff — the right way to take some draft out of the mainsail. The sheet can't be flattened on a reach, but the bend in the mast and the sag in the jib do less harm reaching. The whole procedure is crude, but this is a crude rig.

When the boat is really overpowered, a deep reef is tied into the mainsail and the jib is furled. The area of the reefed mainsail moves forward as it's reefed, so the balance can be good without the jib. Crafty proportioning of the amount of peak in the gaff, the length of the boom, and the relative sizes of the two sails can produce neat results. An intermediate stage, with a less drastic reef in the main played against a smaller jib, is possible. More than one intermediate stage is possible, for that matter, but this isn't a rig that rewards fine tuning.

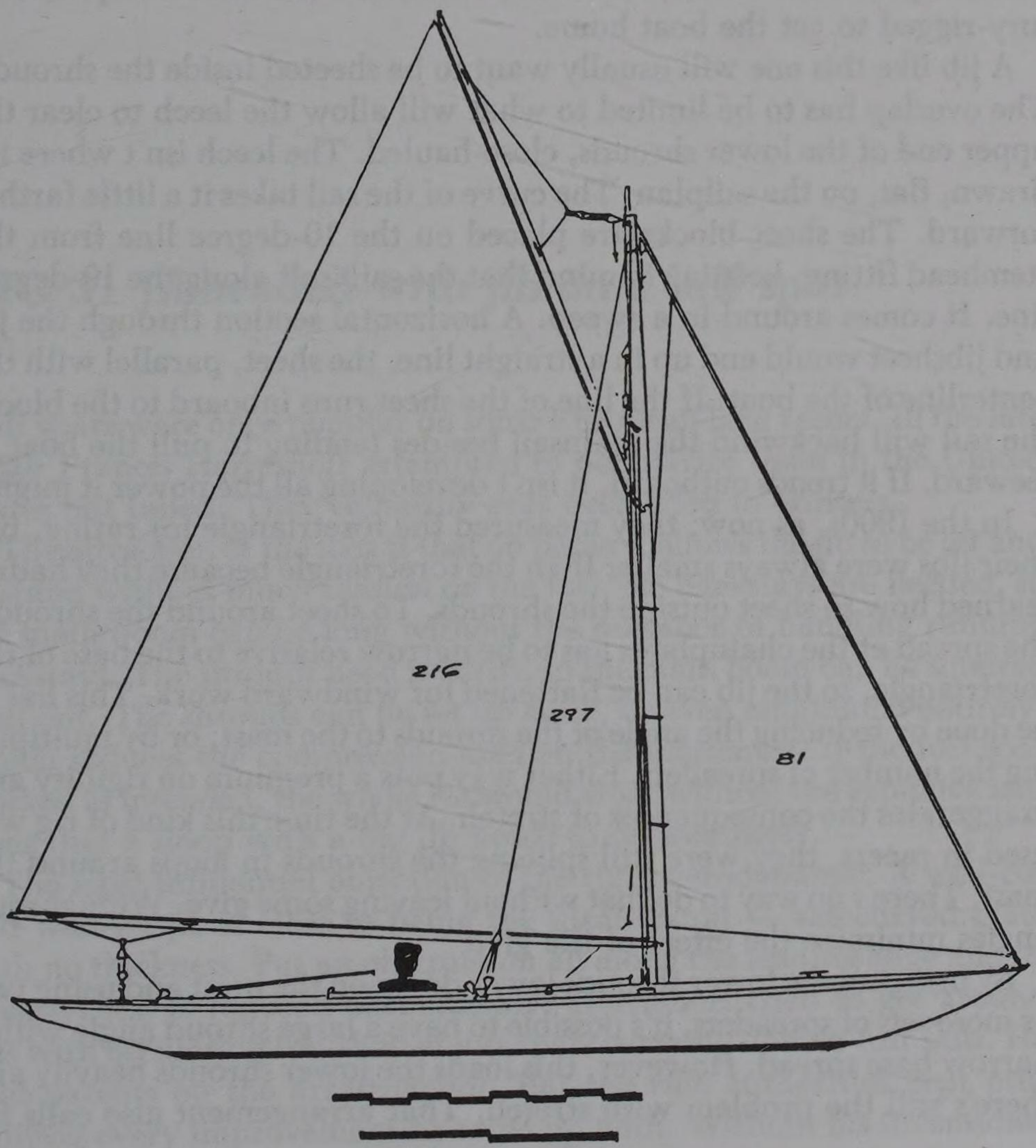
The simplest and most effective way to make it work better in a strong wind is to add running backstays. With a backstay well set up by luffing the boat sharply as it's swayed, the low height of the sails and mast allows the boat to carry full sail, with jib full and drawing and the mainsail started and luffing, in a breeze that would knock her down and blow her away if she had a taller rig.

The stress of the backstays delivers a powerful thrust on the mast, tending to punch it out through the bottom of the boat. This rig imposes less strain on the hull than most sloop rigs, but all sloops are hard on their hulls. They need strong, stiff mast steps and effective bracing against sectional distortion in way of the mast.

RIG 30 Gaff with boomless jib

This is an imitation of a racing rig of the 1900s. An American boat would have been almost certain to have a club on the foot of the jib. Her jib would have been shorter on the foot and have even less overlap. The cartoon looks more like a British boat.

Don't condescend to this rig if you haven't seen one sail. It drove some fast and weatherly boats. They gave the lie to the myth that gaffs sag. They wouldn't point with a 1980 racer, partly because the sailmakers weren't as knowledgeable but mostly because this rigging geometry doesn't control the spars as well. They could foot spectacularly because



the proportions allow a lot of area to be carried low, where it drives the boat without heeling her as much as taller sails.

The flip side of the myth is that a gaff rig is stronger and more seaworthy than the marconi. Flimsy racing machines were just as possible then as now. The dayracers were worse then than they are now because they didn't have the offshore experience behind them. They broke down right and left every time they tried to race in heavy weather. It's true, though, that they usually didn't disintegrate all at once from the deck up, as today's boats do. Except in the most extreme ones, the onset of trouble was somewhat gradual. A spreader would collapse or a backstay fitting would pull out. The rest of the rigging would slack up, the mast would whip, but tension and compression were of a lower order than we're used to. If the boat was promptly eased and sail was taken off her, the collapse could often be arrested; sometimes it was even repaired or jury-rigged to get the boat home.

A jib like this one will usually want to be sheeted inside the shrouds. The overlap has to be limited to what will allow the leech to clear the upper end of the lower shrouds, close-hauled. The leech isn't where it's drawn, flat, on the sailplan. The curve of the sail takes it a little farther forward. The sheet blocks are placed on the 10-degree line from the stemhead fitting, keeping in mind that the sail isn't along the 10-degree line. It comes around in a sweep. A horizontal section through the jib and jibsheet would end up in a straight line, the sheet, parallel with the centerline of the boat. If the line of the sheet runs inboard to the block, the sail will backwind the mainsail besides tending to pull the boat to leeward. If it trends outboard, it isn't developing all the power it might.

In the 1900s, as now, they measured the foretriangle for rating, but their jibs were always smaller than the foretriangle because they hadn't learned how to sheet outside the shrouds. To sheet around the shrouds, the spread at the chainplates has to be narrow relative to the base of the foretriangle, so the jib can be flattened for windward work. This has to be done by reducing the angle of the shrouds to the mast, or by multiplying the number of spreaders. Either way puts a premium on rigidity and exaggerates the consequences of stretch. At the time this kind of rig was used in racers, they were still splicing the shrouds in loops around the mast. There's no way to do that without leaving some give. Wide shroud angles minimize the effect of the give.

By bringing the lower shrouds lower down on the mast and using two or more sets of spreaders, it's possible to have a large shroud angle with a narrow base spread. However, this loads the lower shrouds heavily and there's still the problem with stretch. That arrangement also calls for

using track and slides on the luff of the mainsail to get by the lower shroud attachments. Years ago they knew about track but considered it unreliable compared with hoops. Hoops are also better aerodynamically than track because they let the sail align itself with the mast.

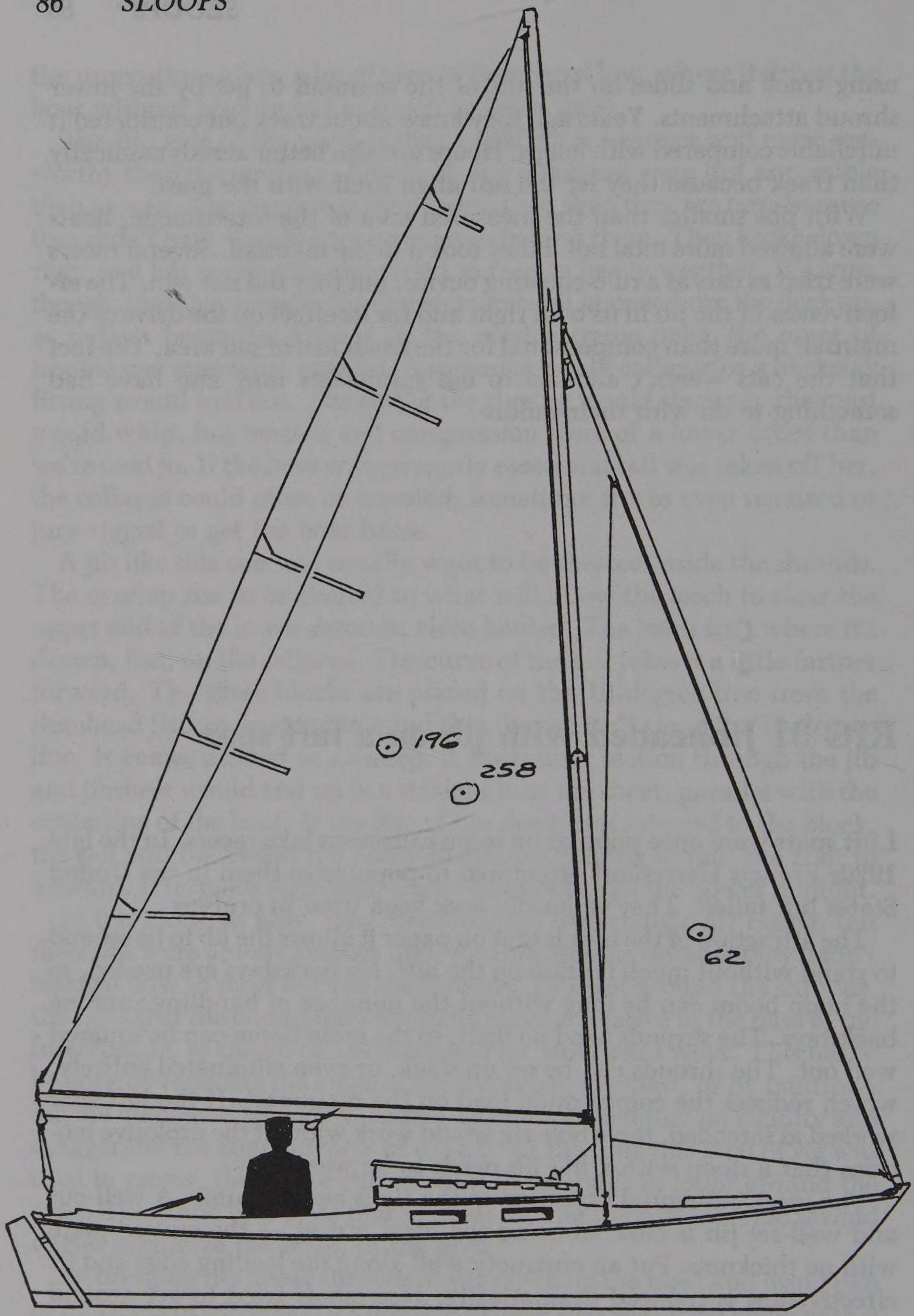
With jibs smaller than the measured area of the foretriangle, boats were allowed more total sail if they took it in the mainsail. Several racers were tried as cats as a rule-cheating device, but they did not win. The effectiveness of the jib in its own right and for its effect on the drive of the mainsail more than compensated for the small loss of sail area. The fact that the cats weren't allowed to use spinnakers may also have had something to do with their failure.

RIG 31 Jibheaded with jib on a luff spar

Luff spars were once popular on some European lake racers. In the late 1920s Francis Herreshoff attempted to popularize them in the United States but failed. They've hardly ever been tried in cruisers.

The attraction of the idea is that on paper it allows the jib to be set and to stand without much tension on the luff. No backstays are needed, so the main boom can be long without the nuisance of handling running backstays. The shrouds need no drift, so the main boom can be squared well out. The shrouds can be set up slack, or even eliminated entirely, which reduces the compression load on the mainmast. If the luff spar worked as intended, the whole rig would work without the explosive tensions that a sloop with a big jib needs to be weatherly.

The most influential objection to the rig is aerodynamic. A well-cut and well-set jib is close to being the ideal airfoil — the curved plate with no thickness. Put an obstruction all along the leading edge and its effectiveness is reduced dramatically. Herreshoff tried to get around this with oscillating foil-shaped luff spars carrying double-luff sails. He held patents on the arrangement. But the rule authorities kept prohibiting every improvement he came up with. Without his inventions,


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his racers, sailing with single-luff jibs tracked on fixed luff spars, were beaten and had to revert to conventional staying. Then they were dismasted because their masts were designed to take advantage of the low luff tension the luff spars allowed.

Cruisers never adopt a new device until it's fashionable in racers. That was even truer in the 1920s than it is now. So the luff-spar idea lapsed. For a cruising boat it had possibilities, especially in its older and cruder form. The double-luff sails are impractical in a cruiser because they're too clumsy to set and take in. The oscillating luff spar needs elaborate bearings at both ends to work well, and it has to be very broad and thin to come anywhere near the low drag of a sail without the spar. Even when broad and thin, it may need positive control to assume the right angle to the wind, a nuisance the shorthanded cruiser doesn't need. The cruiser could afford to take the bad effect on the jib of the fixed spar. She would gain simplicity of rigging and less stress all through her rig.

The weak point in the argument is that the luff spar is only supported at each end, with no way to give it any intermediate support. If it bends, it will have the same bad effect on the jib as a sagging luff without the spar. To get the benefits, the luff spar has to be a very stiff spar indeed, both heavy and fat. The British used to use wooden rollers around their jibstays to roll up jibs. It was noticeable that the luffs sagged, rollers and all, about as much as similar rigs without the rollers. A spar stiff enough to do the job may impose more weight and windage on the rig than the advantages justify.

The fixed-luff spars in Herreshoff's racers had their deck steps far inboard of the stem, and they were stayed forward to the sides of the bow overhang. In pictures of them sailing, the leeside stay is visibly slack. The arrangement would work better in a cutter than a sloop, putting the luff spar up for the forestaysail and retaining the headstay for the jib.

Incidentally, the roller system mentioned has the advantage that its wooden roller doesn't twist up when spun from the lower end, as a wire does. It gives a more even roll and may be worth considering. If you are contemplating using it, take care that the jibstay isn't kinked where it emerges from the roller. If it is, it will fail of fatigue eventually. The roller should have a smooth, bell-muzzle flare inside each end to be kind to the wire.

RIG 32 Jibheaded with three-quarter foretriangle

All through the 1930s, the jibstay moved higher on the masts of racing boats. It stabilized for a while at about the height of this cartoon. There was a set of standard proportions that looked much like this, but the principle was different. They had jumper struts jutting out from the mast at the jibstay attachment point, over which a set of stays ran from the masthead down to spreader level, about halfway between jibstay and deck. The object was to take the tension of the jib up to the standing backstay at the masthead. These rigs were supposed to be rigid. There are still plenty of them around.

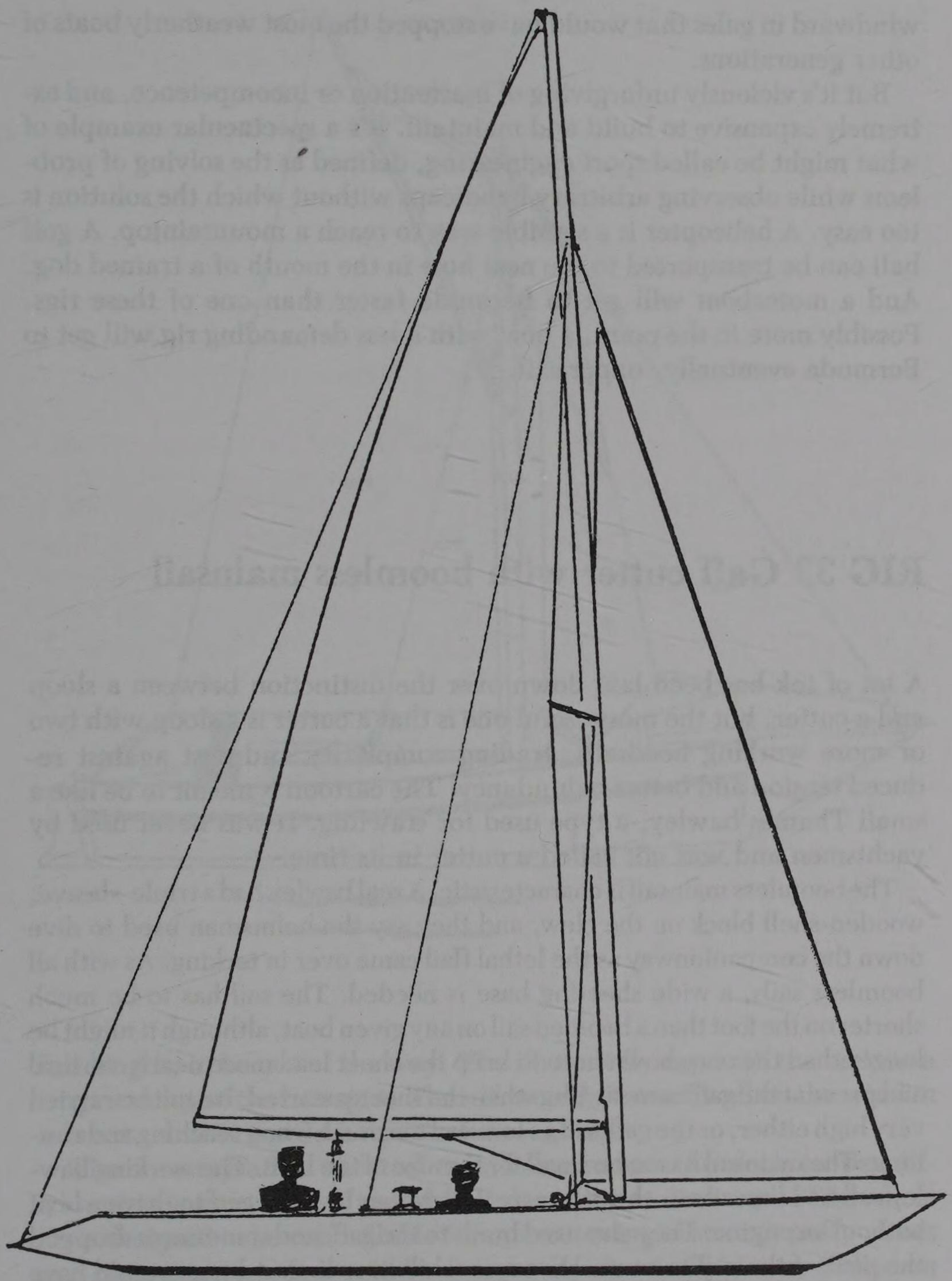
It was assumed that the next step would be to take the jibstay to the masthead, making the jib bigger and the mainsail smaller. See Rig 11 for the reasoning. It did happen, as I'll show in Rig 37, but the developments for controlling sail shape by bending the spars caused the next step to be what looks like a reversion. It isn't. The 1930s rigs were in the process of having their jibs made higher and bigger as fast as the strength and rigidity of available masts and rigging could allow, because the jibs were more effective driving sails than the mainsails.

The contemporary rig in the cartoon represents a very successful effort to make the mainsail more effective by throwing controlled curves into the mast and boom, as outlined in Rig 6. The height of the jibstay is selected to produce the desired curve in the mast. There are running backstays, the elimination of which was one of the main objects of the older three-quarter rigs. The standing backstay is lightly loaded here. Its function is only to control the masthead, not to resist jib tension.

The geometry of the spreaders and lower shrouds is calculated to make the mast bow forward between the jibstay and the deck in strong winds, to flatten the mainsail. As the mast moves, the vertical distance to the jibstay attachments is shortened. The jibstay is slackened and the jib would sag and bag but for the adjustable running backstays.

It's as urgent as ever to keep the luff of the jib straight. The tension needed to do that is infinite (literally!). But the luff can be kept nearly straight with somewhat less than infinite tension — only a few thousand pounds in a small boat. Now, for the good of the mainsail, this tension is delivered to a strut, the mast, with a varying curve in it.

The resulting balance of forces is beautiful or horrifying, depending on how you look at it. The bigger such a rig is built, the more terrible the beauty becomes. This rig is the most weatherly in history and can face the widest range of weather conditions. Boats rigged this way keep racing to



windward in gales that would have stopped the most weatherly boats of other generations.

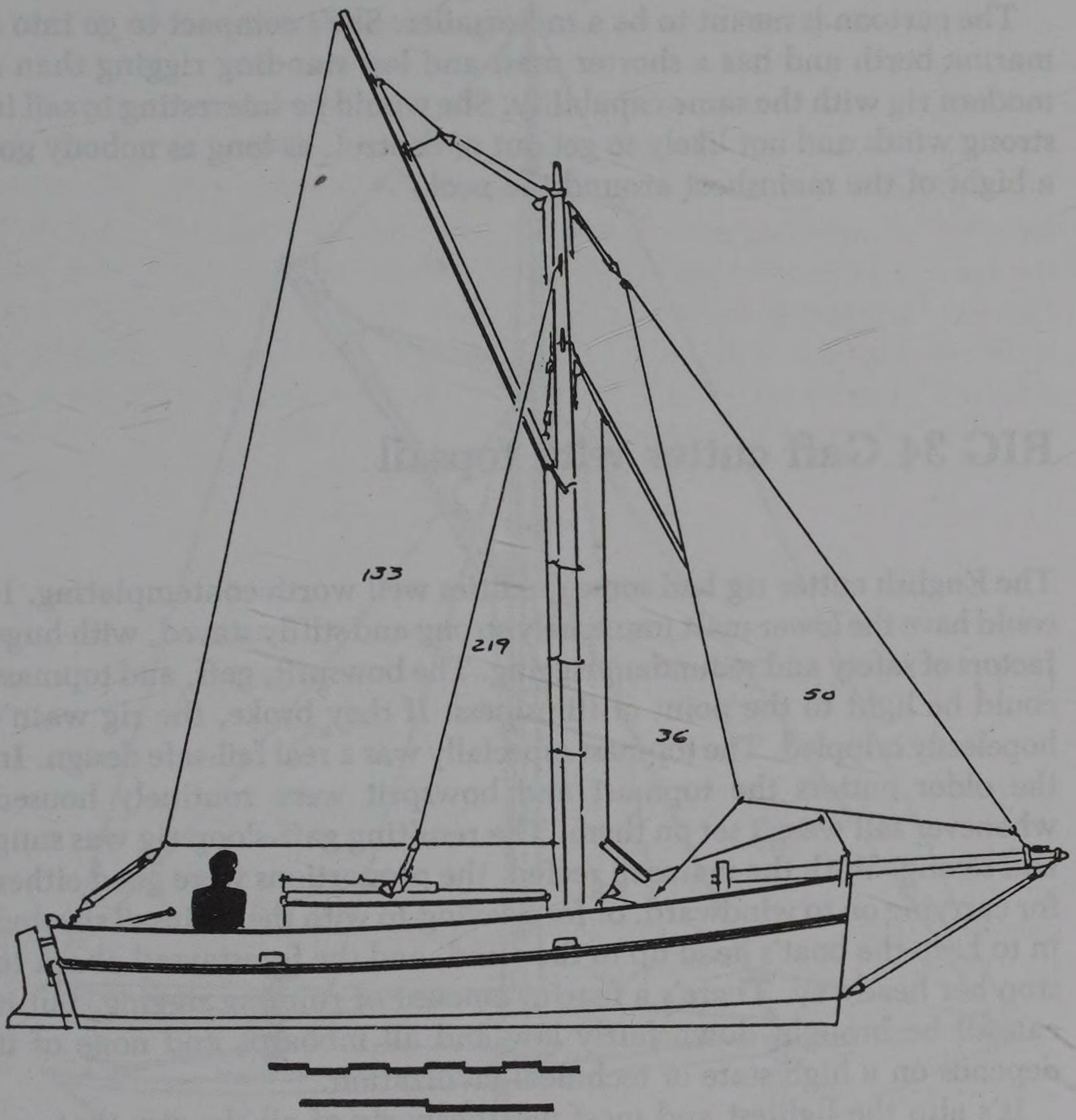
But it's viciously unforgiving of inattention or incompetence, and extremely expensive to build and maintain. It's a spectacular example of what might be called sport engineering, defined as the solving of problems while observing arbitrary handicaps without which the solution is too easy. A helicopter is a sensible way to reach a mountaintop. A golf ball can be transported to the next hole in the mouth of a trained dog. And a motorboat will get to Bermuda faster than one of these rigs. Possibly more to the point, a boat with a less demanding rig will get to Bermuda eventually, under sail.

RIG 33 Gaff cutter with boomless mainsail

A lot of ink has been laid down over the distinction between a sloop and a cutter, but the most useful one is that a cutter is a sloop with two or more working headsails, trading complexity and cost against reduced tension and better redundancy. The cartoon is meant to be like a small Thames bawley, a type used for trawling. It was never used by yachtsmen and was not called a cutter in its time.

The boomless mainsail is characteristic. A real bawley had a triple-sheave, wooden-shell block on the clew, and they say the helmsman used to dive down the companionway as the lethal flail came over in tacking. As with all boomless sails, a wide sheeting base is needed. The sail has to be much shorter on the foot than a boomed sail on any given boat, although it might be longer than the one shown here to keep the sheet lead more nearly vertical and prevent the gaff from sagging when the sheet is started. It can't be carried very high either, or the gaff will go forward too much when reaching and running. The mainsail has to be small for the size of the boat. The working bawleys all had topsails — the only way this rig can be enlarged to drive a boat without an engine. They also used brails to the gaff, and sometimes dropped the peak of the gaff to control the area while trawling. A boom would have slowed down some of these adjustments, but, of course, the main reason it wasn't used was that it would have been in the way of the fishing gear.

As with most European fishing boats, these had to be designed to crowd together in small harbors. The bowsprit runs inboard, almost its



full length, to be out of the way. The jib is set flying, with the tack on a ring running on the bowsprit. The sail wouldn't stand well on the wind in a breeze, but it would be powerful reaching.

The forestaysail is sheeted to a horse across the deck to be self-trimming in short tacks. It would need tending to draw well. The whole rig is designed to be controllable for maneuvering in strong, puffy winds and close quarters. It would be desperately slow in light airs. It died an unmourned death as soon as reliable engines became available.

The small club on the clew of the forestaysail adds a little area to the sail without increasing luff tension. The original object was to distribute the stress at the clew — no problem with modern sails.

"The late Peter Taugvald told me that the loose-footed gaff mainsail works but with more down angle on its sheet; that is, the sail should be longer on the foot with the traveller location shown. P.C.B."

The cartoon is meant to be a motorsailer. She's compact to go into a marina berth and has a shorter mast and less standing rigging than a modern rig with the same capability. She would be interesting to sail in strong winds and not likely to get out of control, as long as nobody got a bight of the mainsheet around the neck.

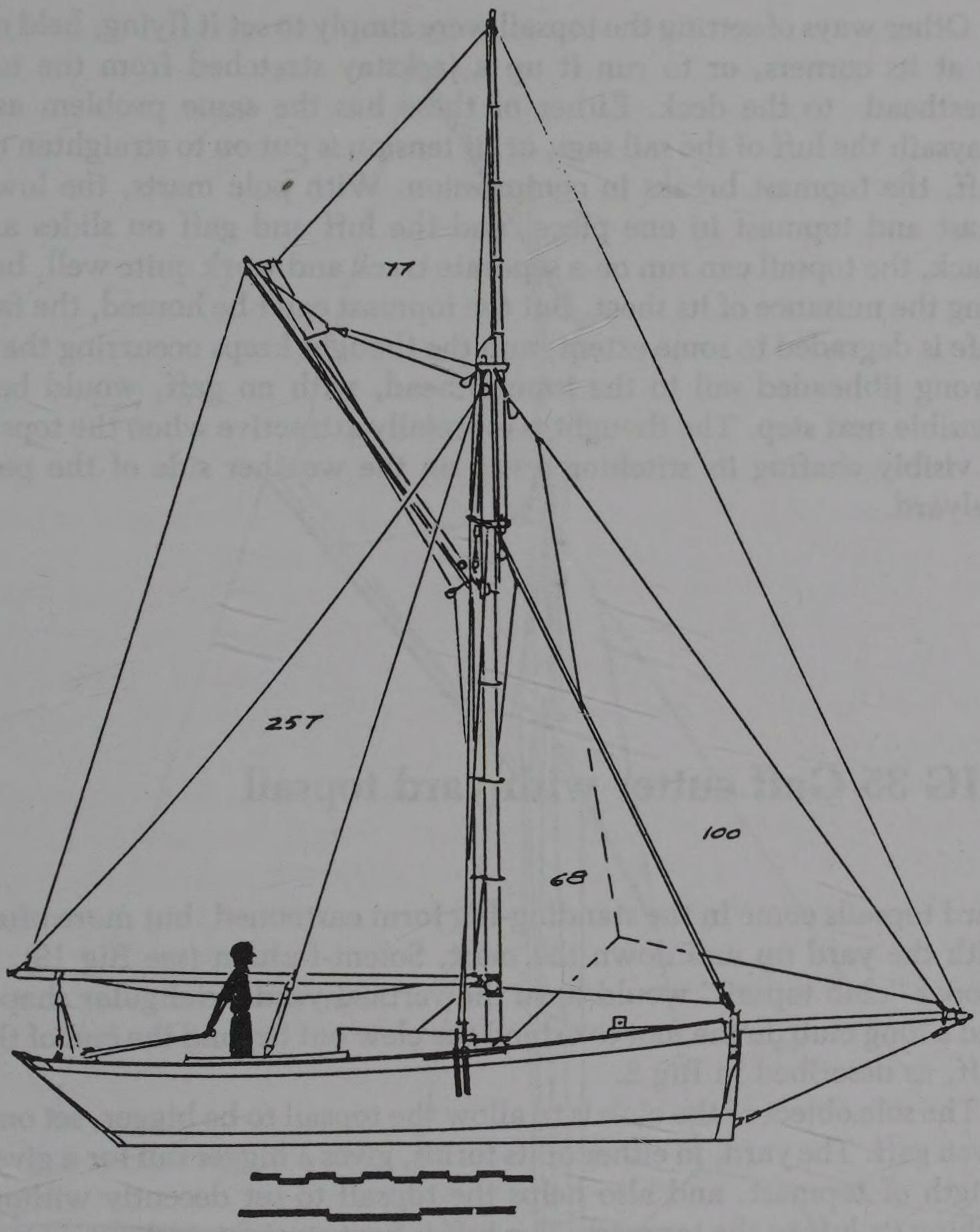
RIG 34 Gaff cutter with topsail

The English cutter rig had some qualities well worth contemplating. It could have the lower mast immensely strong and stiffly stayed, with huge factors of safety and redundant rigging. The bowsprit, gaff, and topmast could be light to the point of flimsiness. If they broke, the rig wasn't hopelessly crippled. The topmast especially was a real fail-safe design. In the older cutters the topmast and bowsprit were routinely housed whenever sail wasn't set on them. The resulting gaff-sloop rig was snug and strong. With the mainsail reefed, the proportions were good either for carrying on to windward, or for heaving-to with the mainsail sheeted in to keep the boat's head up to the wind, and the forestaysail aback to stop her headway. There's a fearful amount of running rigging, but it can all be brought down fairly low and all inboard, and none of it depends on a high state of technical civilization.

It's also the lightest and most weatherly rig of all the rigs that are fail-safe. It can be canvased to be an efficient rig for voyaging in the trade winds, the mast being ideally located and a good height for setting and controlling chafe-free, directionally stable, twin spinnakers or guyed-out staysails. In light winds she can set large running sails from her topmast. Jib topsails were set on these topmasts as well, but they sagged horribly and usually did more harm than good above a beam reach.

A cutter will ride steadily to a sea anchor, since her windage is well aft even with her bowsprit run out and her topmast standing. The long boom does double duty as a riding sail.

To get most of the advantages, the crew labors long and hard. Housing a topmast was a long operation, if everything worked perfectly, and the gear for doing it had a wide range of possible jams and snarls.



There are numerous ways of setting a gaff topsail, all either inconvenient or unsatisfactory. One of the inconvenient ones is shown. The luff of the topsail is hooped or laced to the topmast. With some brails (not shown) or other gear the head can be brought down, and the tack up, to the lower mast cap. To get the sail down on deck, somebody has to climb to the cap and release the sail from the topmast. The topsail sheet remains led to the peak of the gaff; when the gaff is lowered, the slackened bights of the sheet drop across the deck and overboard.

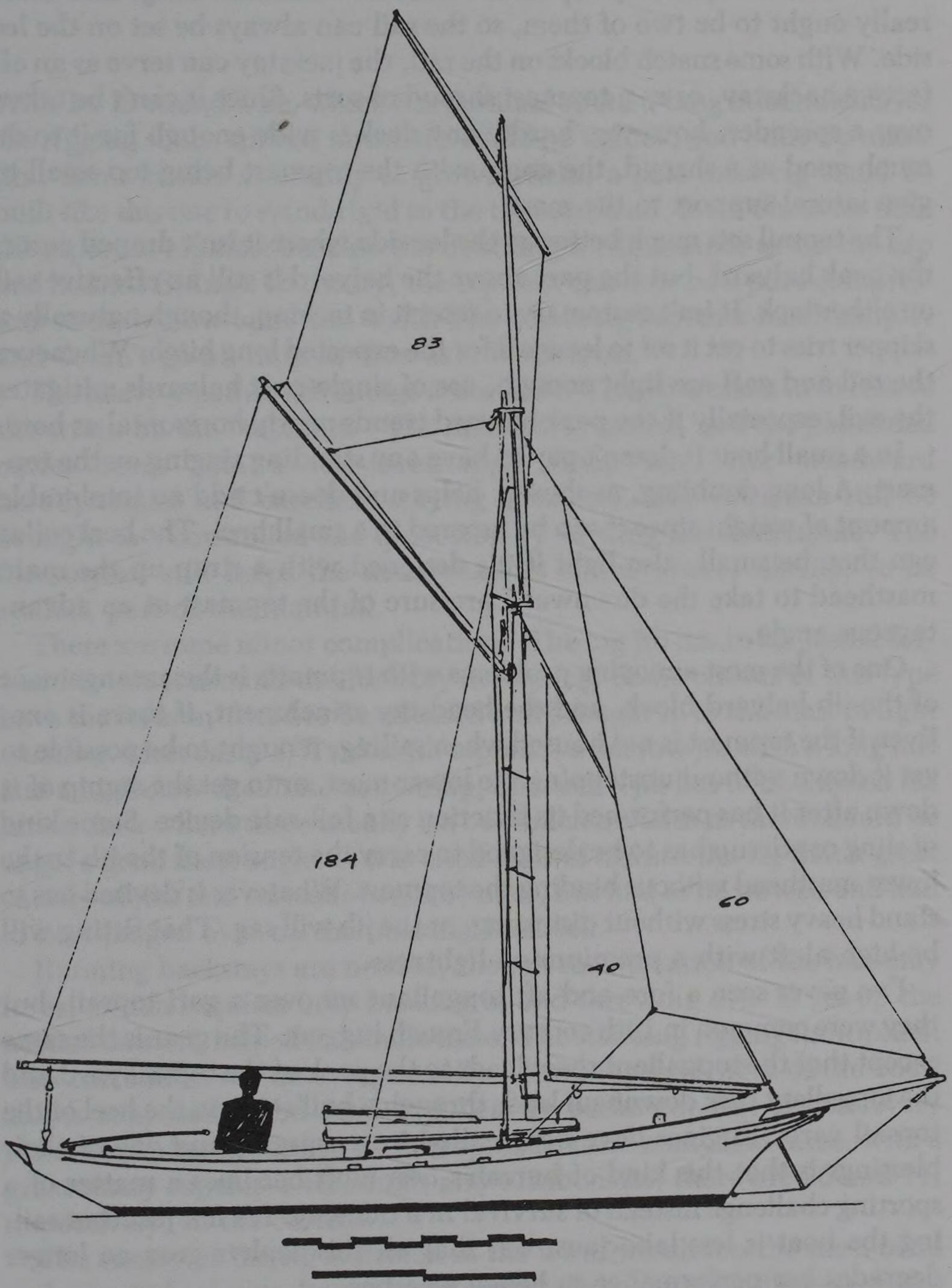
Other ways of setting the topsail were simply to set it flying, held only at its corners, or to run it up a jackstay stretched from the topmasthead to the deck. Either of these has the same problem as a staysail: the luff of the sail sags, or, if tension is put on to straighten the luff, the topmast breaks in compression. With pole masts, the lower mast and topmast in one piece, and the luff and gaff on slides and track, the topsail can run on a separate track and work quite well, barring the nuisance of its sheet. But the topmast can't be housed, the failsafe is degraded to some extent, and the thought keeps occurring that a strong jibheaded sail to the topmasthead, with no gaff, would be a sensible next step. The thought is especially attractive when the topsail is visibly chafing its stitching away on the weather side of the peak halyard.

RIG 35 Gaff cutter with yard topsail

Yard topsails come in the standing-lug form cartooned, but more often with the yard up and down the mast, Solent-fashion (see Rig 19). A proper "club topsail" would have the vertical-yard, triangular shape, and a long club on the foot to extend the clew out beyond the end of the gaff, as described in Rig 2.

The sole object of the club is to allow the topsail to be bigger, set on a given gaff. The yard, in either of its forms, gives a bigger sail for a given length of topmast, and also helps the topsail to set decently without lashing its luff to the topmast. The luff is kept straight without a lot of tension on the tack downhaul, which the light and slender topmast can't stand.

The sail is set flying in the lee of the mainsail, controlled by the halyard, the tack downhaul, and the sheet. It can be stopped up on deck and broken out with the sheet after the halyard is two-blocked. It has spectacular kite potentiality when the halyard is started to lower it. Losing the bitter end of the downhaul in a breeze is embarrassing in the same way as with a spinnaker. A slack jackstay can be run from the deck to the topmasthead for the halyard to travel on; then the sail can't escape upward or to leeward, but it still won't come down without a pull on the


83
184
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downhaul. The jackstay represents a lot of wind-resistance, and there really ought to be two of them, so the sail can always be set on the lee side. With some snatch blocks on the rail, the jackstay can serve as an effective backstay, or as a topmast shroud of sorts. Since it can't be taken over a spreader, however, hardly any deck is wide enough for it to do much good as a shroud, the angle with the topmast being too small to give lateral support to the mast.

The topsail sets much better on the lee side where it isn't draped across the peak halyard, but the part above the halyard is still an effective sail on either tack. It isn't customary to reset it in tacking, though naturally a skipper tries to get it set to leeward for the expected long hitch. Whenever the sail and gaff are light enough, use of single-part halyards mitigates the evil, especially if the peak halyard trends nearly horizontal as here.

In a small boat it doesn't pay to have any standing rigging on the topmast. A long doubling, as shown, helps and doesn't add an intolerable amount of weight since it can be tapered to a small heel. The heel collar can then be small, also light if it's designed with a strap up the main masthead to take the downward pressure of the topmast at an advantageous angle.

One of the most annoying problems with topmasts is the arrangement of the jib halyard block, and the headstay attachment, if there is one. Even if the topmast is not housed when sailing, it ought to be possible to get it down without unstepping the lower mast, or to get the stump of it down after it has performed its function as a fail-safe device. Some kind of sling or stirrup has to be designed to carry the tension of the jib to the lower masthead without binding the topmast. Whatever is devised has to stand heavy stress without distorting, or the jib will sag. That fitting will be high aloft with a premium on lightness.

I've never seen a fore-and-aft topgallant set over a gaff topsail, but they were common in 19th century French luggers. The gear is the same except that the topgallant sheet leads to the peak of the topsail yard and the topgallant tack downhaul leads through a bull's-eye on the heel of the topsail yard. Engines have been called iron topsails, and one of their blessings is that this kind of hurrah's-nest aloft becomes a matter of a sporting challenge instead of survival in a tideway. It's not just that sailing the boat is less laborious, but that all this zephyr gear no longer degrades her performance in heavy weather.

RIG 36 Jibheaded cutter

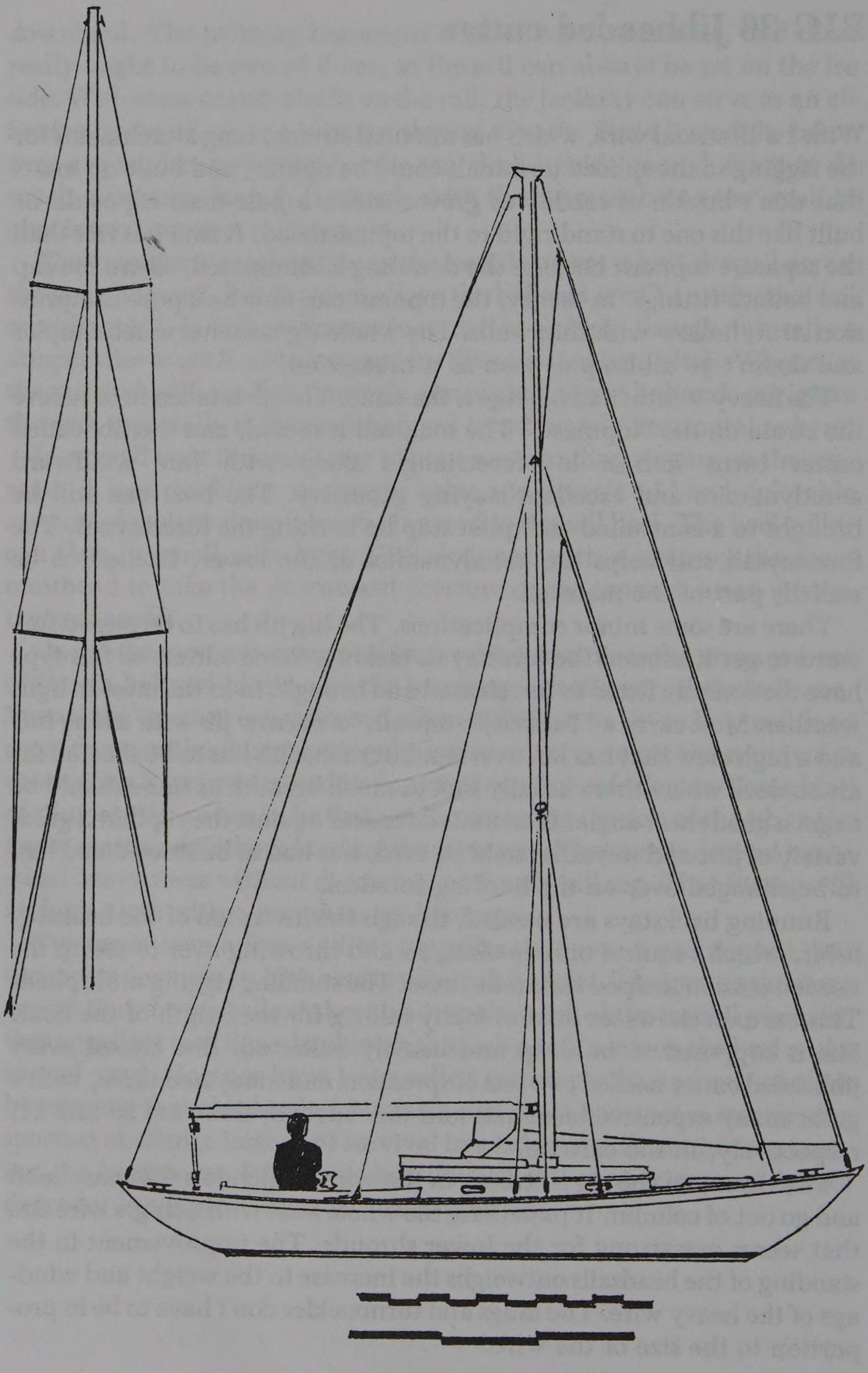
With 1 x 19 strand wire, which has minimal stretch, tang attachments for the rigging so the spliced terminals could be tighter, and built-up masts that don't buckle as readily as grown sticks, a pole-mast rig could be built like this one to stand rigid to the topmasthead. It isn't heavier than the separate topmast because the doubling is eliminated, as are the cap and hounds fittings. In theory, the topmast can now be a pure compression strut, hollow with thin walls. The whole rig becomes much simpler and doesn't go all limp as soon as it breezes on.

The heavy-weather advantage is the same. The jib is taken in to relieve the strain on the "topmast." The mainsail is reefed, and the jibheaded cutter turns into a low-foretriangle sloop with fair windward aerodynamics and excellent staying geometry. The boat can still be brought to a controlled and quiet stop by backing the forestaysail. The forestaysail still helps the aerodynamics of the lower, likeliest to be stalled, part of the mainsail.

There are some minor complications. The big jib has to be passed forward to get it around the forestay in tacking. Some cutters of this type have the forestay fitted to be released and brought in to the mast in light weather. Most carry a "Yankee jib topsail," a narrow jib with a long luff and a high clew that has less overlap, but such a jib has to be sheeted far aft on deck where there usually isn't as much breadth as there should be to get a good sheet angle. It was cited for *and* against the rig that a great variety of jibs and staysails could be used, but had to be stowed and had to be changed over on the bucking foredeck.

Running backstays are needed, though the invention of the backstay lever, which requires only hooking in and throwing over to set up the needed tension, helped to handle these. The standing rigging multiplied. This cartoon shows an exceptionally tall rig for the length of the boat. She is supposed to be deep and heavily ballasted. But almost every jibheaded cutter needed two sets of spreaders and many had three, with a great many expensive terminals and turnbuckles; there are 26 and 11, respectively, in the cartoon.

The enemy of the rig is stretch in the wire, which lets the mast bend and go out of column. It pays to rig the whole boat with a single wire size that seems overstrong for the lower shrouds. The improvement in the standing of the headsails outweighs the increase in the weight and windage of the heavy wire. The tangs and turnbuckles don't have to be in proportion to the size of the wire.



In the end, the rig is an example of "one-hoss-shay engineering" with "every part as strong as the next." It's an art form, an aesthetic experience when well done, but it's to be remembered that the original ended "in a heap on the ground, as if it had been to the mill and ground" (as have plenty of these rigs). One fatigue failure, one cotter pin dropped out, and the whole rig disintegrates. In theory there is still the cutter-rig fail-safe: the upper rigging could fail while the lower rigging still held. In practice it's all so tied together that it's hardly conceivable that the boat could be worked after losing any part of her rigging.

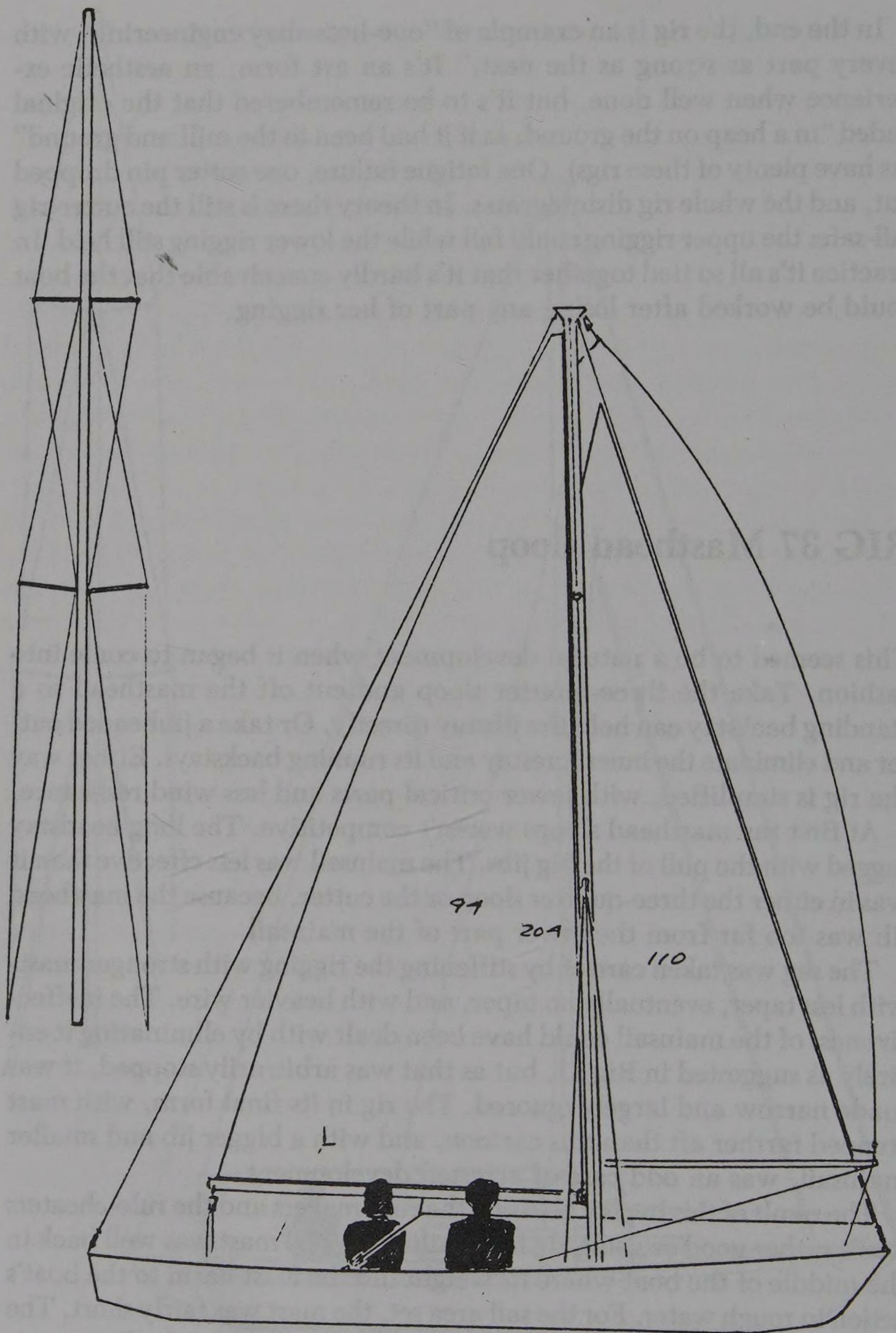
RIG 37 Masthead sloop

This seemed to be a natural development when it began to come into fashion. Take the three-quarter sloop and cut off the masthead so a standing backstay can hold the jibstay directly. Or take a jibheaded cutter and eliminate the inner forestay and its running backstays. Either way the rig is simplified, with fewer critical parts and less wind resistance.

At first the masthead sloops weren't competitive. The long headstay sagged with the pull of the big jibs. The mainsail was less effective than it was in either the three-quarter sloop or the cutter, because the masthead jib was too far from the lower part of the mainsail.

The sag was taken care of by stiffening the rigging with stronger masts with less taper, eventually no taper, and with heavier wire. The ineffectiveness of the mainsail could have been dealt with by eliminating it entirely as suggested in Rig 11, but as that was arbitrarily stopped, it was made narrow and largely ignored. The rig in its final form, with mast stepped farther aft than this cartoon, and with a bigger jib and smaller mainsail, was an odd case of arrested development.

The result of this byplay between the rule-makers and the rule-cheaters was a rather good cruising rig for auxiliaries. The mast was well back in the middle of the boat where its weight did the least harm to the boat's action in rough water. For the sail area set, the mast was fairly short. The whole rig could be stayed stiffly without needing continual adjustment. It was brittle. If something let go, it fell down entirely. But it lent itself to big factors of safety. It needed high tensions to be weatherly, but it came


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along at a time when homogeneous fiberglass hulls, which could be reinforced to stand the stress without problems, had become routine.

It was, and is, a good rig for a cruiser because the big jib gives immense driving power on a straight course, while for maneuvering, short tacking, and for getting to windward in heavy weather, the engine and the small mainsail make a good team. The sail steadies the boat and produces enough thrust to allow her to drive out to windward with far less power than would be needed for bare safety in a straight powerboat. The availability of the big jib for passagemaking means the boat doesn't have to be filled with fuel tanks, while the little mainsail allows shorthanded weatherliness and maneuverability in rough water without devoting a lot of space to bulky machinery. To race a rig like this needs a big, strong crew. To cruise it does not, if inhibitions about using the engine don't get in the way of good sense.

For a daysailer like the cartoon it wasn't a good rig. Either variety of three-quarter rig is faster. The long overlap of the jib makes for slow tacking. If a smaller jib is set, the rig is not powerful because to make the long headstay stand, the mast has to be fat all the way up, which spoils the drive of the mainsail. For the same reason, the rigging can't be simplified much more, even in small sizes, so it's inherently expensive. If expense isn't a problem, it would be better to go on to the natural end of the development process of this rig — the staysail cat.

The lead of the topmost shrouds in the cartoon, diamond-fashion in to the mast tangs, saves the wind resistance of the extra wire needed to bring them down to the hull chainplates. I wouldn't rig a cruiser this way because if a swaged terminal shows a fatigue crack, for example, it's more likely to be noticed before it breaks if it's down on deck. These rigs have too many terminals aloft that can't be reached easily.

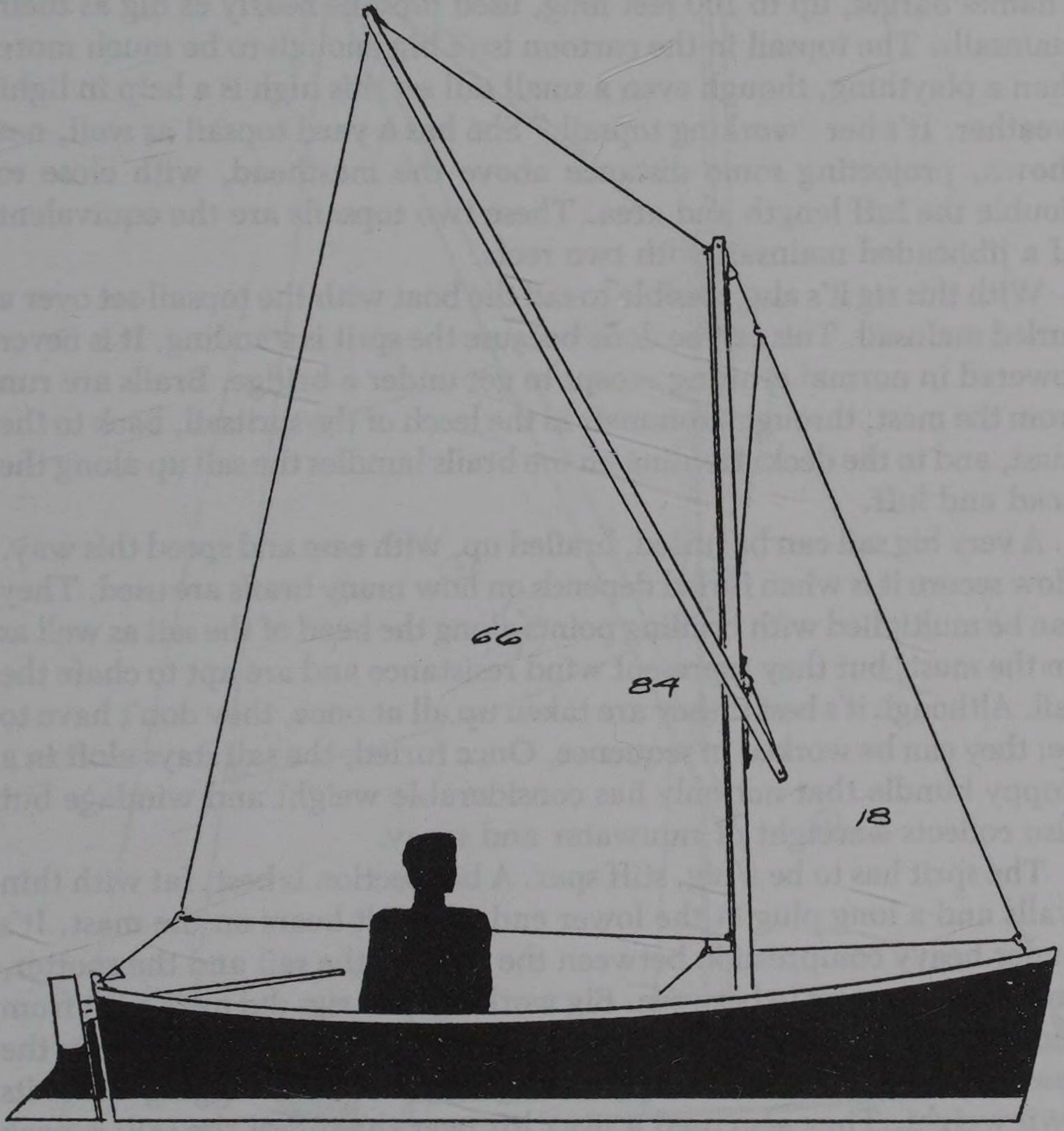
RIG 38 Spritsail sloop

Back to the 17th century. What I've said about spritsails in Rig 23 applies. By adding a jib to the basic boomless spritsail, some extra area is added in an efficient form, without any multiplication or lengthening of the few short spars. The jib is a good airfoil in its own right, and the draft off it improves the drive of the mainsail. The position of the jib is perfect for a leading-edge device. The spritsail is prone to twist on account of the difficulty of keeping the peak up tight. But the jib compensates for the twist to some extent. Taking the jib off doesn't affect the balance of the rig as much as might be thought. If it's sheeted correctly, 10 or 12 degrees out from the centerline, the pull of the sheet tends to swing the bow into the wind. The forward position of the sail has a surprisingly small tendency to knock her bow off the wind. By the same token, if you want to make a boat weathercock downwind, as in a broken-down powerboat that won't steer if she gets broadside to the wind, a loose-footed staysail is not the best sail to make her do it.

This is one of the few sloop rigs that can be weatherly without backstays or standing rigging of any sort. The spritsail's mast is so short that it can be built very stiff without its weight overpowering the boat. With the sloop rig the mast is stepped farther aft than in a cat, so the weight of a heavy mast does still less harm.

Moreover, the head of a spritsail is in tension, even when it isn't set up as hard as it should be, and that holds the masthead. The peak halyard of a gaff sail has the same effect, but it's not as powerful because there's less trouble keeping a gaff sail properly peaked: the angle of the halyard to the top of the taller mast of the gaff sail works at a better mechanical advantage. The halyard is also slipping on a sheave, with the vector of its force dividing the angle of the standing part and the fall, while the throat of a spritsail can be lashed, or even shackled, solidly in place.

Of course any cantilevered mast has some give. A big boat with this rig would need something by way of a backstay to get the most drive out of the close-hauled jib. In the 15-footer cartooned, with a 13½-foot mast and sprit, and a jib of 18 square feet, the backstay isn't crucial. The rig is auxiliary to the oars, and since it is a spritsail, the spars can not only be stowed in the boat, but stowed out to the sides to be out of the way of the oarsmen. This is the most powerful and weatherly rig that can meet that specification. The fact that it's a cheap rig, easily built, strong and reliable, easy to maintain, and readily repaired with makeshift material, is an incidental bonus.


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RIG 39 Spritsail sloop with topsail

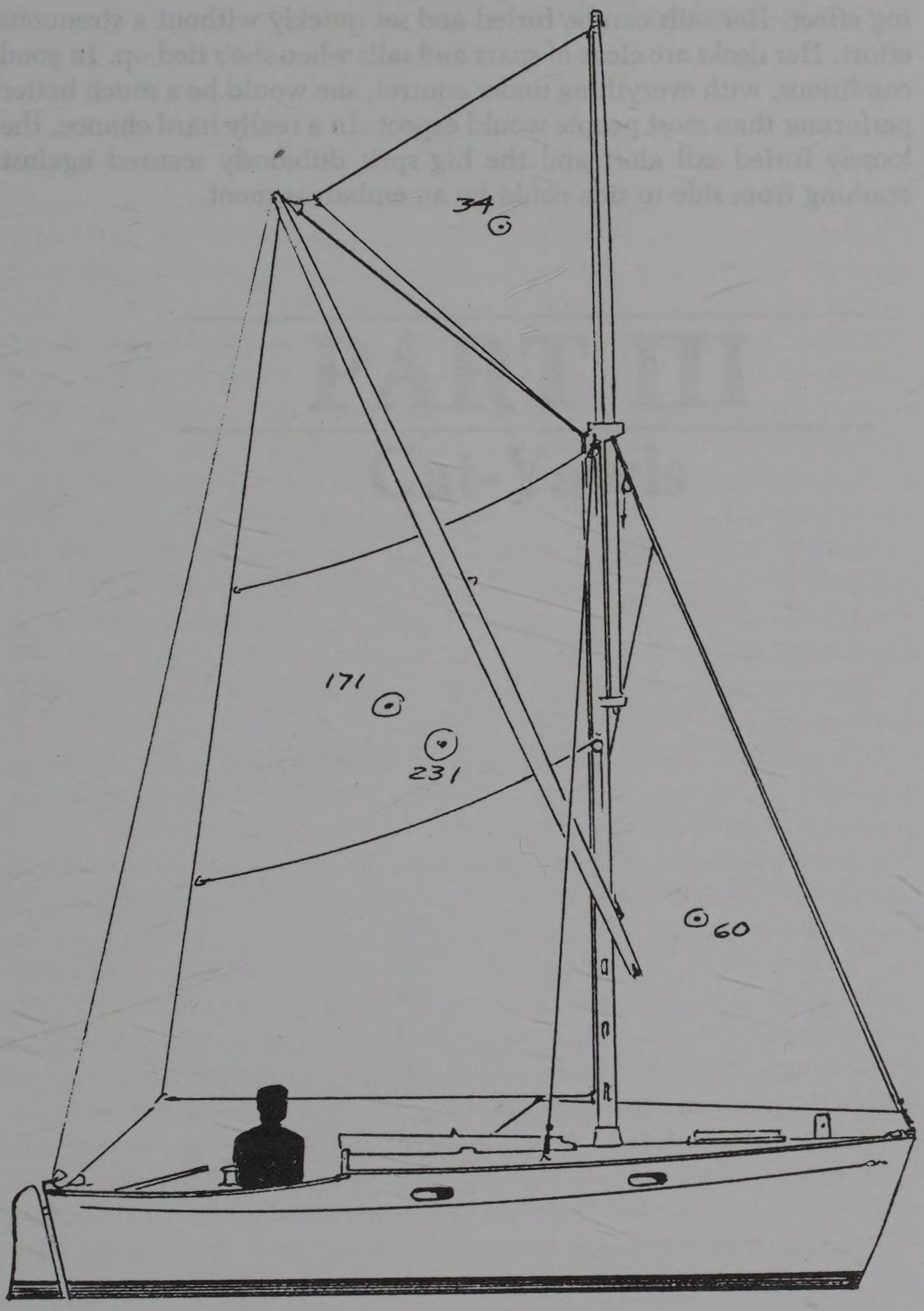
Since a spritsail is a hard sail to arrange for reefing, many working rigs that used it kept it small and set a topsail over it. The bigger the boat, the less proportion of her sail was likely to be in the spritsail. The big Thames barges, up to 100 feet long, used topsails nearly as big as their mainsails. The topsail in the cartoon isn't big enough to be much more than a plaything, though even a small sail set this high is a help in light weather. It's her "working topsail." She has a yard topsail as well, not shown, projecting some distance above the masthead, with close to double the luff length and area. These two topsails are the equivalent of a jibheaded mainsail with two reefs.

With this rig it's also possible to sail the boat with the topsail set over a furled mainsail. This can be done because the sprit is standing. It is never lowered in normal cruising except to get under a bridge. Brails are run from the mast, through grommets in the leech of the spritsail, back to the mast, and to the deck. Hauling on the brails bundles the sail up along the head and luff.

A very big sail can be furled, brailed up, with ease and speed this way. How secure it is when furled depends on how many brails are used. They can be multiplied with brailing points along the head of the sail as well as on the mast, but they represent wind resistance and are apt to chafe the sail. Although it's best if they are taken up all at once, they don't have to be; they can be worked in sequence. Once furled, the sail stays aloft in a sloppy bundle that not only has considerable weight and windage but also collects a weight of rainwater and spray.

The sprit has to be a big, stiff spar. A box section is best, fat with thin walls and a long plug at the lower end where it bears on the mast. It's under heavy compression between the peak of the sail and the snotter, and has no support in between. Big working sprit rigs did have a lift from the center of the sprit to the masthead. This was primarily to lower the sprit, but it could also be set up to keep the sprit from sagging under its own weight. They also used a peak lift over the top of the sail; a peak outhaul led in to the masthead and thence to the deck; a halyard at the throat of the spritsail; and two guys from the peak of the sprit to the quarters to hold the sprit steady with the sail brailed up. The peak snotter was a length of chain that was not adjustable. This list makes it clear that if a small spritsail is a simple sail, a big one is not. A big spritsail rig is one of the most complicated rigs of all.

The little cruiser in the cartoon has a rig that is powerful for its heel-


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ing effect. Her sails can be furled and set quickly without a strenuous effort. Her decks are clear of spars and sails when she's tied up. In good conditions, with everything under control, she would be a much better performer than most people would expect. In a really hard chance, the loosely furled sail aloft and the big sprit dubiously secured against crashing from side to side could be an embarrassment.

PART III

Cat-Yawls

RIG 40 Jibheaded with sprit booms

All cats have a control problem if they lose headway. If the sail is allowed to luff, their wind resistance, the mast and the shaking sail, is all forward, so they tend to fall away from the wind to wind abeam or more. Then if the sheet is hauled in to get way on the boat, the first part of the sail to fill is the leech at the tack, so they may come up to the wind only to fall off again without gaining steerageway.

If they have to reef underway, the sail has to be lowered broad-off, workable with a topping lift and lazyjacks but not very desirable. Then the reefing has to be done with the boat rolling in the troughs.

Cats also tend to walk all around their anchors; hence, they are apt to drag, apt to foul the neighbors, and are most uncomfortable. Putting up a small riding sail on the stern improves control wonderfully. Sheeted flat, it will hold the boat close to head-to-wind even with the mainsail all shaking. The boat also rides steadily to her anchor.

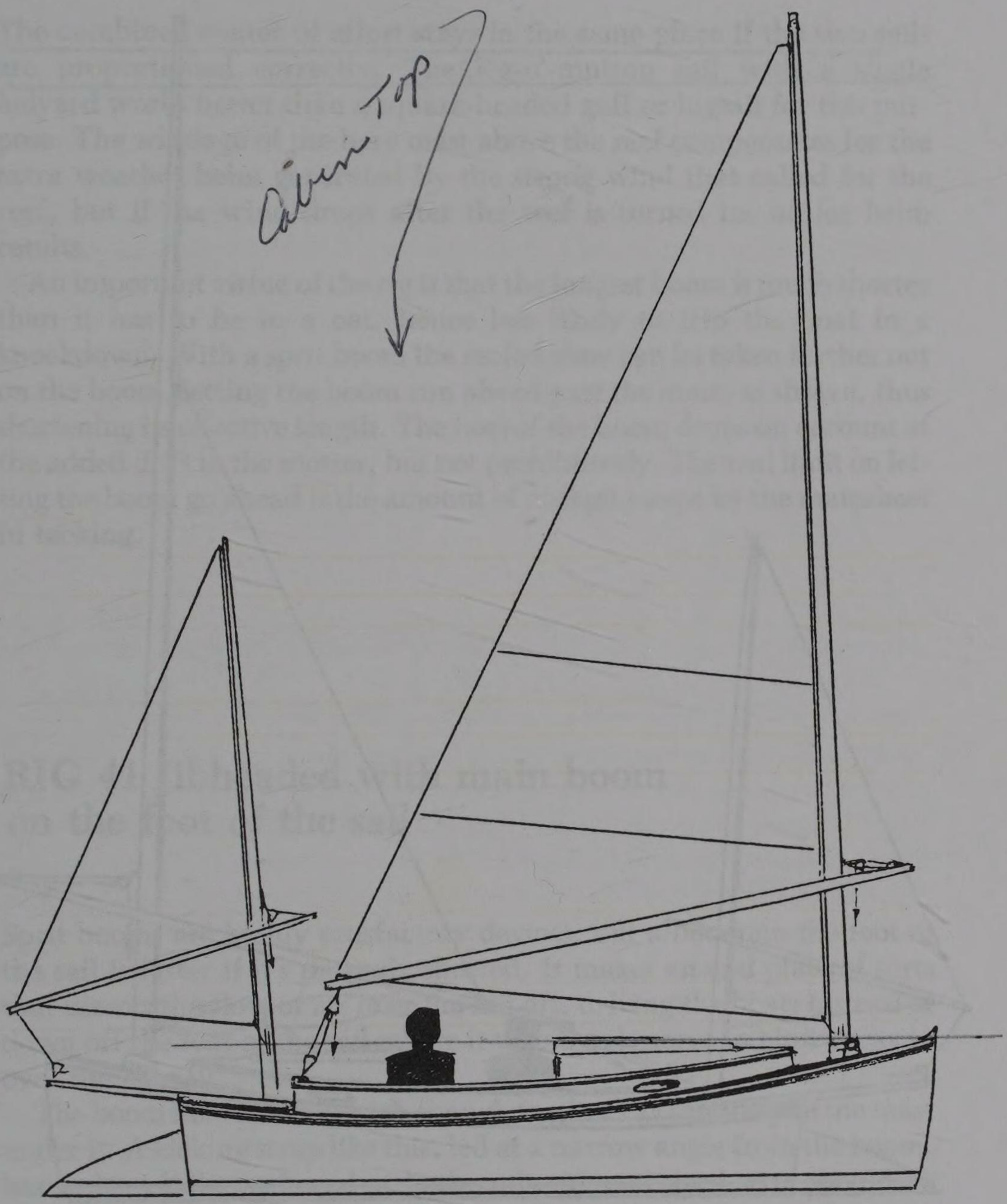
Contrariwise, if a heavy weather helm develops, the mizzensheet can be started. A cat-yawl can be made to steer herself with the mizzensheet slackened more than the mainsheet, for the mizzen fills as the boat falls off and luffs when she heads up.

The mizzen can be forced over to throw a boat's head either way from head-to-wind. It isn't as effective or as easy to use for this purpose as a sloop's jib, but it has some capability.

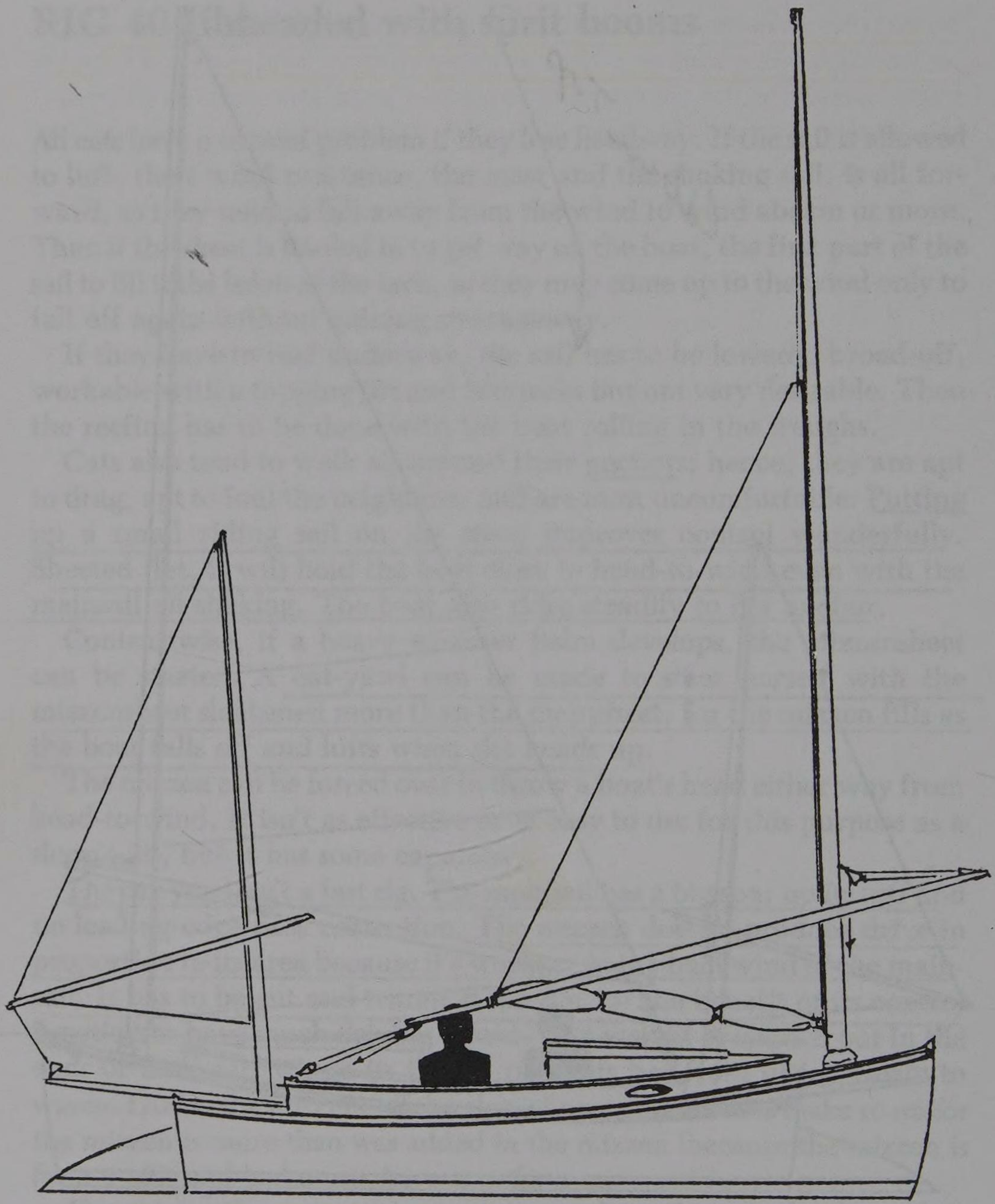
The cat-yawl isn't a fast rig. The mainsail has a big spar up its luff and no leading-edge flow correction. The mizzen doesn't produce drive in proportion to its area because it's working in the backwind of the mainsail. It has to be cut and trimmed too flat for the benefit of its control function to have much driving power. The weight of spars is out in the ends of the boat, where its inertia prevents her from lifting easily to waves. Lastly, the area cut off the clew of a cat's mainsail to make room for the mizzen is more than was added in the mizzen (because the mizzen is farther aft), and had more drive area for area.

The cat-yawl's mainsail is no easier to sheet than the bigger sail of the cat, because the boom is a shorter lever arm and the narrower sail needs more sheeting down to keep it from twisting. The mizzensheet calls for an extra pair of hands in all maneuvers except tacking to windward; if it isn't started promptly, the boat may not be able to bear away, for instance.

This is, nevertheless, the best all-around rig for daytime cruising in crowded waters. The sails stand properly without any standing rigging.



The masts are out of the way of the cabin and cockpit. And it has the quickest and simplest sheeting geometry of any rig that allows positive control of the boat without steerageway.



The second cartoon shows the overpowering advantage of the rig. When a reef is pulled down in the mainsail, the geometrical center of the sail moves forward, but its area is reduced relative to the mizzen.

The combined center of effort stays in the same place if the two sails are proportioned correctly. The leg-o'-mutton sail with a single halyard works better than a square-headed gaff or lugsail for this purpose. The windage of the bare mast above the reef compensates for the extra weather helm generated by the strong wind that called for the reef, but if the wind drops after the reef is turned in, no lee helm results.

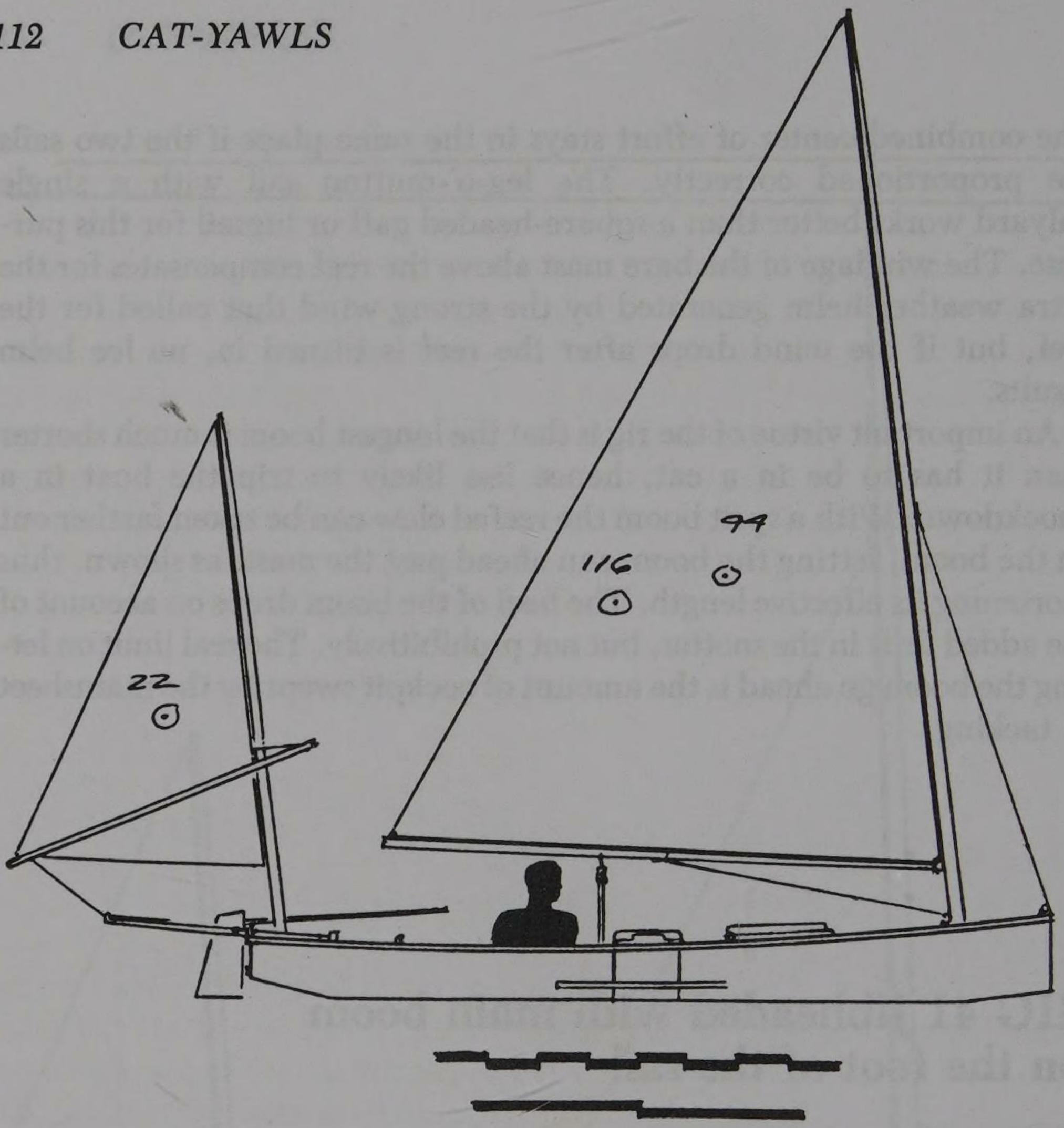
An important virtue of the rig is that the longest boom is much shorter than it has to be in a cat, hence less likely to trip the boat in a knockdown. With a sprit boom the reefed clew can be taken farther out on the boom, letting the boom run ahead past the mast, as shown, thus shortening its effective length. The heel of the boom drops on account of the added drift in the snotter, but not prohibitively. The real limit on letting the boom go ahead is the amount of cockpit swept by the mainsheet in tacking.

RIG 41 Jibheaded with main boom on the foot of the sail

Sprit booms are highly satisfactory devices, but a boom on the foot of the sail is faster if it's properly sheeted. It makes an end plate of sorts that directs the flow of air over the sail aft, driving the boat, instead of down off the foot of the sail where it would only serve to blow spray in over the lee rail.

The boom here is barely high enough to get a kicking strap to the mast under it. A kicking strap like this, led at a narrow angle from the boom, has to be solidly anchored at both ends. A good-sized wire should be used, as rope will stretch so much it's hardly worth the trouble of rigging it. The sheet runs on a track set into the cockpit sole to help hold the boom down, and also to bend the boom to take fullness out of the sail in strong winds. The boom is tapered to be stiff at its outer end and more flexible toward the mast to shape the flow of the sail.

To keep all these pulls on the boom from bending the mast aft there's a forestay, placed low to get a tolerable angle with the mast, and, again, to make the mast bend in a way to flatten the sail.



The sails have no halyards and are furled by rolling them in from the leech as described in Rig. 1. The slender masthead will stand stiffer than its looks suggest because there's no downward force from a halyard on it.

It's doubtful if the little sharpie camping cruiser depicted is an appropriate object for these sheeting arrangements. The track for the sheet is more or less in the way, and the forestay has to be disconnected before the mast can be unstepped.

The mizzen has an ordinary sprit boom so it can be sheeted to a point, the end of the boomkin, and still stand flat. The boomkin should be set into a socket with loose fit so it can be unshipped readily. The stress on it is up and in, with no tendency to unship it accidentally.

Tiny yawls with outboard rudders have had some wonderful ingenuity devoted to getting the tiller past the mizzenmast. Tillers with kinks and loops, torsion bars with cranked ends, yokes and lines of assorted

shapes, and arms and drag links, have all been used. The best way is to put the mizzen off-center, clear of the tiller. The mizzen has to be back close to the rudder axis for this. In the cat-yawl cartoon, Rig 40, the mast couldn't be offset enough to allow the tiller to swing as far as is sometimes needed.

An off-center mast, even a tiny mizzen, seems to trouble some people on paper, but in the boat it's unobtrusive. The same people who find it distasteful often don't notice it until their attention is deliberately drawn to it. It has no effect on performance, nor, for that matter, does a mainmast considerably off-center. After all, any boat becomes asymmetrical as she heels.

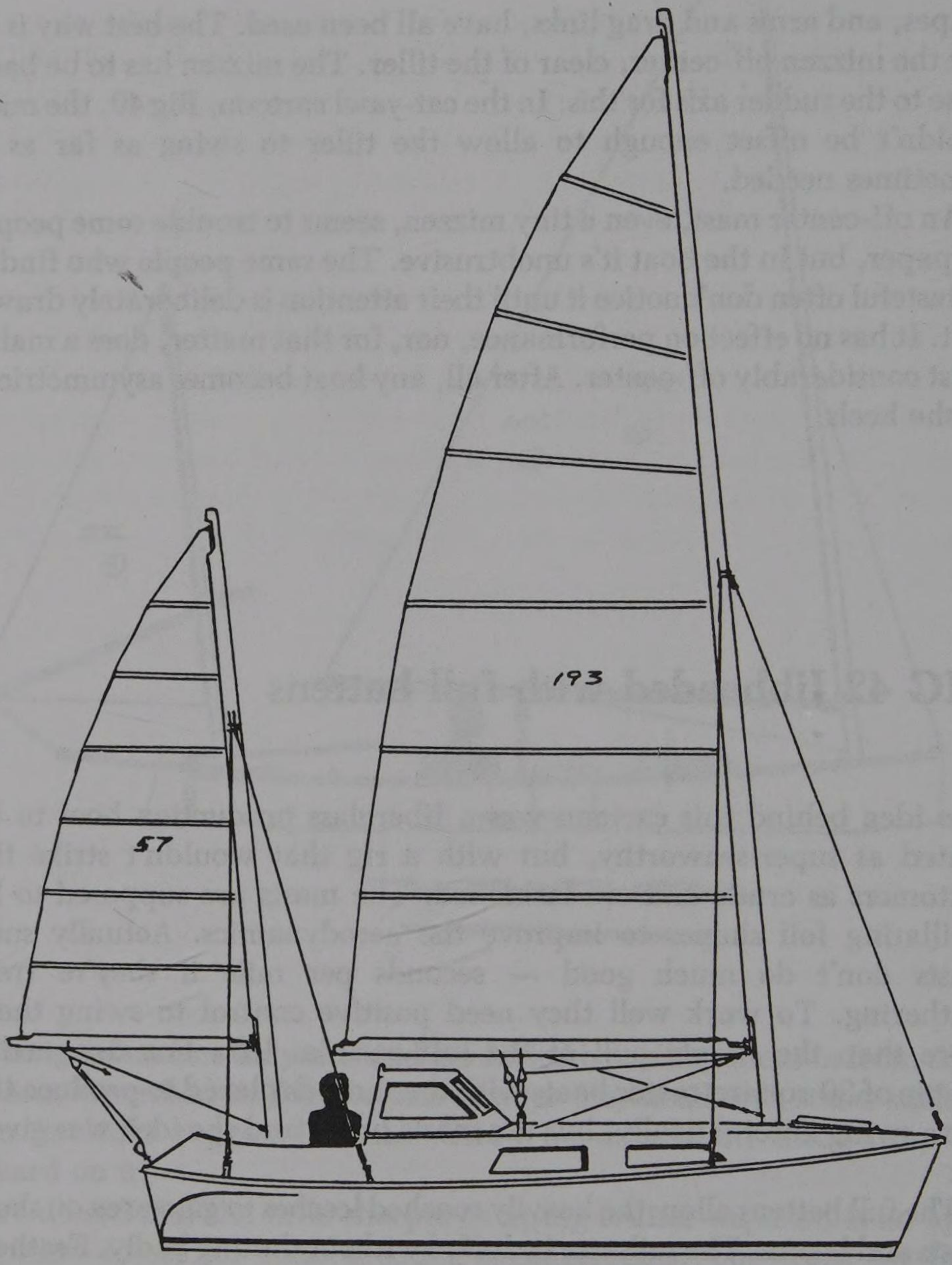
RIG 42 Jibheaded with full battens

The idea behind this cartoon was a fiberglass production boat to be touted as super-seaworthy, but with a rig that wouldn't strike the customers as crude and old-fashioned. The masts are supposed to be oscillating foil shapes to improve the aerodynamics. Actually such masts don't do much good — seconds per mile if they're free-feathering. To work well they need positive control to swing them more than the simple pull of the luff can do. Uffa Fox designed a couple of 30-square-meter boats with the shrouds placed to produce the extra swing automatically, but the masts broke and the idea was given up.

The full battens allow the heavily roached leeches to gain area on short masts and booms. The sails can be luffed without slatting badly. Feathering becomes a better word than luffing. The effect can be used to postpone reefing. See Rig 8 for comments on the rig.

The full battens are more valuable on the mizzen than on the main. A riding sail that slats is bad company in strong wind. Noise and vibration aside, the sail will destroy itself in short order. The battens damp the fluttering so much that the sail can be left standing for weeks on end without much wear and tear, barring whatever ultraviolet does to it.

If the wind is strong enough, the full-batten sail will develop high-frequency fluttering in between the battens. Part of Admiral Beaufort's



definition of a hurricane was "no sail will stand," but if the battens are close together a sail like this will stand in a gale.

A full-batten sail can have a sprit boom. It won't hurt the battens but the sail is messy to furl. When the snotter is started, the boom starts to run inboard, but the battens can't until the luff is detached from the

mast. The battens get bent in compression and don't bundle up well. With a boom on the foot, a topping lift can be run from boom-end to masthead and hold the boom parallel with the battens, which can then nest down on the boom in a docile fashion. The furled mizzen hangs out over the stern too far to get as many ties around it as it ought to have for a secure furl, and the shape of the bulwarks around the stern compounds the problem. The bulwark shape is for manufacturing convenience, tolerated because this sail would be furled only in a marina.

The mizzen boom is held down by a heavy vang. With this set up hard the sail can swing around as far as the shrouds allow without twisting. The mizzen is not far from being a rigid vane.

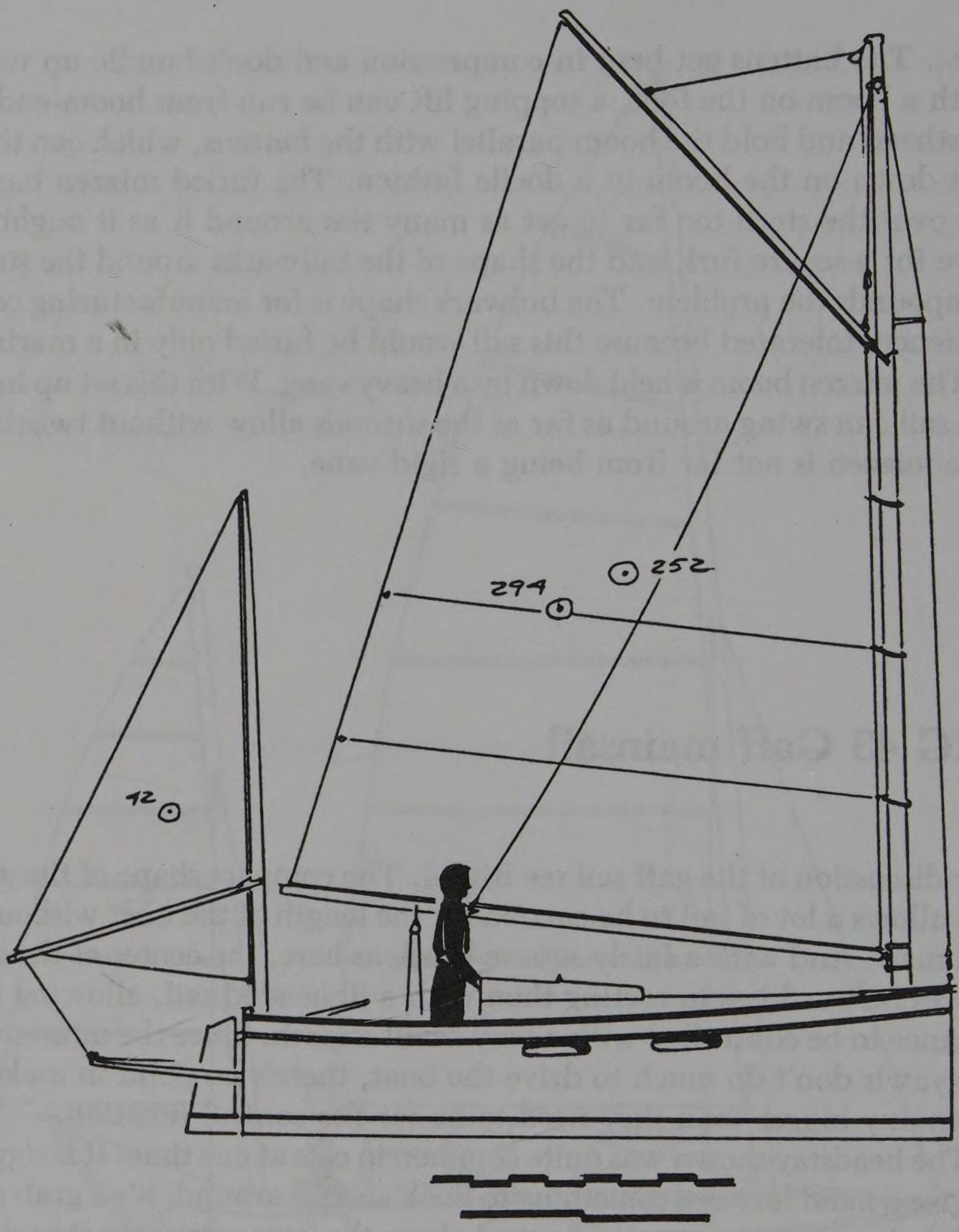
RIG 43 Gaff mainsail

For discussion of the gaff sail see Rig 14. The compact shape of the gaff sail allows a lot of sail to be carried for the length of the boat without a tall mast. And with a fairly square head, as here, the center of the sail moves forward less in reefing than with a jibheaded sail, allowing the balance to be controlled with a very small mizzen. Since the mizzens of cat-yawls don't do much to drive the boat, there's no point in making them any bigger than they need to be for the control function.

The headstay shown was quite common in cats at one time. It is rigged to give a hand forward something to hook an arm around; it's a grab rail rather than a mast support. The strut above the jaws carries the stay clear of the hoops and gaff parrel. With this much masthead above the jaws, the peak halyard doesn't produce thrust of the gaff against the mast.

The gooseneck of the main boom slides on a short vertical rod. Hoisted as far as it will go to begin with, the weight of the boom will drop down the road as the halyards stretch, keeping the luff taut and avoiding some jigging on the halyard.

The mizzen is stepped off-center to clear the tiller. The mizzen boom has a jaw on one side to engage the mast. In this small boat the jaw can be reached from the deck. Clew tension is produced simply by pulling the boom lower on the mast. To furl the sail the jaw is lifted and pulled off the mast, the boom run inboard and stowed, and the sail furled up and



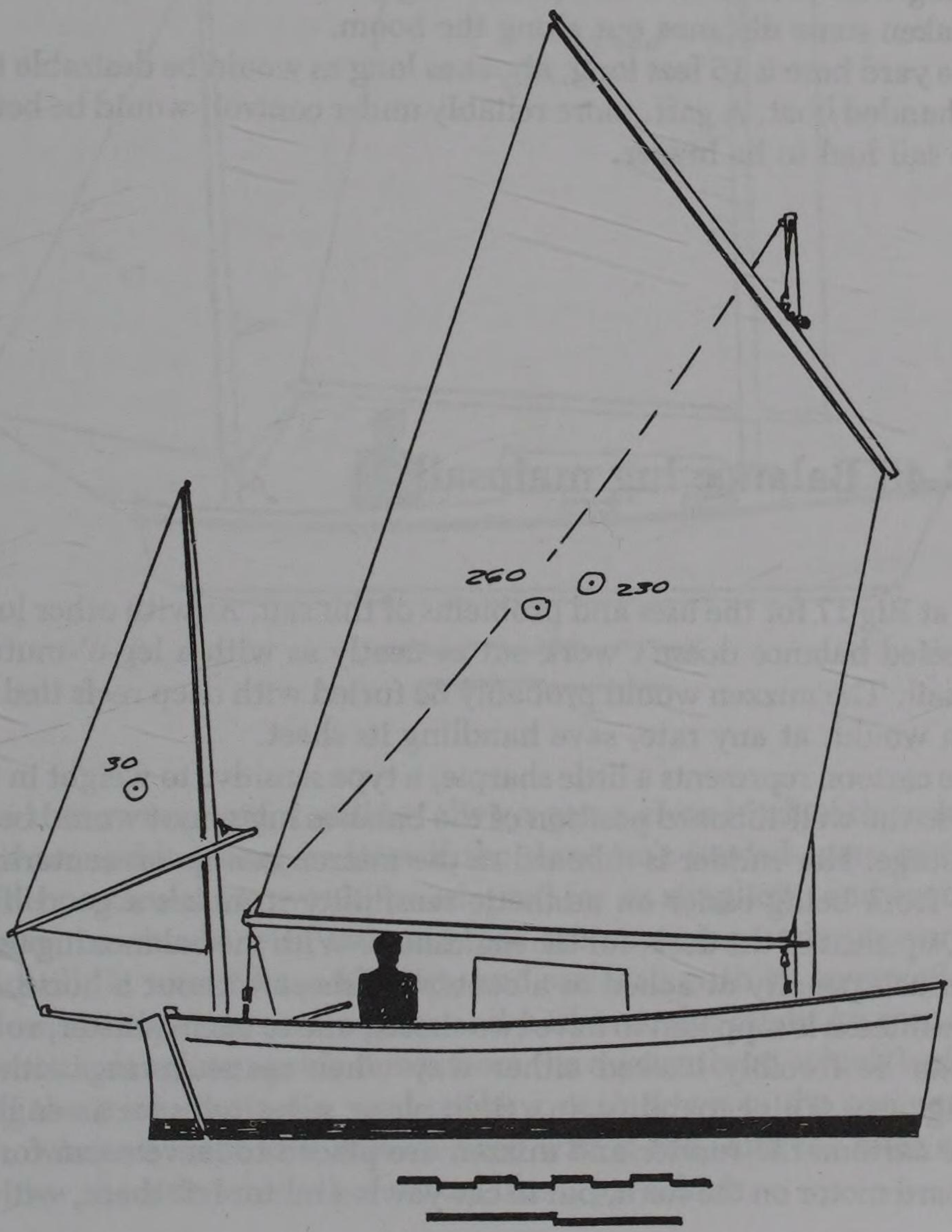
down the mast. Given a halyard, the sail can be pulled down into the cockpit. A sail with 13 feet of luff and 42 square feet of area doesn't call for much respect in rigging. It can be grabbed at the clew, or anywhere, and smothered by brute force.

The stepping of the mizzenmast right against the inside of the transom clears out the cockpit, leaves the swing of the tiller unobstructed, and as with the headstay, does double duty as a grab. A big bitt on the other side, clear of the mizzen rigging, would be handy for towing a skiff or a swimmer.

RIG 44 Standing lug main

What was said about the standing lug in Rig 16 applies to this one. Adding a riding sail isn't as big an improvement with a lugsail as it is with a gaff or jibheader because as the sail is lowered the yard hangs head down. It's not as hard to smother the lugsail with wind abeam. The cartoon shows a topping lift to the end of the boom to help.

The rig might be selected for a small seagoing boat for the sake of the short, strong mainmast, not so close to the stem that there's any problem



with deck space. The stubby mast with no rigging doesn't have so much wind resistance that the little mizzen won't hold her bow up to the wind in a gale. In a wind so strong that the mizzen won't stand and the boat falls off broadside to the wind, "ahull," the short mainmast isn't likely to whip itself off of its own weight as the boat rolls.

The lugger is a little better adapted than most rigs to set a trysail on her mainmast. There's no idle halyard to make wind resistance, chafe, and noise, or hoops and jaws in the way as with a gaff rig, or an unnecessarily long mast as in the jibheader.

With jaws on the boom, some stretch in the halyard can be compensated for by pulling the boom down. The boom downhaul, while still working well enough as a downhaul, might have some vang effect if it was taken some distance out along the boom.

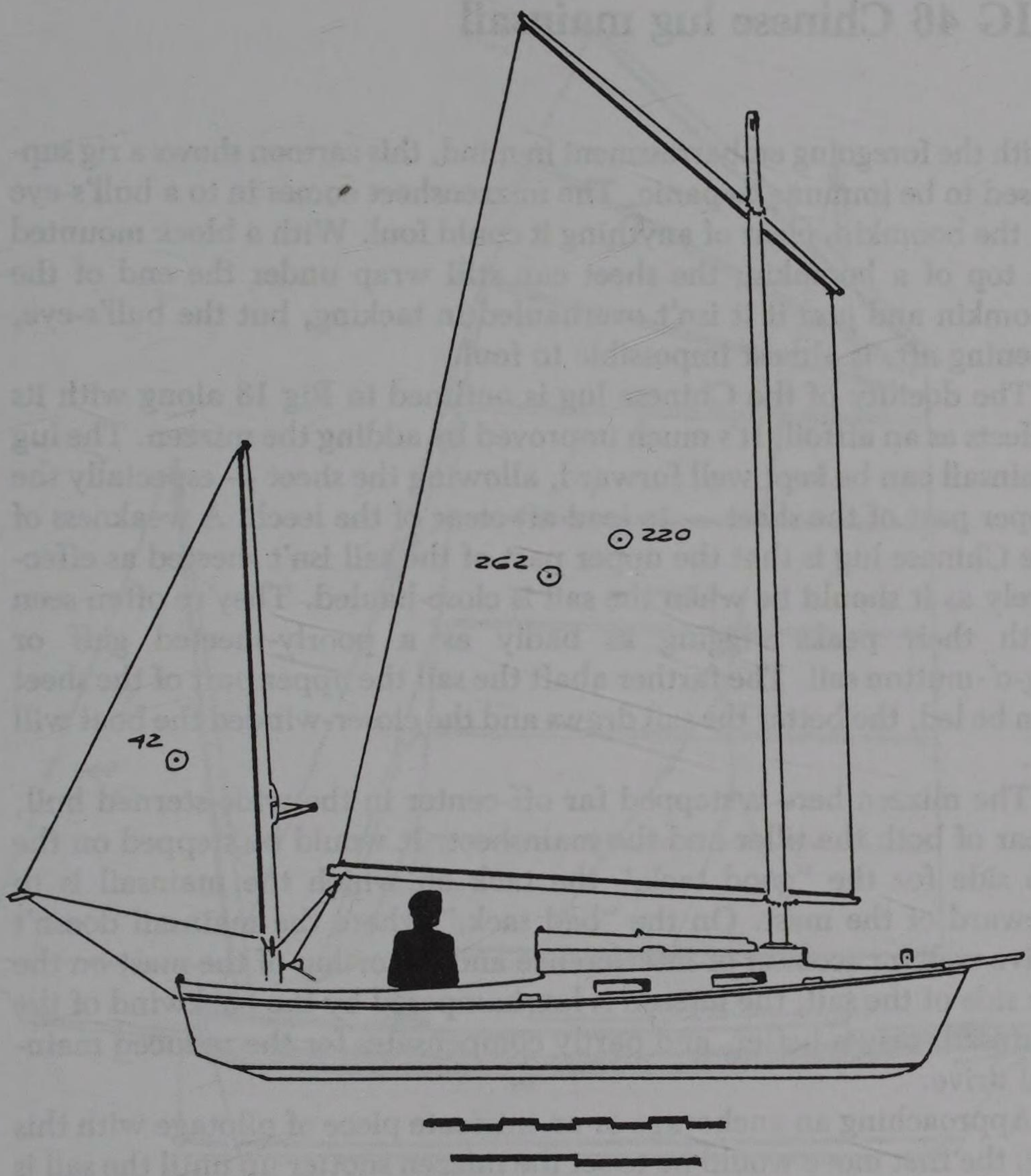
The yard here is 15 feet long, about as long as would be desirable in a shorthanded boat. A gaff, more reliably under control, would be better if the sail had to be bigger.

RIG 45 Balance lug mainsail

Look at Rig 17 for the uses and problems of this sail. As with other lugs, the reefed balance doesn't work out as neatly as with a leg-o'-mutton mainsail. The mizzen would probably be furled with deep reefs tied in, which would, at any rate, save handling its sheet.

The cartoon represents a little sharpie, a type sensitive to weight in the bow, so the well-inboard position of the balance lug's mast would be an advantage. Her rudder is inboard so the mizzen can go on centerline. Aside from being easier on aesthetic sensibility it makes a good hard point, up clear of the deck, for the mainsheet. With the balance lug there isn't much penalty attached to a centerline sheet without a horse.

The mizzen is supposed to have two sheets, one to each quarter, so the sail can be forcibly backed either way when maneuvering without steerageway. This capability, in a tight place, substitutes for an engine. In the cartoon the rudder and mizzen are placed to leave room for an outboard motor on the stern, but in cat-yawls a motor left there, with its



drive unit swung up for sailing, always gets a clove hitch of the mizzen-sheet around it sooner or later if the sheet isn't tended every instant.

This particular rig would be adopted for its simplicity and economy of gear, combined with neat, sudden maneuvering underway or at a standstill. It would have all that, and sail well with its large sail area set low. With some carelessness and bad luck she might be seen with her motor dangling upside down from the mizzensheet, which had torn it off the stern, the main yard sticking peak down in the companion-way, where it went as it was lowered with a run, and the bunt of the sail over the side and full of water like a parachute.

RIG 46 Chinese lug mainsail

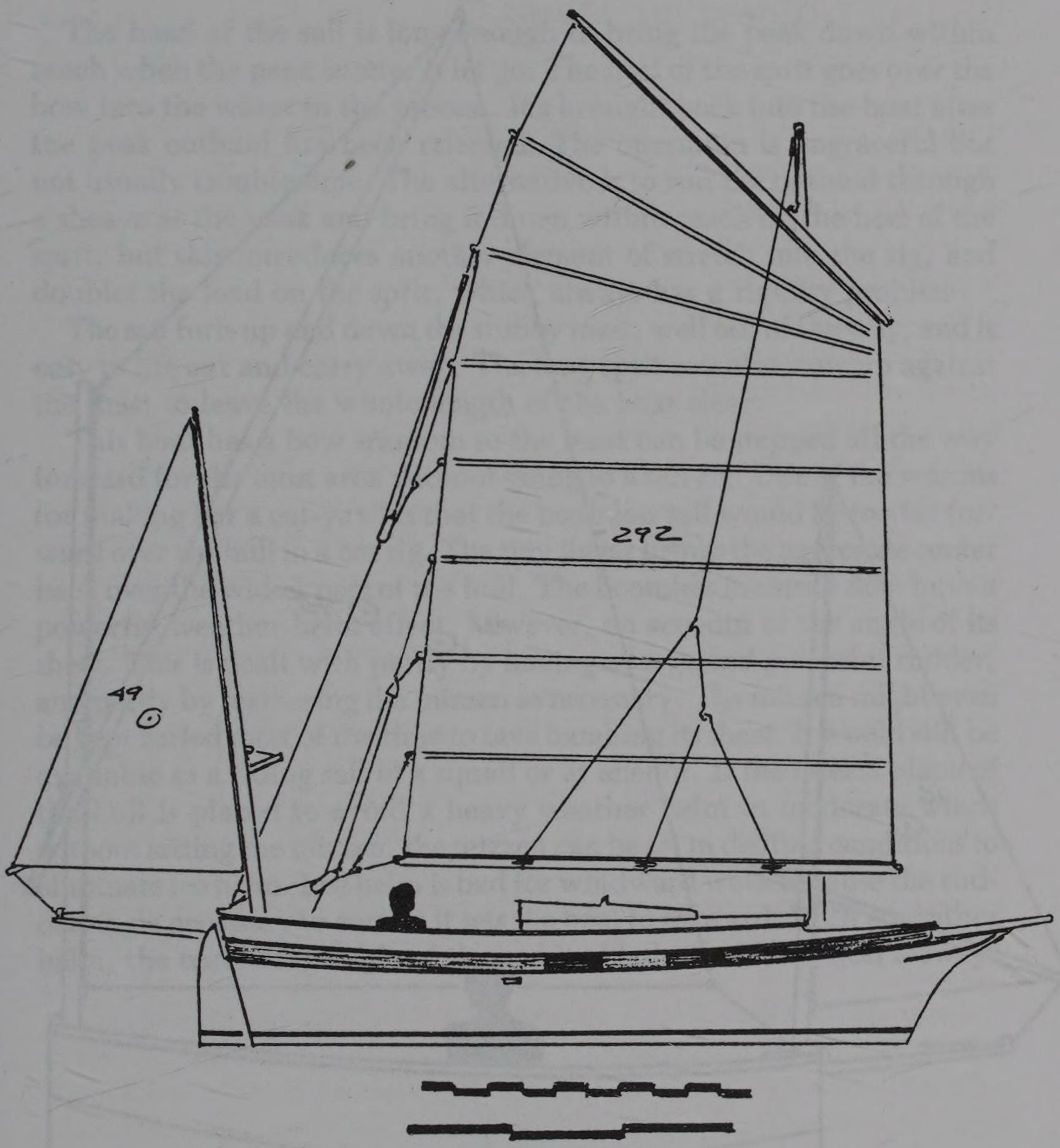
With the foregoing embarrassment in mind, this cartoon shows a rig supposed to be immune to panic. The mizzensheet comes in to a bull's-eye on the boomkin, clear of anything it could foul. With a block mounted on top of a boomkin, the sheet can still wrap under the end of the boomkin and jam if it isn't overhauled in tacking, but the bull's-eye, opening aft, is almost impossible to foul.

The docility of the Chinese lug is outlined in Rig 18 along with its defects as an airfoil. It's much improved by adding the mizzen. The lug mainsail can be kept well forward, allowing the sheet — especially the upper part of the sheet — to lead aft clear of the leech. A weakness of the Chinese lug is that the upper part of the sail isn't sheeted as effectively as it should be when the sail is close-hauled. They're often seen with their peaks sagging as badly as a poorly-sheeted gaff or leg-o'-mutton sail. The farther abaft the sail the upper part of the sheet can be led, the better the sail draws and the closer-winded the boat will be.

The mizzen here is stepped far off-center in the wide-sterned hull, clear of both the tiller and the mainsheet. It would be stepped on the lee side for the "good tack," the tack on which the mainsail is to leeward of the mast. On the "bad tack," where the mainsail doesn't drive well on account of interference and distortion of the mast on the lee side of the sail, the mizzen is less hampered by the backwind of the mainsail, drives better, and partly compensates for the reduced mainsail drive.

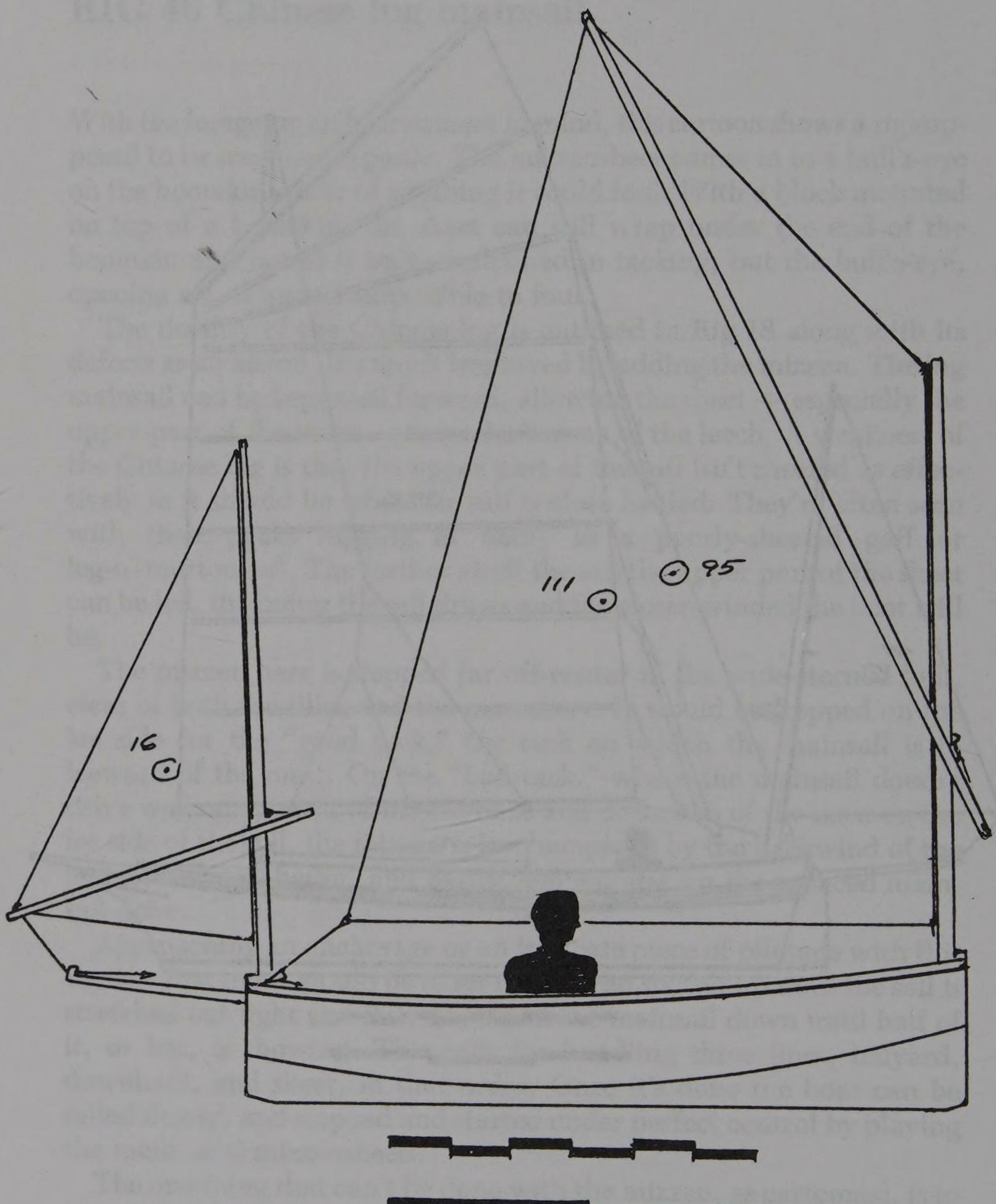
Approaching an anchorage or an intricate piece of pilotage with this rig, the first move would be to set the mizzen snotter up until the sail is stretched out tight and flat. Then pull the mainsail down until half of it, or less, is showing. This calls for handling three lines, halyard, downhaul, and sheet, in that order. Once it's done the boat can be sailed slowly, and stopped and started under perfect control by playing the main- and mizzensheets.

The one thing that can't be done with the mizzen, as cartooned, is to force her through stays without steerageway. To use the mizzen as an air rudder to that extent, it would have to be rigged with more positive control than the single sheet allows.



RIG 47 Sprit mainsail, boomless

This represents a roomy but compact sailing dinghy intended to be sailed by one person with several passengers. Once the peak snotter is set up, everything works from the stern without complex leads. The stern is wide



enough to sheet the boomless mainsail all the way aft. There's no boom to pick off unwary passengers or to trip the boat in a knockdown. With snatchblocks on the quarters, the sheet can be passed across in tacking to save the clutter of duplicate sheets.

The head of the sail is long enough to bring the peak down within reach when the peak snotter is let go. The heel of the sprit goes over the bow into the water in the process. It's brought back into the boat after the peak outhaul has been released. The operation is ungraceful but not usually troublesome. The alternative is to run the outhaul through a sheave at the peak and bring it down within reach on the heel of the sprit, but this introduces another element of stretch into the rig, and doubles the load on the sprit, which always has a rigidity problem.

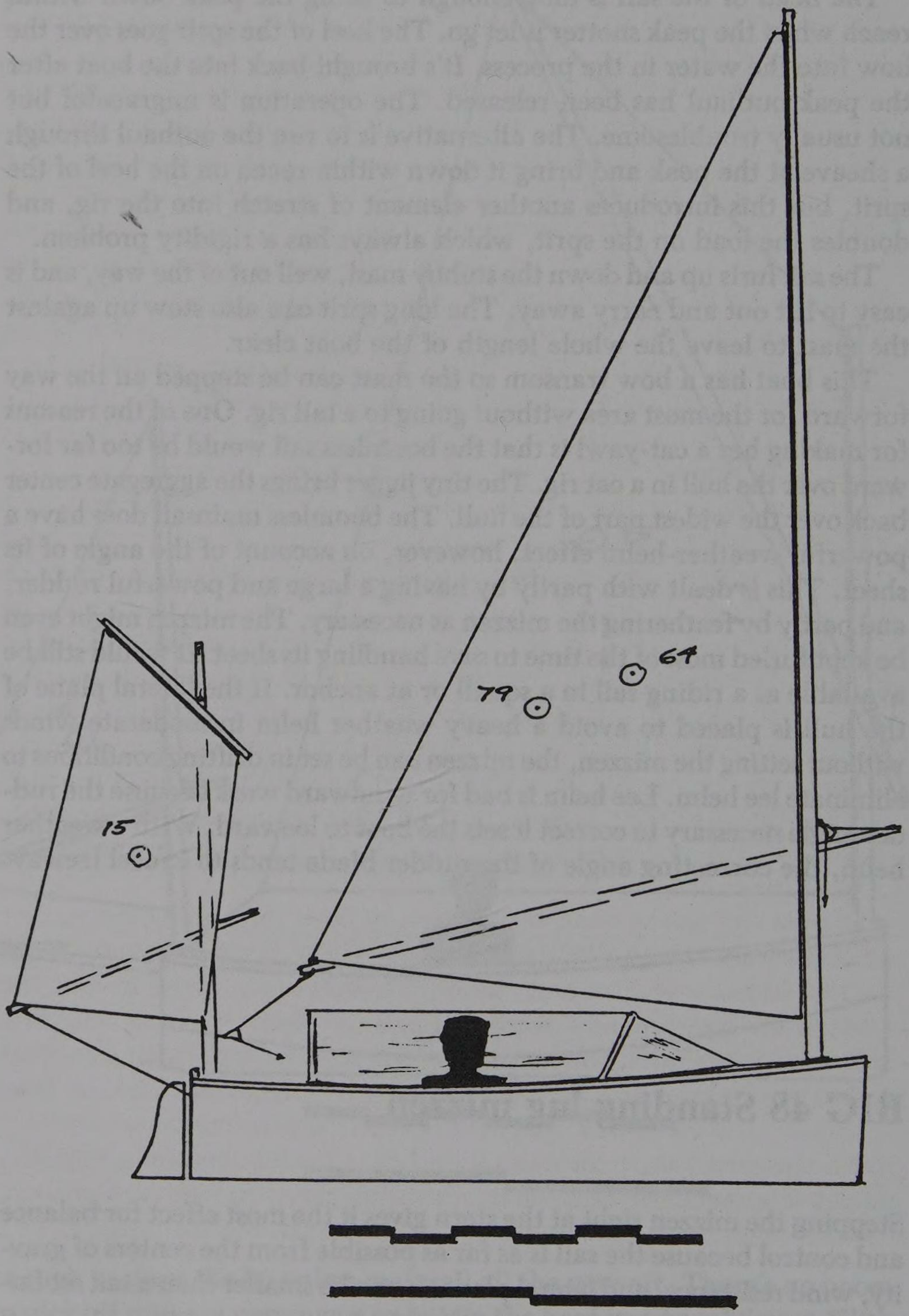
The sail furls up and down the stubby mast, well out of the way, and is easy to lift out and carry away. The long sprit can also stow up against the mast to leave the whole length of the boat clear.

This boat has a bow transom so the mast can be stepped all the way forward for the most area without going to a tall rig. One of the reasons for making her a cat-yawl is that the boomless sail would be too far forward over the hull in a cat rig. The tiny jigger brings the aggregate center back over the widest part of the hull. The boomless mainsail does have a powerful weather-helm effect, however, on account of the angle of its sheet. This is dealt with partly by having a large and powerful rudder, and partly by feathering the mizzen as necessary. The mizzen might even be kept furled most of the time to save handling its sheet. It would still be available as a riding sail in a squall or at anchor. If the lateral plane of the hull is placed to avoid a heavy weather helm in moderate winds without setting the mizzen, the mizzen can be set in drifting conditions to eliminate lee helm. Lee helm is bad for windward work because the rudder angle necessary to correct it sets the boat to leeward. With a weather helm, the correcting angle of the rudder blade tends to cancel leeway.

RIG 48 Standing lug mizzen

Stepping the mizzen right at the stern gives it the most effect for balance and control because the sail is as far as possible from the centers of gravity, wind resistance, and lateral plane. It can be smaller than a sail set farther inboard.

The mizzen is that much farther from the backwind of the mainsail. It's easier to carry the steering linkage past the mizzenmast because the


79
64
15

mast is close to the rudder axis. The mast can be a handy grab stanchion; if there are steps up the rudder, for instance, something higher is needed to steady yourself as you step to the afterdeck.

The drawback is that furling the mizzen is precarious. The standing lug allows the sail to be hauled in past the mast on deck as it's lowered. With a sprit boom as cartooned, the snotter is freed and the boom passed inboard, bringing the clew of the sail with it, sheets and all. The leech is stopped up to the luff and the sail gathered as the halyard is lowered. No parrel would be used on the yard, so the yard can be passed forward as far as is convenient as it comes down. The sail handler has no need to go farther aft than within arm's reach of the mast. This style of furling will work with larger sails than the 15-square-foot sail of the cartoon. If the sail was much over 75 square feet it would be a good idea to have a downhaul rigged on the yard to make sure it didn't get free and kite away while lowering.

The mizzen boom here has two sheets, led out to the quarters of the stern, so it can be forced aback from the helm to throw the boat's head either way without steerageway. A boat can be backed down through a crowded anchorage under good control with this arrangement. The boomkin is eliminated as well. With the two sheets the boom could be along the foot of the sail, eliminating the snotter. The lee-side mizzen-sheet would be slack, but when there was time, and the twist in the sail became excessive due to sheeting it in rather than down, taking up on the lee sheet would pull the boom down and correct the shape of the sail.

If a boom on the foot is used, it ought to have open jaws on the mast, not a gooseneck, so the boom can be pulled off the mast to bring the sail inboard for furling.

The boat in the cartoon is supposed to be a keel sailing dinghy for winter sailing. She's decked at both ends. The cockpit extends from rail to rail and has a transparent canopy on each side, curved in over the heads of the crew as they sit out in the bilge on the weather side. The canopy is open all along the centerline, but the opening is so narrow that the boat can't ship water even in a beam-ends knockdown. The cat-yawl rig allows good control of the boat in all normal maneuvers without exposing the crew. Once the mainsail is hoisted and its snotter set up, the centerline opening can be covered with a fabric flap for complete shelter, since all controlling lines come to the helm from the stern.

RIG 49 Lateen mainsail, boomless

This rig was considered for a tall, light-weather sail set without the long mast that would be needed for a jibheader of this height. See Rig 20 for the problems and virtues of the lateen.

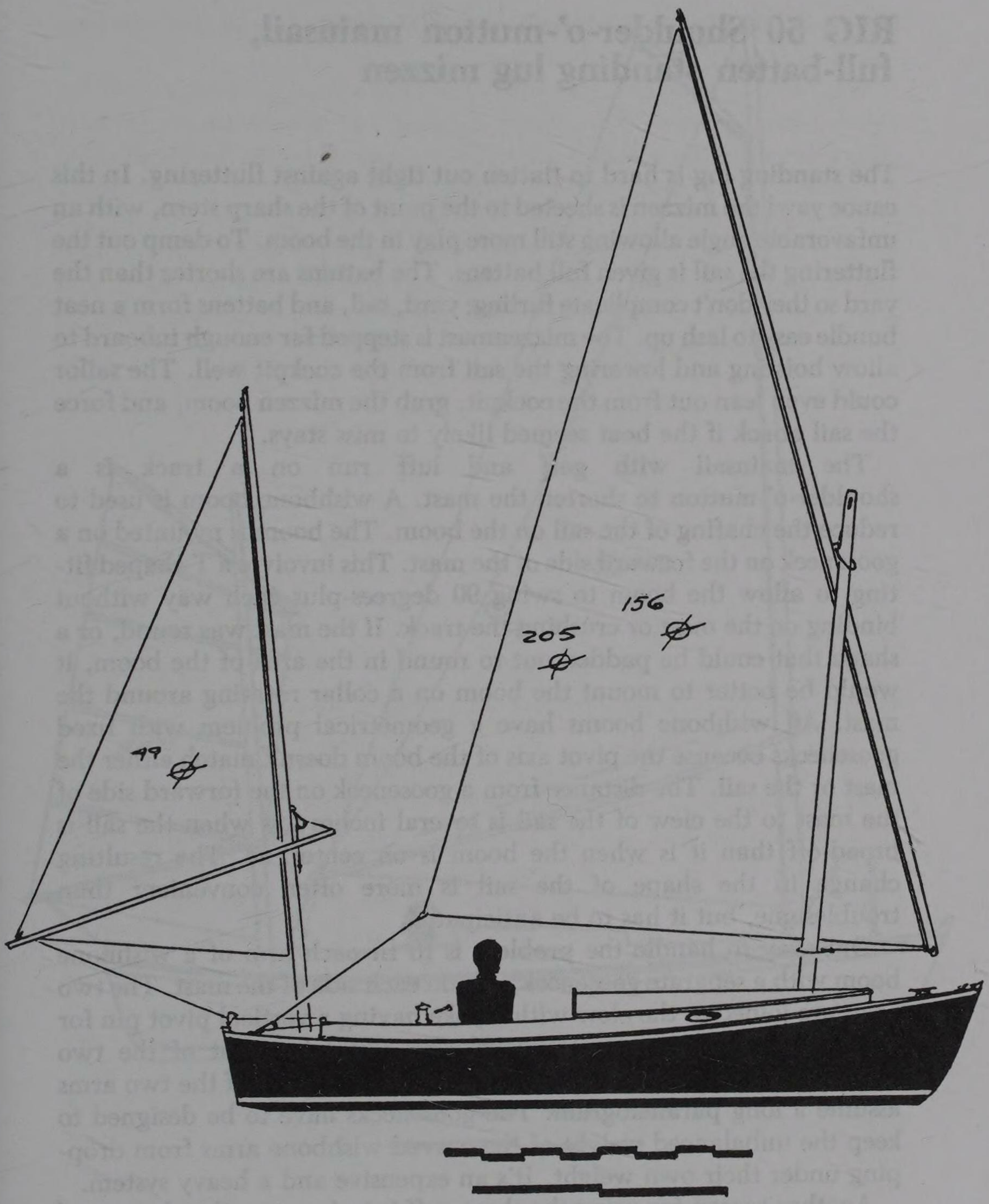
This one was designed to pivot freely around the mast axis without adjusting the heel guy. The mast should rotate if possible, for if it's fixed it needs more drift between the halyard sheave and the point of attachment of the halyard to the yard. If one or the other isn't provided, the halyard will chafe on the flanges of the sheave, or the twisting stress as the yard swings from side to side may open up the mast at the sheave slot. In the first case there's the possibility of the yard falling, and in the second it may be jammed immovably aloft with the halyard caught between the sheave and the side of the slot.

A parrel is shown holding the yard to the mast. With the parrel, the yard slides down the mast as the halyard is payed out, but the heel guy has to be slacked at the same time since the rigid triangle of mast, yard, and fixed-heel guy won't render. When fully lowered the heel of the yard ends up far out over the bow of the boat, but the peak clears the mizzen. If the parrel is left off, the yard comes down in an arc with its apex at the guyed heel. Only the halyard has to be handled, but the peak may foul the mizzen. Also, the yard is free to swing off the mast if the boat rolls when the yard is partway down, and may come back with a great crash.

Since lowering the yard may be inconvenient, this one has a peak outhaul that runs over a sheave at the peak and down to belay at the heel of the yard. Its function is the same as a halyard in a leg-o'-mutton sail. The luff of the sail runs on a track, or in a slot, on the yard. The sail can be lowered and taken off the yard without lowering the yard. In tight berths the best place for the yard is aloft.

This arrangement allows replacing the sail with a smaller one, or one of different shape or cut. The main objections are that the yard has to be stiffer to stand the tension of the fall of the outhaul, and that the long outhaul makes a lot of wind resistance, especially when the sail is lowered. A minor objection is that the heel of the yard isn't anchored solidly; hence, it will move and jerk while the sail is being fed on and off the track.

A lateen has less weather-helm impulse than any other boomless sail because the swing of the heel of the yard out to windward allows the clew to be sheeted nearer the centerline of the boat; hence, the rather large mizzen shown. In all cat-yawls lee helm can be obviated by mak-



ing the mizzen oversized, and feathering it if it produces too much weather helm. Since the mizzen doesn't provide an important part of the drive of the rig, not much is lost by trimming it purely for control.

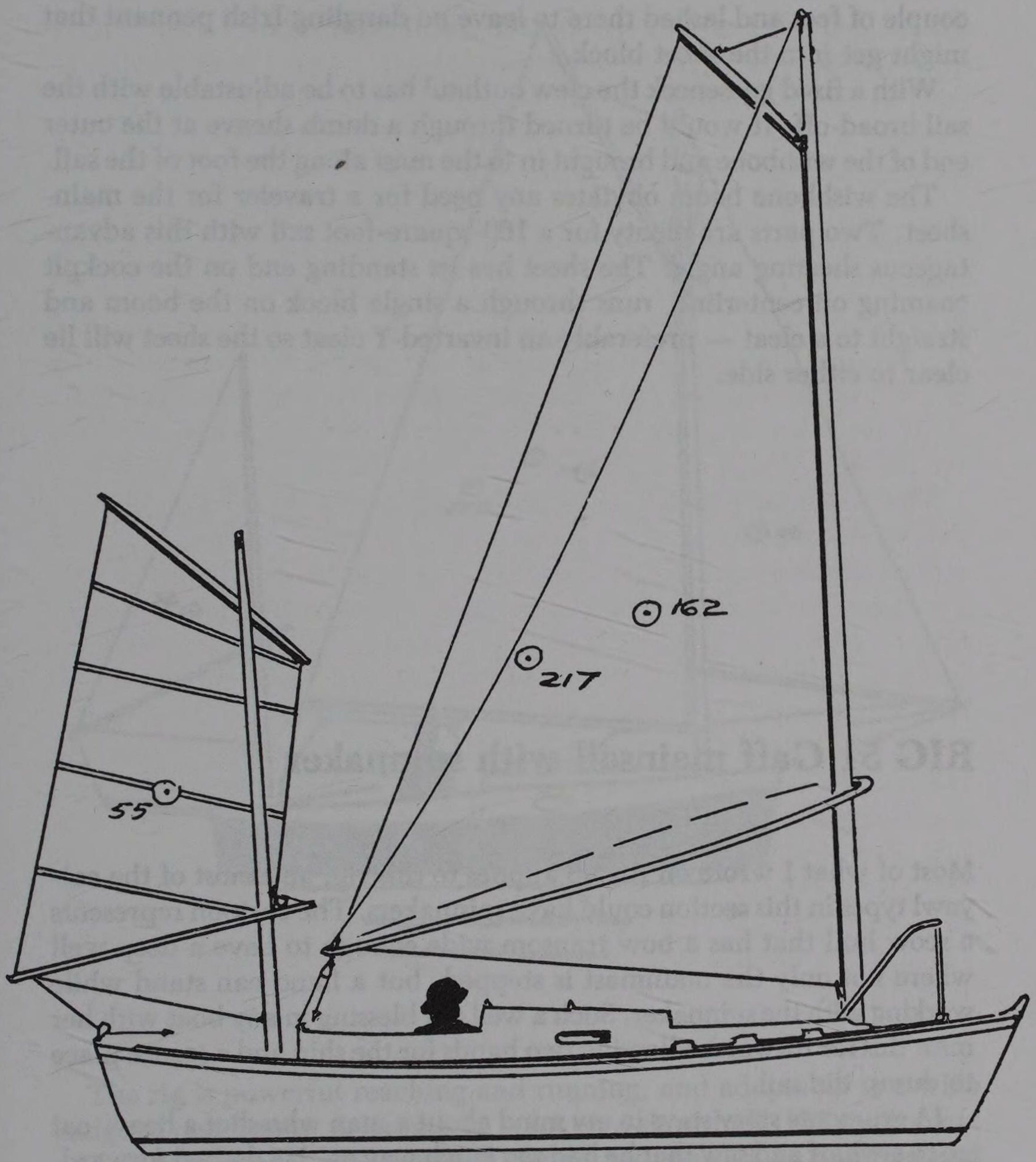
RIG 50 Shoulder-o'-mutton mainsail, full-batten standing lug mizzen

The standing lug is hard to flatten out tight against fluttering. In this canoe yawl the mizzen is sheeted to the point of the sharp stern, with an unfavorable angle allowing still more play in the boom. To damp out the fluttering the sail is given full battens. The battens are shorter than the yard so they don't complicate furling; yard, sail, and battens form a neat bundle easy to lash up. The mizzenmast is stepped far enough inboard to allow hoisting and lowering the sail from the cockpit well. The sailor could even lean out from the cockpit, grab the mizzen boom, and force the sail aback if the boat seemed likely to miss stays.

The mainsail with gaff and luff run on a track is a shoulder-o'-mutton to shorten the mast. A wishbone boom is used to reduce the chafing of the sail on the boom. The boom is mounted on a gooseneck on the forward side of the mast. This involves a T-shaped fitting to allow the boom to swing 90 degrees-plus each way without binding on the mast or crushing the track. If the mast was round, or a shape that could be padded out to round in the area of the boom, it would be better to mount the boom on a collar rotating around the mast. All wishbone booms have a geometrical problem with fixed goosenecks because the pivot axis of the boom doesn't match either the mast or the sail. The distance from a gooseneck on the forward side of the mast to the clew of the sail is several inches less when the sail is broad-off than it is when the boom is on centerline. The resulting change in the shape of the sail is more often convenient than troublesome, but it has to be anticipated.

One way to handle the problem is to fit each arm of a wishbone boom with a separate gooseneck, one on each side of the mast. The two arms are joined at the clew with a yoke having a vertical pivot pin for each arm. The spacing of the yoke pins matches that of the two goosenecks. As the wishbone swings out, the four pins of the two arms assume a long parallelogram. The goosenecks have to be designed to keep the unbalanced weight of the curved wishbone arms from dropping under their own weight. It's an expensive and a heavy system.

Another reason for using the short gaff is to improve the chances of the sail coming down when the halyards are let go, instead of having to haul them down. The shorter luff makes less friction on the track, and the weight of the gaff itself helps. The gaff hoisted horizontal or below horizontal can go up on either side of the topping lift. The lift has its



standing end at the masthead to save a doubling of its length aloft. The length is adjusted simply by belaying it on a pin through the end of the boom. The tail of the lift, after belaying, is taken in along the boom a

couple of feet and lashed there to leave no dangling Irish pennant that might get into the sheet block.

With a fixed gooseneck the clew outhaul has to be adjustable with the sail broad-off. It would be turned through a dumb sheave at the outer end of the wishbone and brought in to the mast along the foot of the sail.

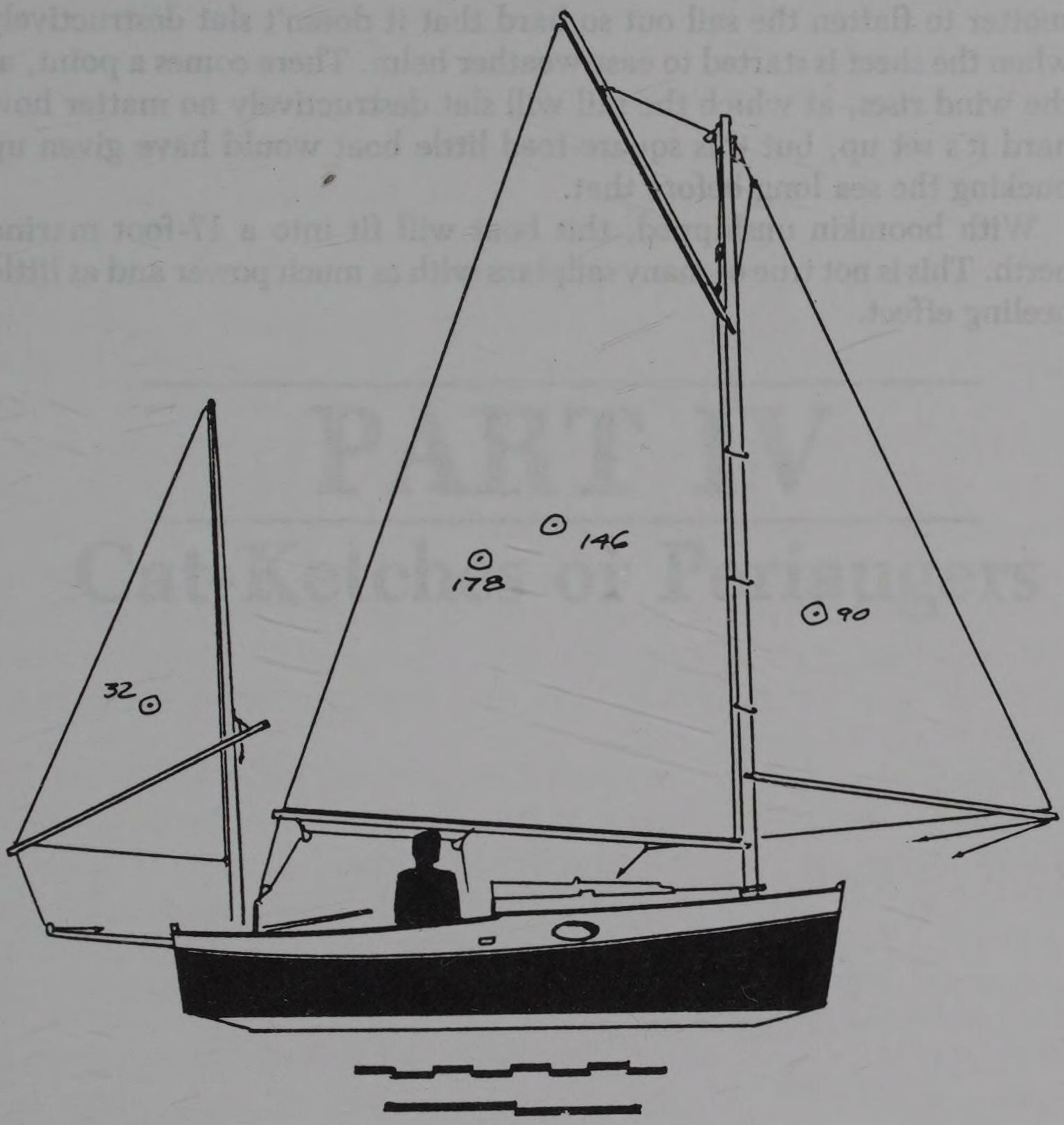
The wishbone boom obviates any need for a traveler for the mainsheet. Two parts are plenty for a 160-square-foot sail with this advantageous sheeting angle. The sheet has its standing end on the cockpit coaming on centerline, runs through a single block on the boom and straight to a cleat — preferably an inverted-Y cleat so the sheet will lie clear to either side.

RIG 51 Gaff mainsail with spinnaker

Most of what I wrote on Rig 43 applies to this rig, and most of the cat-yawl types in this section could have spinnakers. The cartoon represents a scow hull that has a bow transom wide enough to have a deep well where not only the mainmast is stepped, but a hand can stand while working with the spinnaker. Such a well is a blessing in any boat with her mast this far forward, allowing two hands for the ship and a secure place to dump the sail.

(A gruesome story stays in my mind about a man who shot a heavy cat up to a wharf and saw that he had too much way on. He dashed forward, braced his back against the mast, and tried to stop the boat with his hands against the stringpiece of the wharf, which was chest high. He might have stopped the boat in this cartoon that way, but his boat had a lot more momentum . . . .)

The well allows stepping the mast where it doesn't pierce the watertight envelope, saving a lot of fiddling with mast coats and drips from inadequate coats. The mast can be allowed to swivel, a feature almost impossible to combine with watertight partners.



The rig is powerful reaching and running, and adaptable to a wide range of conditions. A large area is set on a short hull (178 square feet and 17 feet respectively) without using a tall mast. Two hundred and thirty-six square feet of sail are effective before the wind, with self-steering potential and little chafe. The gear is all light and straightforward. No standing rigging is needed.

Going dead to windward, the spinnaker won't stand and both pointing and footing will be modest, but the advantages described in Rig 40 all apply except that the reefed balance is not so neat with the gaff sail, as mentioned in Rig 43. With a deep-reefed mainsail and the spinnaker not set, the mizzen here would be feathered by setting up hard on its

snotter to flatten the sail out so hard that it doesn't slat destructively when the sheet is started to ease weather helm. There comes a point, as the wind rises, at which the sail will slat destructively no matter how hard it's set up, but this square-toed little boat would have given up bucking the sea long before that.

With boomkin unshipped, this boat will fit into a 17-foot marina berth. This is not true of many sailplans with as much power and as little heeling effect.

PART IV

Cat-Ketches or Periaugers

RIG 52 Jibheaded with full battens

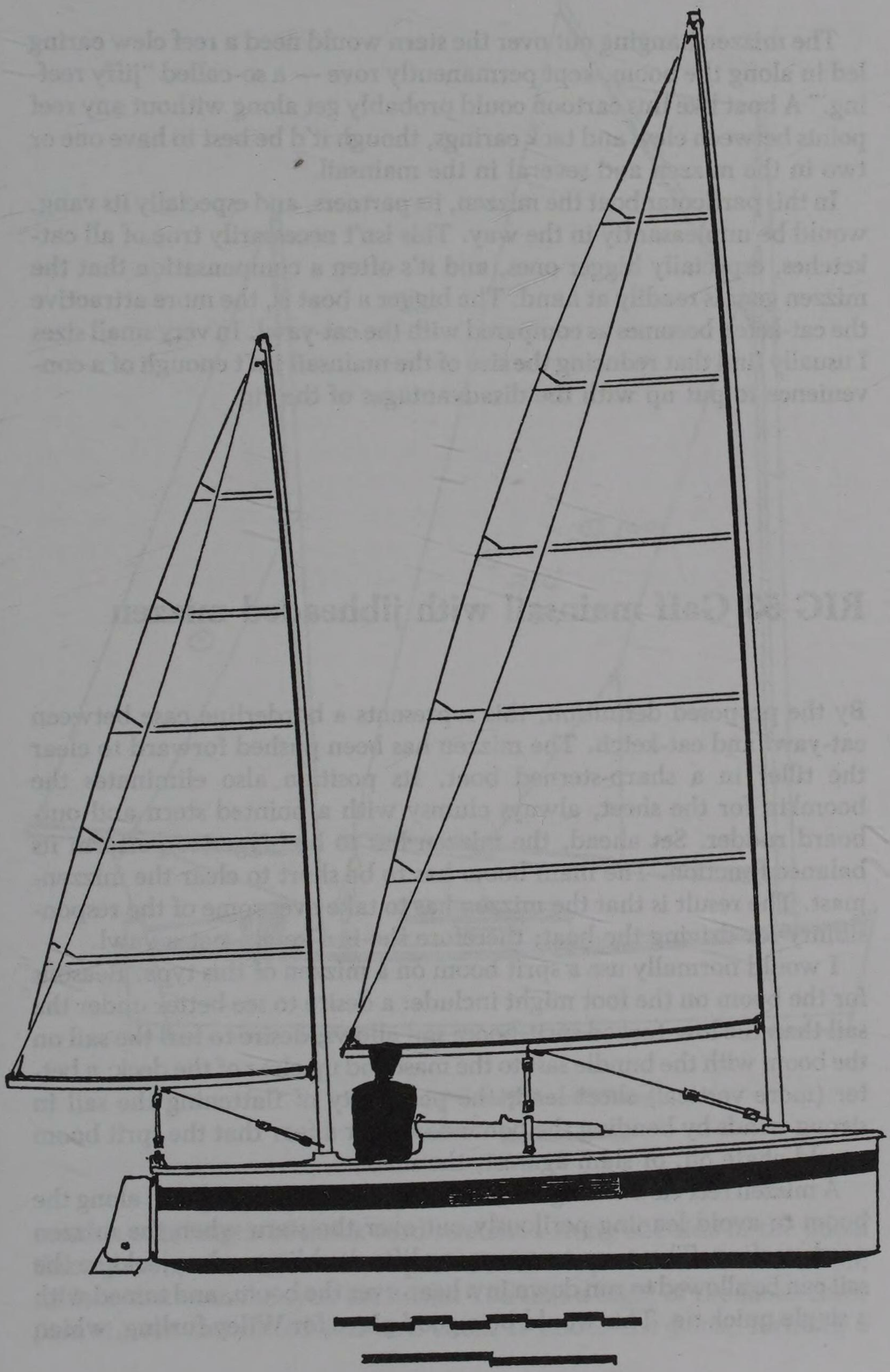
The distinction between a cat-ketch and a cat-yawl is more a matter of intent than proportion. A cat-yawl's mizzen is primarily for balance and handling convenience. A cat-ketch's mizzen is an important part of her drive and can be almost as big and tall as her mainsail. The advantage of the rig is that the sail area is split into two, presumably less formidable, sails, both of which will work tolerably without any standing rigging.

The drawback is that the mizzen stands in the flow of air that has been diverted by the mainsail, so it's always pinched when the boat is close-hauled, and gives less power than it should for its area and height. The distance and angle of the mainsail relative to the mizzen aren't good for smoothing the lee-side flow on the mizzen, though there's some benefit; the action of the mainsail's flow does reduce the heeling effect of the mizzen. The usual final result is that a cat-ketch is the least powerful rig for its area and heeling effect, for windward work, of all the common rigs.

It can, nevertheless, work well if it's well designed. In the cartoon the sheets travel on long horses, and the booms are fitted with powerful vangs to keep the heads of the narrow sails from falling off. The booms are designed to bend down from the pull of the sheets and the vangs for automatic flattening of the sails as the wind increases. The bend of the unstayed masts has the same effect, allowing the sails to be cut very full for good drive in light airs.

The balance of a cat-ketch can be finely adjusted as she is reefed, but both sails have to be reefed to accomplish this. One reason the sails have full battens here is to allow the mizzen to be feathered instead of reefed in a crisis. A deep reef can be pulled down in the mainsail while the full mizzen keeps her bow to the wind. As soon as the mainsail is reefed she can fill and go, with mizzen luffing. The closely spaced battens will keep the mizzen from destroying itself as it luffs, and reduce the wind resistance, which is large in a flapping sail.

While the battens also allow a big roach in the leeches, hence more area on a given mast height, and a larger head angle for the spar lengths, they can make a sail hard to lower and stow. Laid parallel with the boom, as here, they fit down nicely on paper. To make it work in practice, topping lifts (shown) are necessary to support the boom at the right angle to receive the battens. Lazyjacks aren't as necessary since the successive triangles of fabric above the battens keep them lined up as the sail comes down. They can be gathered on the boom without much effort where one or two ties will keep them.



The mizzen hanging out over the stern would need a reef clew earing led in along the boom, kept permanently rove — a so-called "jiffy reefing." A boat like this cartoon could probably get along without any reef points between clew and tack earings, though it'd be best to have one or two in the mizzen and several in the mainsail.

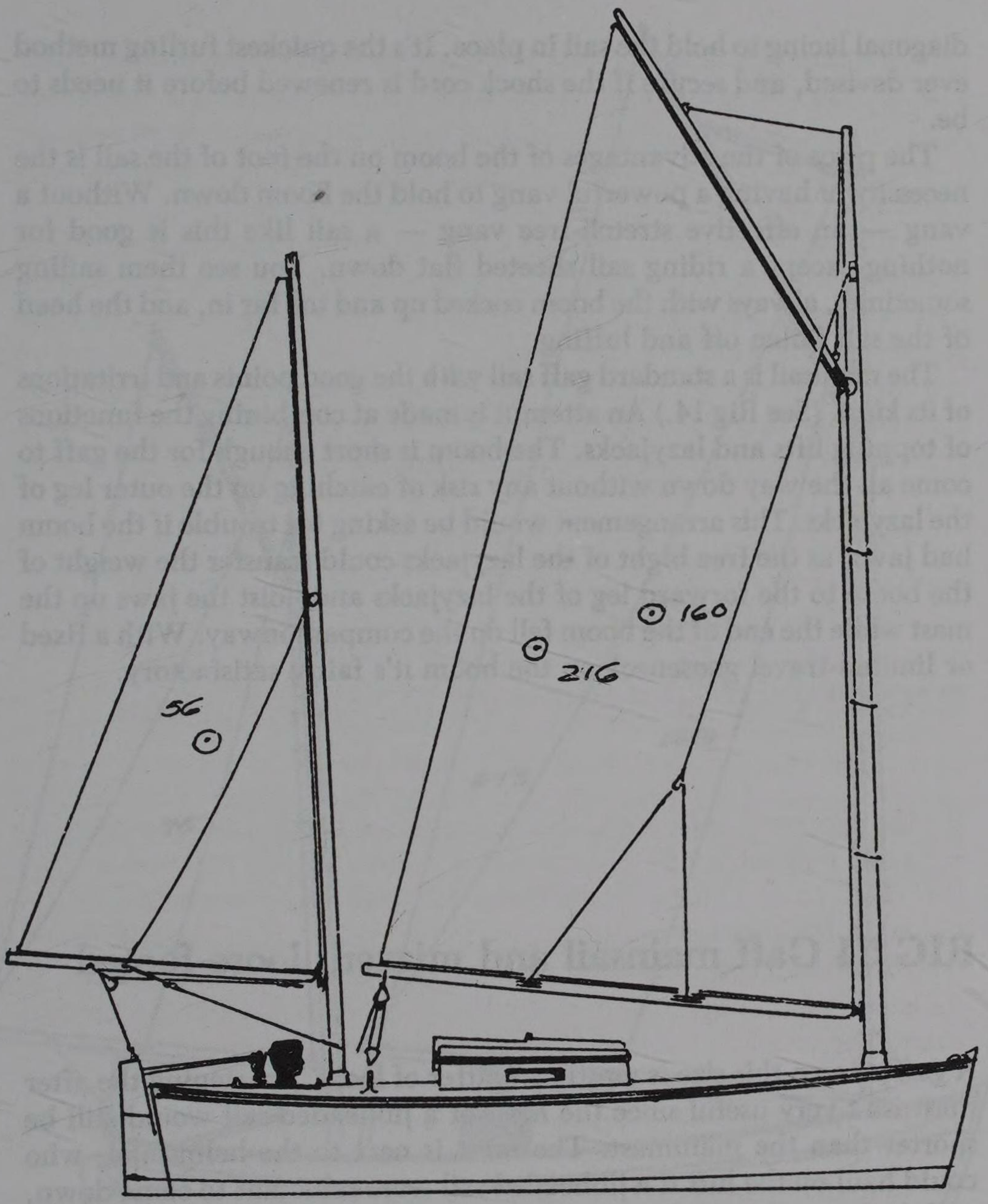
In this particular boat the mizzen, its partners, and especially its vang, would be unpleasantly in the way. This isn't necessarily true of all cat-ketches, especially bigger ones, and it's often a compensation that the mizzen gear is readily at hand. The bigger a boat is, the more attractive the cat-ketch becomes as compared with the cat-yawl. In very small sizes I usually find that reducing the size of the mainsail isn't enough of a convenience to put up with the disadvantages of the rig.

RIG 53 Gaff mainsail with jibheaded mizzen

By the proposed definition, this represents a borderline case between cat-yawl and cat-ketch. The mizzen has been pushed forward to clear the tiller in a sharp-sterned boat. Its position also eliminates the boomkin for the sheet, always clumsy with a pointed stern and outboard rudder. Set ahead, the mizzen has to be bigger to perform its balance function. The main boom has to be short to clear the mizzenmast. The result is that the mizzen has to take over some of the responsibility for driving the boat; therefore she is a ketch, not a yawl.

I would normally use a sprit boom on a mizzen of this type. Reasons for the boom on the foot might include: a desire to see better under the sail than the low-tacked sprit-boom sail allows; desire to furl the sail on the boom with the bundle fast to the mast and up clear of the deck; a better (more vertical) sheet lead; the possibility of flattening the sail in strong winds by bending the boom down; or a fear that the sprit boom would chafe on, or slam against, the mast.

A mizzen reef clew earing would be kept rove and brought in along the boom to avoid leaning perilously out over the stern when the mizzen needs reefing. There are two topping lifts doubling as lazyjacks so the sail can be allowed to run down in a heap over the boom, and tamed with a single quick tie. This would be a good place for Wiley furling, which



consists of a length of shock cord stretched along one side of the boom through eyes about three feet apart. On the opposite side of the boom, midway between the eyes, are hooks. You take a bight of the shock cord, pass it over the furled sail and catch it under the hook, forming a

diagonal lacing to hold the sail in place. It's the quickest furling method ever devised, and secure if the shock cord is renewed before it needs to be.

The price of the advantages of the boom on the foot of the sail is the necessity of having a powerful vang to hold the boom down. Without a vang — an effective stretch-free vang — a sail like this is good for nothing except a riding sail sheeted flat down. You see them sailing sometimes, always with the boom cocked up and too far in, and the head of the sail fallen off and luffing.

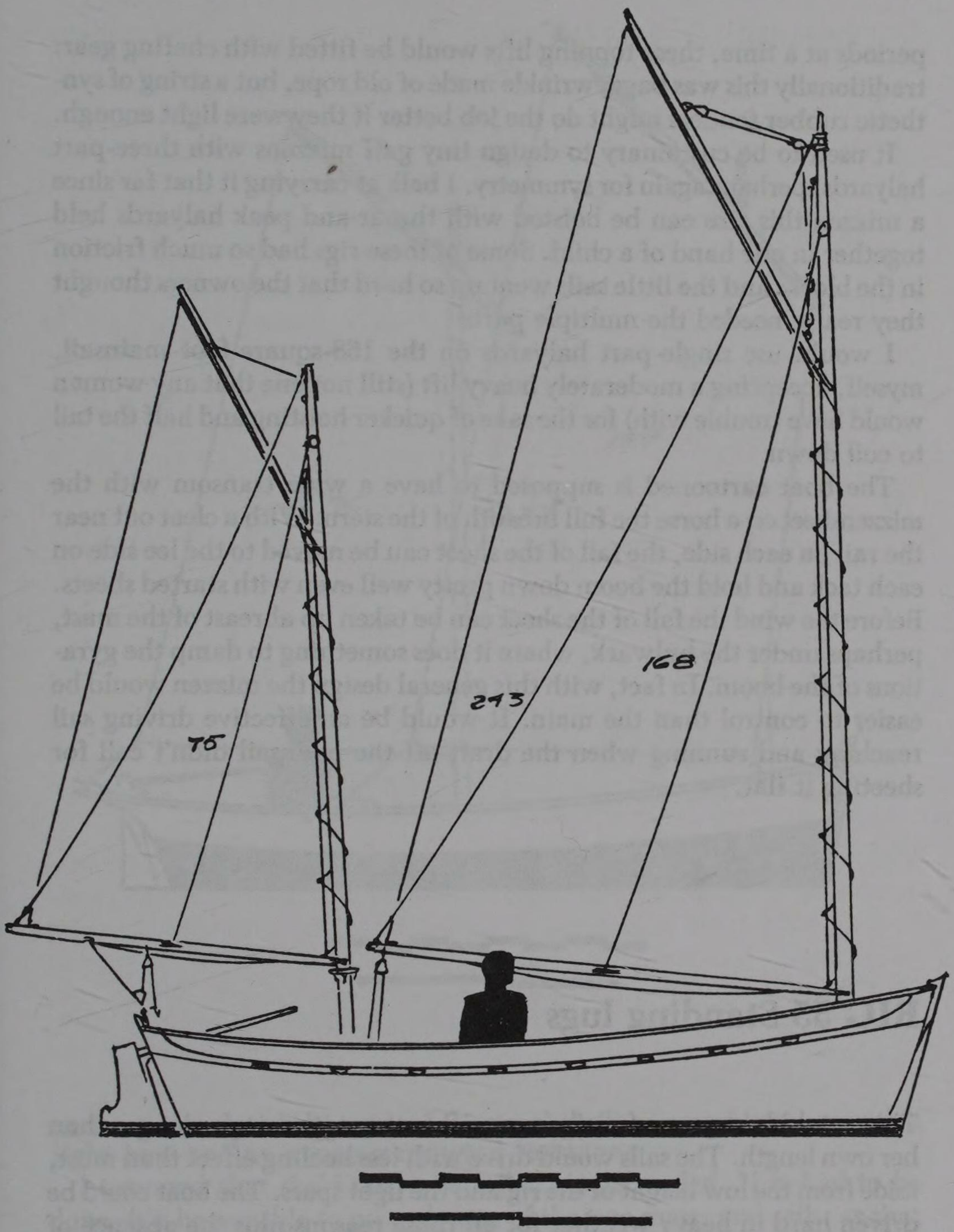
The mainsail is a standard gaff sail with the good points and irritations of its kind. (See Rig 14.) An attempt is made at combining the functions of topping lifts and lazyjacks. The boom is short enough for the gaff to come all the way down without any risk of catching on the outer leg of the lazyjacks. This arrangement would be asking for trouble if the boom had jaws, as the free bight of the lazyjacks could transfer the weight of the boom to the forward leg of the lazyjacks and hoist the jaws up the mast while the end of the boom fell on the companionway. With a fixed or limited-travel gooseneck on the boom it's fairly satisfactory.

RIG 54 Gaff mainsail and mizzen, loose-footed

A gaff mizzen this size is mostly a matter of looks. Shortening the after mast isn't very useful since the mast of a jibheaded sail would still be shorter than the mainmast. The mast is next to the helmsman, who could haul on the luff if a jibheaded sail were reluctant to come down, and the bunt of a jibheaded sail would come down more into the boat, actually more convenient to smother than the gaff sail, too much of which will come down out over the stern.

There is the advantage that if you want a laced luff, as here, the topping lifts and lazyjacks would have to be much longer and lead higher aloft to clear the mast for the lacing up to the head of a leg-o'-mutton sail.

As may be, many people think that the symmetry of the two similar sails is good to look at, and that dissimilar sails disturb the eye.



Since the booms are free on jaws, topping lifts are rigged from boom-ends to mastheads clear above the peak halyard blocks. The gaffs can go up on either side of the lifts without fouling. In a boat underway for long

periods at a time, these topping lifts would be fitted with chafing gear: traditionally this was baggywrinkle made of old rope, but a string of synthetic rubber fenders might do the job better if they were light enough.

It used to be customary to design tiny gaff mizzens with three-part halyards, perhaps again for symmetry. I balk at carrying it that far since a mizzen this size can be hoisted with throat and peak halyards held together in one hand of a child. Some of these rigs had so much friction in the blocks and the little sails went up so hard that the owners thought they really needed the multiple parts.

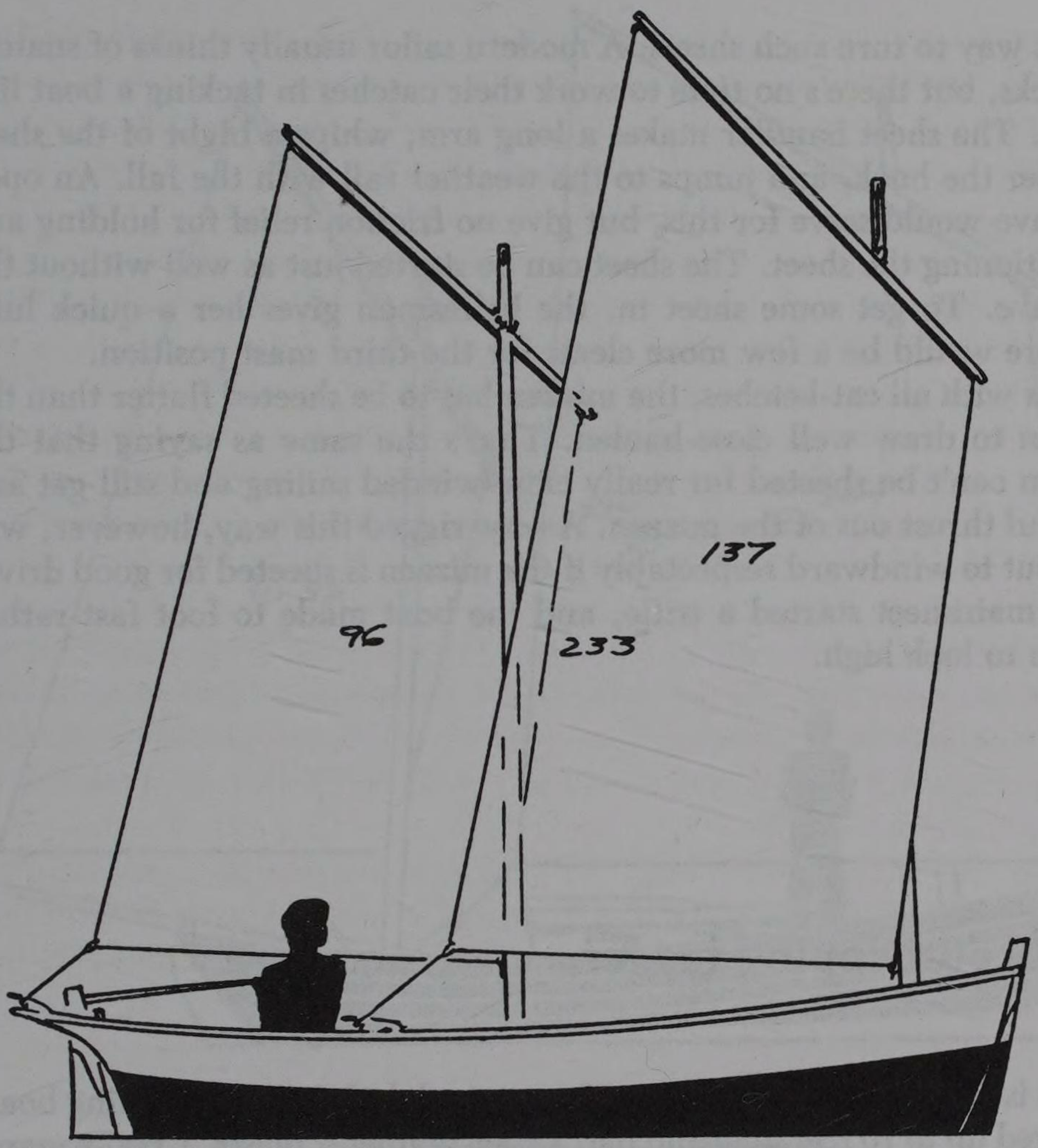
I would use single-part halyards on the 168-square-foot mainsail, myself, accepting a moderately heavy lift (still not one that any woman would have trouble with) for the sake of quicker hoisting and half the tail to coil down.

The boat cartooned is supposed to have a wide transom with the mizzensheet on a horse the full breadth of the stern. With a cleat out near the rail on each side, the fall of the sheet can be moved to the lee side on each tack and hold the boom down pretty well even with started sheets. Before the wind the fall of the sheet can be taken up abreast of the mast, perhaps under the bulwark, where it does something to damp the gyrations of the boom. In fact, with this general design the mizzen would be easier to control than the main. It would be an effective driving sail reaching and running when the draft off the mainsail didn't call for sheeting it flat.

RIG 55 Standing lugs

This would be a powerful rig for an 18-footer with no spar longer than her own length. The sails would drive with less heeling effect than most, aside from the low height of the rig and the light spars. The boat could be driven hard in heavy weather for all those reasons plus the absence of booms to trip her in a knockdown.

A boat rigged this way would probably have another mast step between the two regular ones. Instead of reefing, one mast and sail would be stowed and the other shifted to the third step. With the mizzen stepped there and the mainmast struck down with its heel in the boat



and masthead sticking out over the stern, she'd be superbly snug, with a light bow and no unnecessary wind resistance.

I assumed that she'd never be sailed singlehanded. If it had to be done, it'd be sensible to use only one of the two masts and sails, as that probably would be as much sail as she'd want in moderate weather with only one man to hold her up. Each sail has only one sheet, which is shifted from side to side in tacking. The gunwale is extended over the stern on each side like a set of wheelbarrow handles to get an optimum sheeting angle for the mizzen. The open hooks or cleats shown are the

best way to turn such sheets. A modern sailor usually thinks of snatch-blocks, but there's no time to work their catches in tacking a boat like this. The sheet handler makes a long arm, whips a bight of the sheet under the hook, and jumps to the weather rail with the fall. An open sheave would serve for this, but give no friction relief for holding and positioning the sheet. The sheet can be started just as well without the sheave. To get some sheet in, the helmsman gives her a quick luff. There would be a few more cleats for the third mast position.

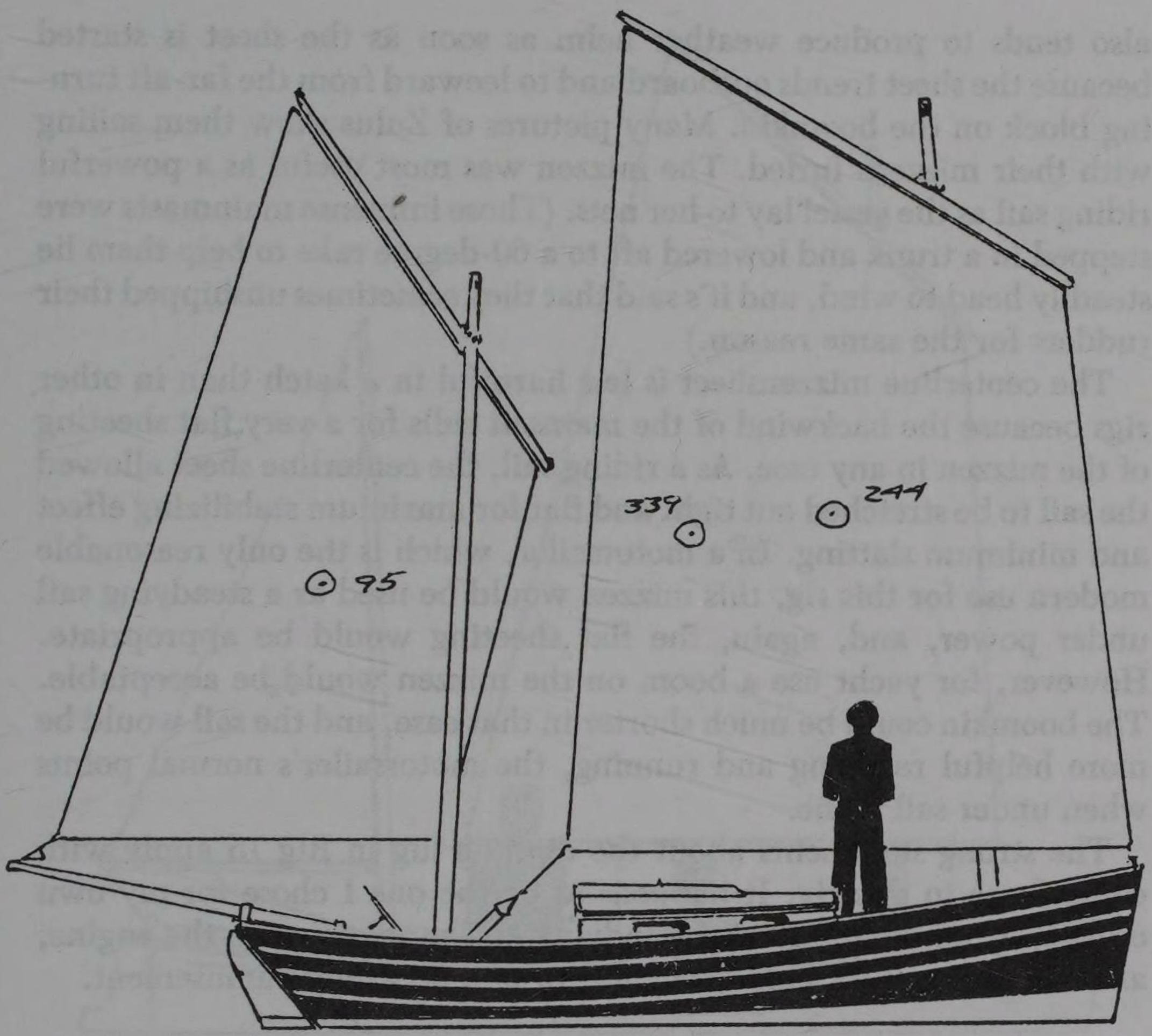
As with all cat-ketches, the mizzen has to be sheeted flatter than the main to draw well close-hauled. That's the same as saying that the main can't be sheeted for really close-winded sailing and still get any useful thrust out of the mizzen. A boat rigged this way, however, will go out to windward respectably if the mizzen is sheeted for good drive, the mainsheet started a trifle, and the boat made to foot fast rather than to look high.

RIG 56 Dipping lugger

This is a miniature Scots Zulu. The original drift (gill-net) fishing boats ranged up to 70 feet long and had 2-foot-diameter masts, 1,600-square-foot mainsails, and no engines. Huge fleets of them stormed in and out of miserable harbors we wouldn't go near in powerboats, in weather that would stand an American yachtsman's hair on end. There were men in those days! But a lot of the vessels were wrecked and a lot of the men drowned.

The working Zulus (also their competitors, the Fifies, which were quite similar except for having little or no rake in their sternposts or drag in their keels) had a standard set of proportions just about as shown. The tack of the mainsail hooked to the weather side of the stem. Many of them had long running bowsprits on which a reaching jib could be set.

Sheeting with a block on the clew is less dangerous with a dipping lug than on other sails because the sail doesn't swing across the boat, flailing the block, in tacking. Instead the sheet is kept fast as it's dipped in tacking until the sail is down on deck. The single block without a becket, giving 2:1 mechanical advantage, would make this 244-square-foot sail



heavy to sheet in a strong wind, but would save a great length of line. Any dipping lug can readily shift from a single-part sheet direct to the clew, to a single block as shown, to a single block with a becket for a power of three, and to a double block with a power of four as the wind increases, but the sheet has to be four times as long with the last arrangement than the first. Winches begin to look very attractive before this process has gone far.

The boomkin for the mizzensheet is the way it was done; and suggests that these boats were really more yawl than ketch; that is, the mizzen wasn't an important part of their driving power in spite of its size. A boomless sail can't be sheeted this way, to the centerline, and have anything like the power its area suggests. This kind of sheet lead

also tends to produce weather helm as soon as the sheet is started because the sheet trends outboard and to leeward from the far-aft turning block on the boomkin. Many pictures of Zulus show them sailing with their mizzens furled. The mizzen was most useful as a powerful riding sail as the vessel lay to her nets. (Those immense mainmasts were stepped in a trunk and lowered aft to a 60-degree rake to help them lie steadily head to wind, and it's said that they sometimes unshipped their rudders for the same reason.)

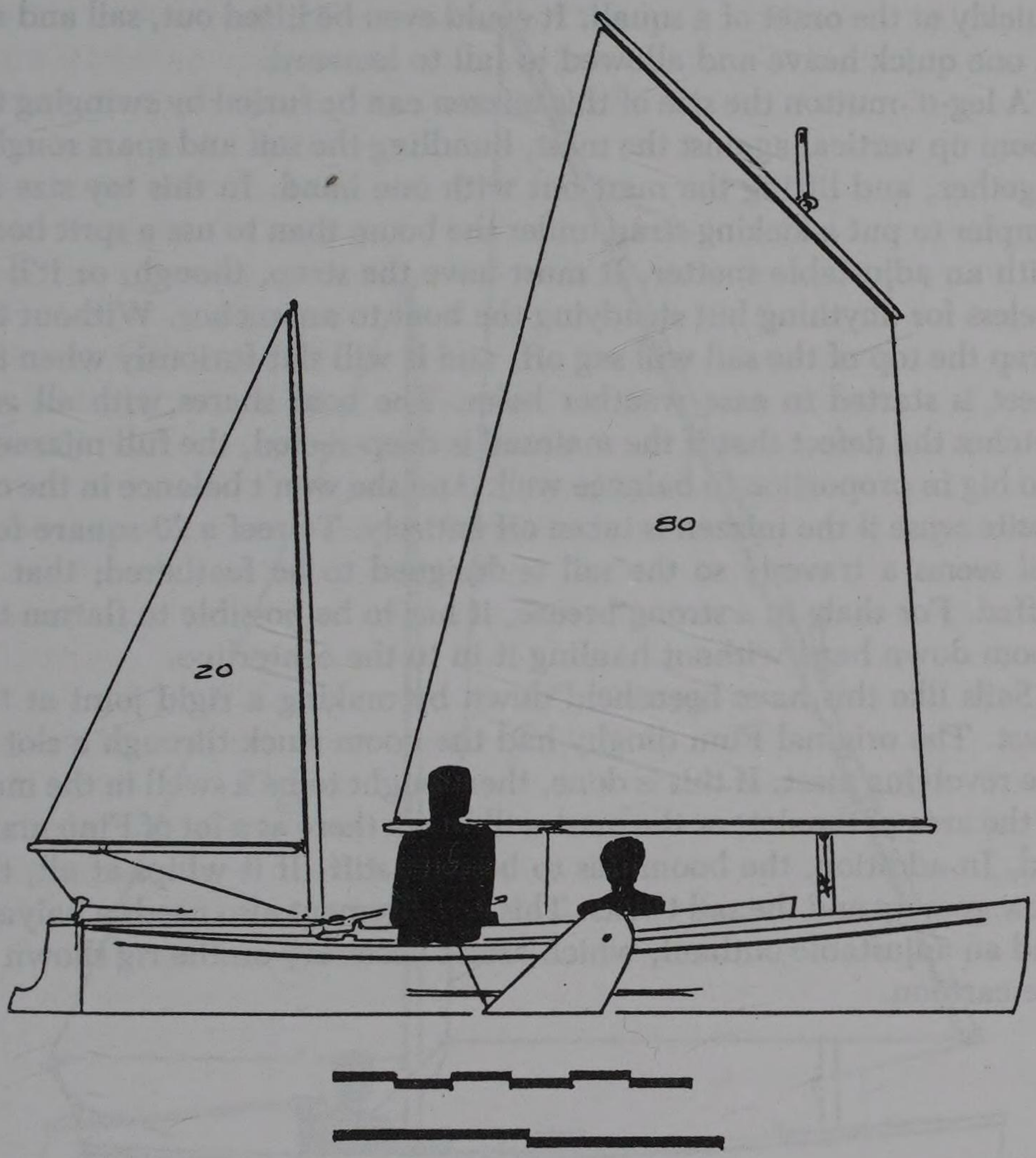
The centerline mizzensheet is less harmful in a ketch than in other rigs because the backwind of the mainsail calls for a very flat sheeting of the mizzen in any case. As a riding sail, the centerline sheet allowed the sail to be stretched out tight and flat for maximum stabilizing effect and minimum slatting. In a motorsailer, which is the only reasonable modern use for this rig, this mizzen would be used as a steadying sail under power, and, again, the flat sheeting would be appropriate. However, for yacht use a boom on the mizzen would be acceptable. The boomkin could be much shorter in that case, and the sail would be more helpful reaching and running, the motorsailer's normal points when under sail alone.

The strong statements about the dipping lug in Rig 15 apply with equal force to this rig. It happens to be the one I chose for my own cruiser, using the mizzen for steadying and supplement to the engine, and the mainsail for emergency power and occasional amusement.

RIG 57 Balance lug mainsail with leg-o'-mutton mizzen

This 16-foot cruising canoe would have only about a 4-foot beam. To cruise in her, a space 6 feet 6 inches long needs to be kept clear of the rig. The traditional sharp stern precludes stepping a mizzen right aft as in a yawl. Still, as drawn, she's a functional yawl since the tiny mizzen is for balance and control, not realistically for propulsion.

One of the characteristics of the balance lug is that the boom's vertical movement is dampened by the part ahead of the mast. It needs no horse or vang that would be in the way in the cruising cockpit. It's so



light to sheet that this little one would have no blocks at all. The sheet is a straight length of line bent to the boom. There'd be a cleat on each side, in under the coaming out of the way, to turn the sheet under, or to belay it in light weather.

The balance lug's mast can be well back from the stem to relieve the bow of its weight and to bring the halyard and boom downhaul within reach of the cockpit. The part of the boom that swings out, the part abaft the mast, is less than twice the breadth of the boat to decrease the risk of tripping her in rough water and squally weather. The mast is only 15 feet long for the 80-square-foot mainsail; it could be lifted out

quickly at the onset of a squall. It could even be lifted out, sail and all, in one quick heave and allowed to fall to leeward.

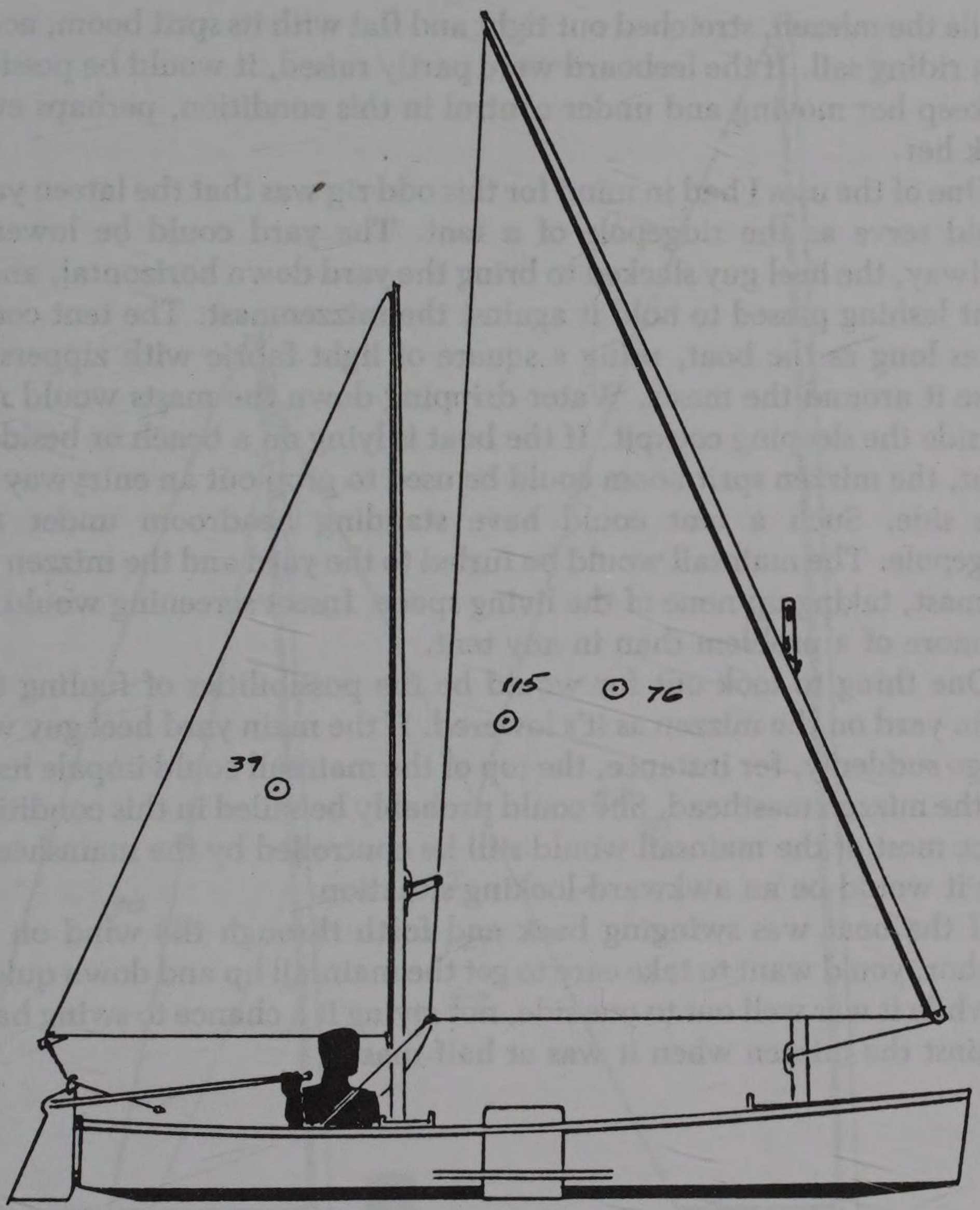
A leg-o'-mutton the size of this mizzen can be furled by swinging the boom up vertical against the mast, bundling the sail and spars roughly together, and lifting the mast out with one hand. In this toy size it's simpler to put a kicking strap under the boom than to use a sprit boom with an adjustable snotter. It must have the strap, though, or it'll be useless for anything but steadying the boat to an anchor. Without the strap the top of the sail will sag off, and it will slat furiously when the sheet is started to ease weather helm. The boat shares with all cat-ketches the defect that if the mainsail is deep-reefed, the full mizzen is too big in proportion to balance well. And she won't balance in the opposite sense if the mizzen is taken off entirely. To reef a 20-square-foot sail seems a travesty so the sail is designed to be feathered; that is, luffed. For that, in a strong breeze, it has to be possible to flatten the boom down hard without hauling it in to the centerline.

Sails like this have been held down by making a rigid joint at the mast. The original Finn dinghy had the boom stuck through a slot in the revolving mast. If this is done, there ought to be a swell in the mast in the area of the slot, or the mast will break there as a lot of Finn masts did. In addition, the boom has to be very stiff. If it whips at all, the clew goes up and the sail twists. This arrangement also needs a halyard and an adjustable outhaul, which aren't necessary on the rig shown in the cartoon.

RIG 58 Lateen mainsail with leg-o'-mutton mizzen

I don't know of a boat actually rigged this way, but it would work with one or two reservations. The cartoon represents another little camping cruiser, this time one with a prefabricated flat-bottomed hull for home builders.

A pedant might argue that this is a cat-schooner, not a cat-ketch, since the mainmast is much shorter than the mizzen. That would be a reason for adopting this rig. A tall sail, good in light airs, can be set on a mast so short that it can be left standing without blowing her bow



off. The rig would be good in waters that have occasional strong squalls punctuating prevailing gentle winds. At the onset of the squall, the lateen yard would be lowered. Its total vertical travel is only eight feet and its angle is controlled by the heel guy. With sail furled to the yard, the bundle would lie along the gunwale, sticking out over the stern,

while the mizzen, stretched out tight and flat with its sprit boom, acted as a riding sail. If the leeboard were partly raised, it would be possible to keep her moving and under control in this condition, perhaps even tack her.

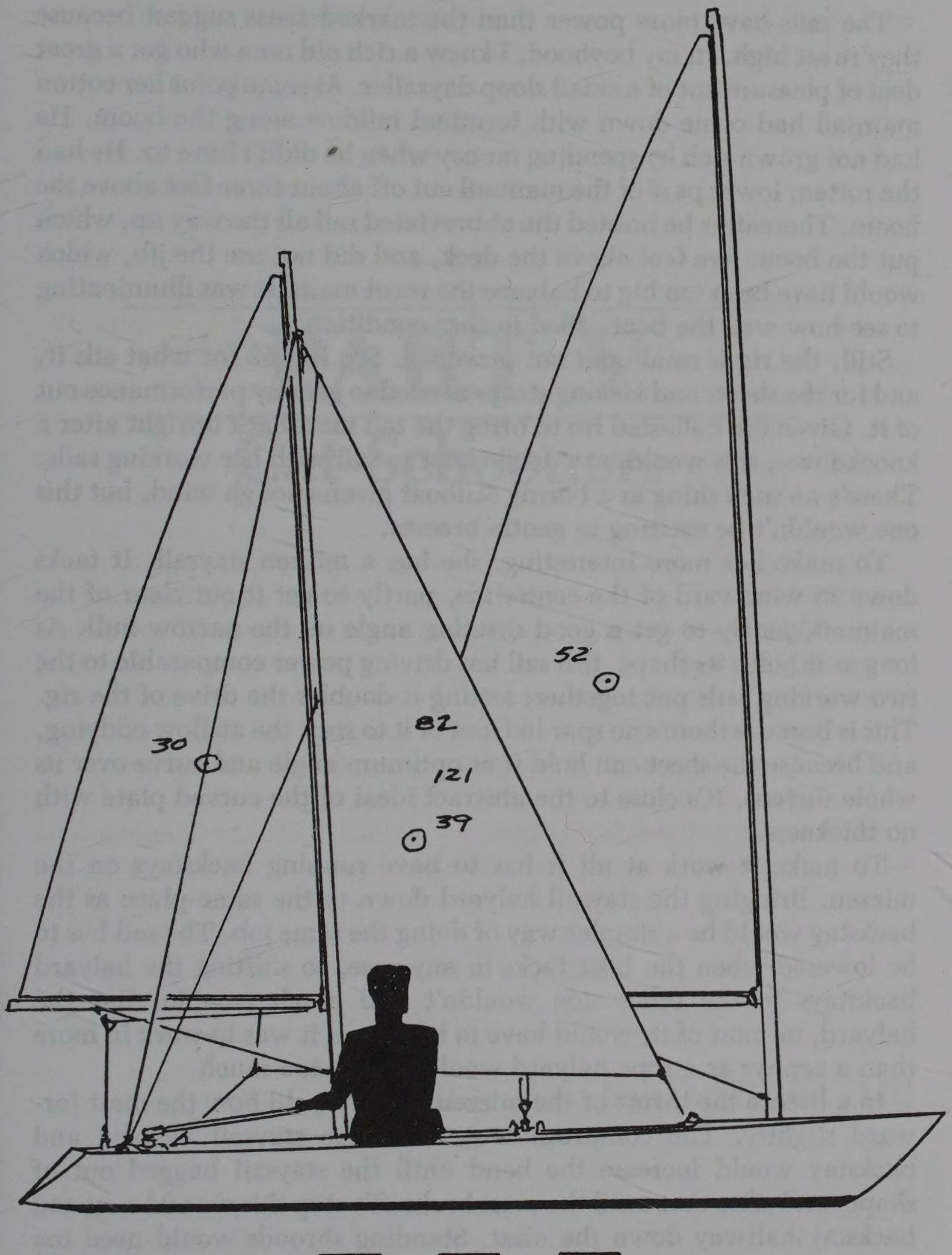
One of the uses I had in mind for this odd rig was that the lateen yard could serve as the ridgepole of a tent. The yard could be lowered halfway, the heel guy slacked to bring the yard down horizontal, and a light lashing passed to hold it against the mizzenmast. The tent could be as long as the boat, using a square of light fabric with zippers to close it around the masts. Water dripping down the masts would run outside the sleeping cockpit. If the boat is lying on a beach or beside a float, the mizzen sprit boom could be used to prop out an entryway on one side. Such a tent could have standing headroom under the ridgepole. The mainsail would be furled to the yard and the mizzen up its mast, taking up none of the living space. Insect screening would be no more of a problem than in any tent.

One thing to look out for would be the possibilities of fouling the main yard on the mizzen as it's lowered. If the main yard heel guy was let go suddenly, for instance, the top of the mainsail could impale itself on the mizzen masthead. She could probably be sailed in this condition since most of the mainsail would still be controlled by the mainsheets, but it would be an awkward-looking situation.

If the boat was swinging back and forth through the wind on an anchor, you'd want to take care to get the mainsail up and down quickly while it was well out to one side, not giving it a chance to swing back against the mizzen when it was at half-mast.

RIG 59 Jibheaded sails with mizzen staysail

The hull cartooned is supposed to be a light, slender, slack-bilged fin-keeler, 15½ feet long on deck. In other words, she doesn't need much sail to drive her. If she needed more, the jibheaded cat-ketch would be a poor choice, since the short booms inherent in her mast placement make it impractical to go much higher. The sails here have as acute a head angle as will allow shape to be built into the tops of the sails.


52
82
30
121
39

The sails have more power than the marked areas suggest because they're set high. In my boyhood, I knew a rich old man who got a great deal of pleasure out of a small sloop daysailer. At some point her cotton mainsail had come down with terminal mildew along the boom. He had not grown rich by spending money when he didn't have to. He had the rotten, lower part of the mainsail cut off about three feet above the boom. Thereafter he hoisted the abbreviated sail all the way up, which put the boom five feet above the deck, and did not use the jib, which would have been too big to balance the recut main. It was illuminating to see how well the boat sailed in that condition.

Still, the rig is small and not powerful. See Rig 52 for what ails it, and for the sheets and kicking straps needed to get any performance out of it. Given the ballasted fin to bring the tall mast back upright after a knockdown, this would be a docile boat to sail with her working sails. There's no such thing as a boring sailboat given enough wind, but this one wouldn't be exciting in gentle breezes.

To make her more interesting, she has a mizzen staysail. It tacks down to windward of the centerline, partly to get it out clear of the mainsail, partly to get a good sheeting angle on the narrow hull. As long as it holds its shape, this sail has driving power comparable to the two working sails put together; setting it doubles the drive of the rig. This is because there's no spar in front of it to start the airflow eddying, and because the sheet can hold it at optimum angle and curve over its whole surface. It's close to the abstract ideal of the curved plate with no thickness.

To make it work at all it has to have running backstays on the mizzen. Bringing the staysail halyard down to the same place as the backstay would be a simpler way of doing the same job. The sail has to be lowered when the boat tacks in any case, so shifting the halyard backstays to the other side wouldn't add much trouble. But the halyard, or most of it, would have to be wire if it was to work in more than a zephyr as a rope halyard would stretch too much.

In a breeze the thrust of the mizzen boom would bow the mast forward slightly. The compression stress of the staysail halyard and backstay would increase the bend until the staysail bagged out of shape, and after that until the mast broke. To stop this we add a second backstay halfway down the mast. Standing shrouds would need too much spread for the staysail to go out around on the lee side. At this point we might conclude that the rig is impractical, until it is recalled that the staysail, and therefore the backstays, don't have to be set if the crew has something better to do.

PART V

Cat-Schooners

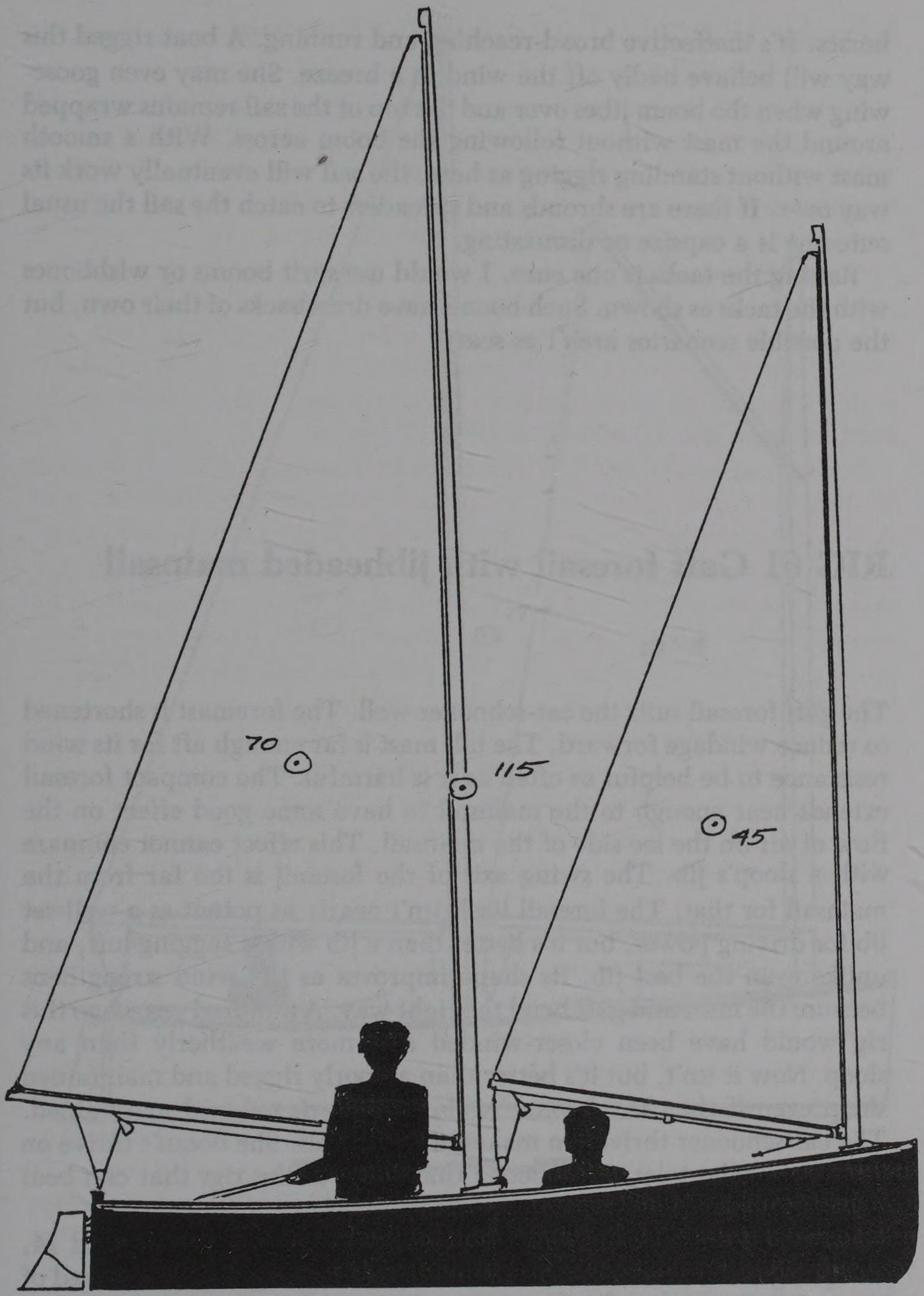
RIG 60 Jibheaded foresail and mainsail

A cat-schooner has the same advantage as the cat-ketch; that is, the biggest sail is small for the total size of the rig. If two similar boats with identical masts and sails are rigged one with the shorter mast forward and one with it aft, the schooner rig will win because the backwind of her small foresail doesn't kill the drive of the mainsail to the same extent that the ketch's mainsail kills her mizzen. The mainsail may even work better than it would if it stood alone, as the airflow from the foresail will have some tendency to smooth out the lee-side flow on the mainsail where the disturbance of the mainmast and the twist of the mainsail have started eddies.

In fact, cat-schooners, and schooners in general, are closely related to sloops. In a cat-schooner the foresail performs the functions of a sloop's jib. It doesn't do the job nearly as well as the jib in the usual cat-schooner because the top of the foresail is too far from the luff of the mainsail to be effective as a flow corrective, while it still forces the mainsail to be sheeted flatter than is desirable. The foresail has a mast up its luff, reducing its power. The foremast represents weight in a position that hurts the boat's action in rough water.

The cat-schooner will work without standing rigging but the sloop will not. The schooner can be cheaper to build, less liable to breakage, and impose less strain on the hull. Being farther aft than that of a sloop, the mainsail has less tendency to make the boat charge around her anchor as soon as it's hoisted. On the other hand, the mainsail is too big to be a good riding sail, and the aggregate wind resistance of the two masts is too far forward to promote steady riding under bare poles.

The position of the booms in the cartoon, with low tack and high clew, is old-fashioned. The object is to get as long a luff as possible with a given mast height, then cock up the clew to clear wave crests and to see under the sail to leeward. The objection is that no room is left for kicking straps to hold the booms down. In this open boat, the main boom could have one led to the foot of the mast, but there's no room in the narrow bow to rig one for the foreboom. The foresail is therefore sheeted to a long traveler horse, with the fall of the sheet brought forward near the axis of swing, so no part of the sheet will be pulling the boom in rather than down. The mainsheet also has a long travel. Its fall is supposed to be hooked under a pin on the lee side. These arrangements will hold the shape of the sail close-hauled, and more or less adequately with started sheets, depending on the length of the


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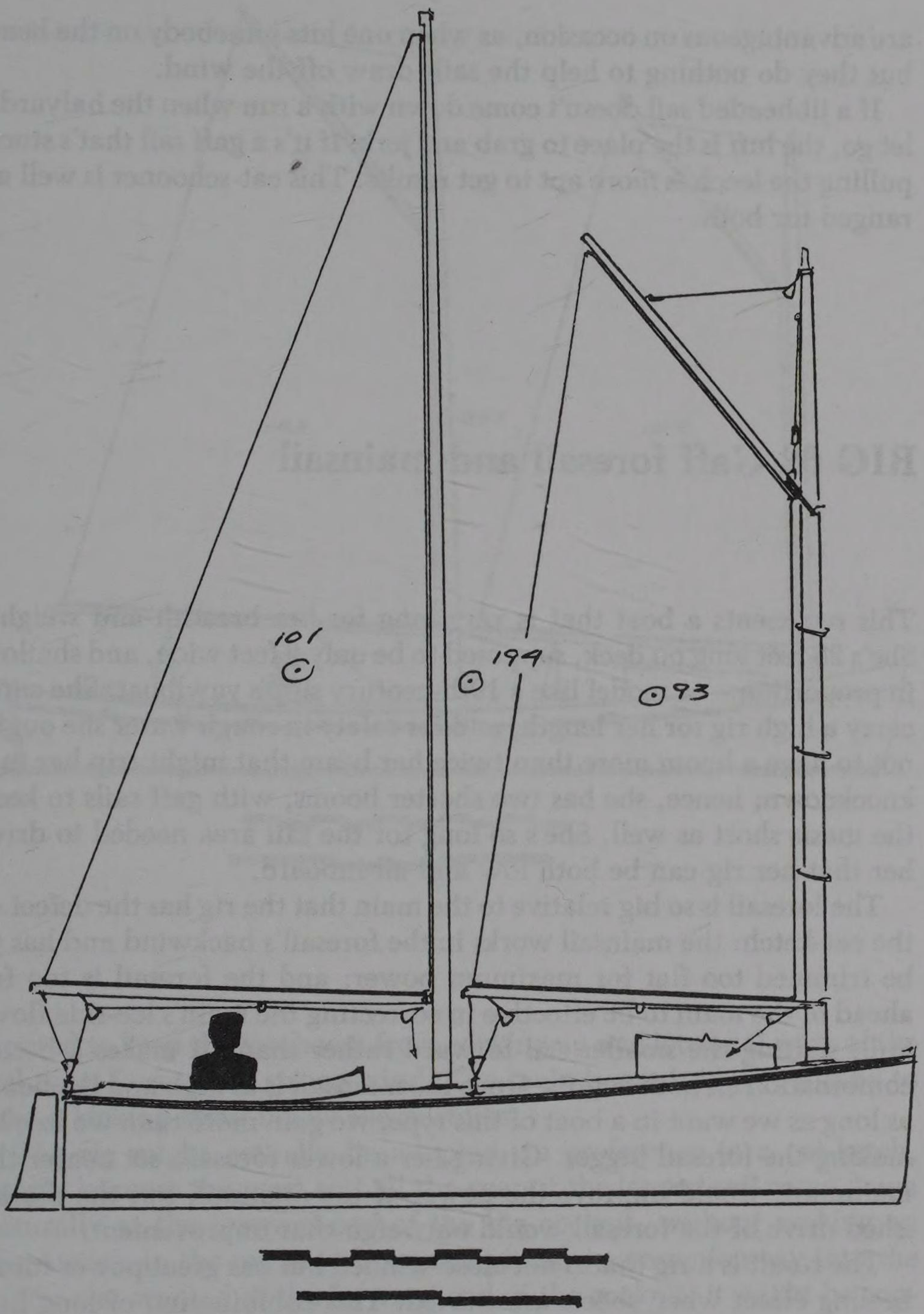
horses. It's ineffective broad-reaching and running. A boat rigged this way will behave badly off the wind in a breeze. She may even goose-wing when the boom jibes over and the top of the sail remains wrapped around the mast without following the boom across. With a smooth mast without standing rigging as here, the sail will eventually work its way over. If there are shrouds and spreaders to catch the sail the usual outcome is a capsize or dismasting.

Raising the tacks is one cure. I would use sprit booms or wishbones with the tacks as shown. Such booms have drawbacks of their own, but the possible scenarios aren't as scary.

RIG 61 Gaff foresail with jibheaded mainsail

The gaff foresail suits the cat-schooner well. The foremast is shortened to reduce windage forward. The tall mast is far enough aft for its wind resistance to be helpful as often as it is harmful. The compact foresail extends near enough to the mainsail to have some good effect on the flow of air on the lee side of the mainsail. This effect cannot compare with a sloop's jib. The swing axis of the foresail is too far from the mainsail for that. The foresail itself isn't nearly as potent as a well-set jib for driving power, but it's better than a jib with a sagging luff, and unlike even the best jib, its shape improves as the wind strengthens because the mast and gaff bend the right way. A hundred years ago this rig would have been closer-winded and more weatherly than any sloop. Now it isn't, but it's better than a poorly rigged and maintained sloop even if the cat-schooner is also poorly rigged and maintained. The cat-schooner thrives on makeshift materials. She doesn't thrive on neglect but she tolerates it better than most of the rigs that can beat her.

The sheets are rigged as described, for example, in Rigs 3 and 14, with long horses for the travelers. Neither the fore gaff nor the head of the mainsail will sag off when she's close-hauled or close-reaching. The clews will start to lift and the sails to twist on a beam reach, but in this case the booms are high enough to be guyed down to the rail when a



long reach or run is in prospect. A couple of padeyes on the topsides below the deck edge on each side, to hook a guy into, are worth installing, especially with the short and light booms of this rig. Light booms

are advantageous on occasion, as when one hits somebody on the head, but they do nothing to help the sails draw off the wind.

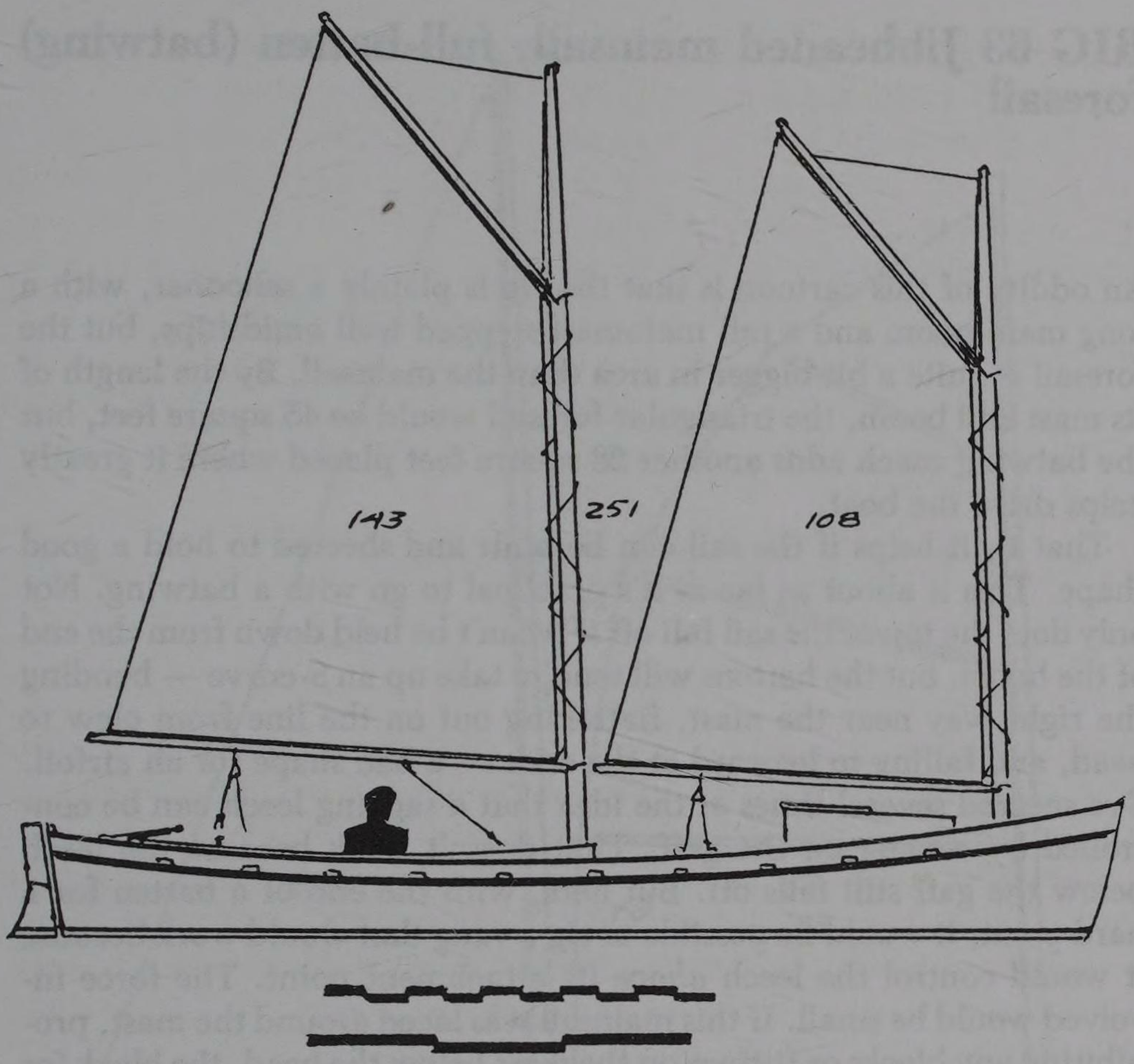
If a jibheaded sail doesn't come down with a run when the halyard is let go, the luff is the place to grab and jerk. If it's a gaff sail that's stuck, pulling the leech is more apt to get results. This cat-schooner is well arranged for both.

RIG 62 Gaff foresail and mainsail

This represents a boat that is very long for her breadth and weight. She's 28 feet long on deck, supposed to be only 6 feet wide, and shallow in proportion — a model like a 19th-century ship's yawlboat. She can't carry a high rig for her length, and for safety in rough water she ought not to have a boom more than twice her beam that might trip her in a knockdown; hence, she has two shorter booms, with gaff sails to keep the masts short as well. She's so long for the sail area needed to drive her that her rig can be both low and all inboard.

The foresail is so big relative to the main that the rig has the defect of the cat-ketch: the mainsail works in the foresail's backwind and has to be trimmed too flat for maximum power; and the foresail is too far ahead of the main to be effective in correcting the main's lee-side flow. Still, putting the smaller sail forward rather than aft makes a better combination on both counts. Once the mainsail is as high and the boom as long as we want in a boat of this type, we gain more than we lose by making the foresail bigger. Giving her a lower foresail, set nearer the mainmast, would improve the power of the mainsail, but the diminished drive of the foresail would outweigh that improvement.

The result is a rig that is not close-winded but has great power for its heeling effect when sheets are started. This combination of long hull and low sailplan will go very fast on a reach. And, except when close-hauled, the sails don't interfere with each other. Even dead before the wind, if the main boom is brought aft a little, the resulting flow of air across the sail will blow the foresail out on the other side wing and wing, and keep it out, drawing well. Some kind of guy would be



wanted to keep the foreboom from cocking up and letting the top of the sail twist forward in strong wind. The main boom is ideally placed to take a kicking strap below the partners.

The rig might actually be adopted, in preference to a cat-ketch, simply because the mast and all the gear of the largest sail come down naturally at the forward end of the big cockpit, without making an obstruction in the middle of the cockpit. If a companionway into the cuddy was wanted at the forward end of the cockpit, it might be convenient to move the mainmast back out of the way and start calling it a mizzen and the boat a cat-ketch. The point about the existence of all these rigs is that one or another will be naturally suited to any conceivable deck or cabin arrangement, if the designer has an open mind at the conception.

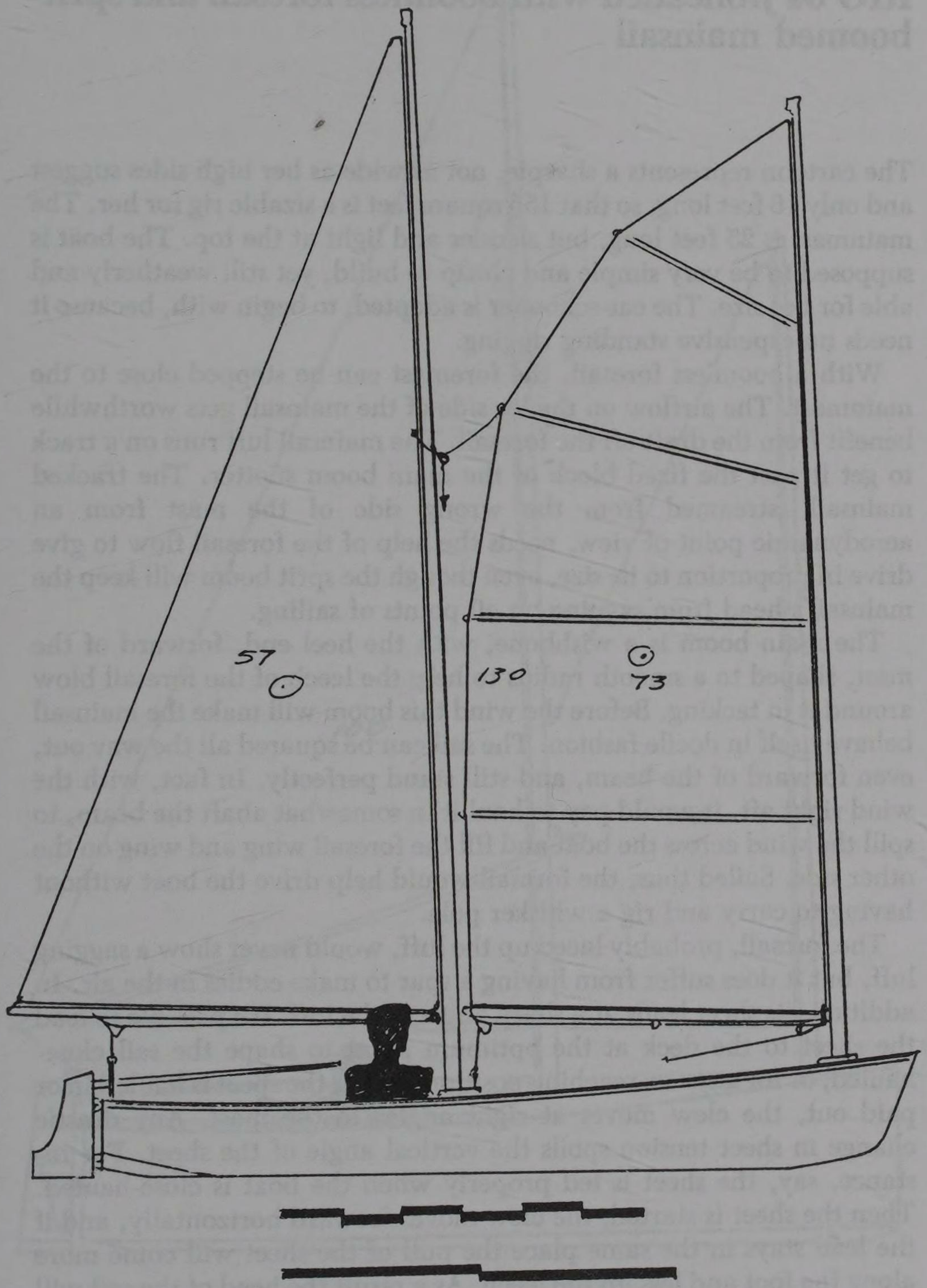
RIG 63 Jibheaded mainsail, full-batten (batwing) foresail

An oddity of this cartoon is that the rig is plainly a schooner, with a long main boom and a tall mainmast stepped well amidships, but the foresail is quite a bit bigger in area than the mainsail. By the length of its mast and boom, the triangular foresail would be 45 square feet, but the batwing roach adds another 28 square feet placed where it greatly helps drive the boat.

That is, it helps if the sail can be built and sheeted to hold a good shape. This is about as far as it's practical to go with a batwing. Not only does the top of the sail fall off if it can't be held down from the end of the boom, but the battens will tend to take up an S-curve — bending the right way near the mast, flattening out on the line from clew to head, and falling to leeward at the ends — a bad shape for an airfoil. I've sneered several times at the idea that a sagging leech can be controlled by a vang on the gaff. That doesn't work because the leech below the gaff still falls off. But here, with the end of a batten for a hard point, it would be possible to rig a vang that would work because it would control the leech *above* its attachment point. The force involved would be small. If this mainsail was laced around the mast, prohibiting any blocks or fittings on the mast below the head, the block for the vang could be sent up hung on a grommet in the luff of the mainsail, with the incidental benefit that it would be lowered along with the mainsail, and not left aloft all the time slapping against the mast.

I've shown the foresail sheet led forward to the mast, so that the whole sheet force acting on the sail is at the lee end of the traveler horse where it flattens the sail down and helps control the leech. But in this little boat, it would be more sensible to take the fall of the sheet straight back down from the block on the end of the boom to a cleat on the lee side. It wouldn't be much trouble, even for a singlehander, to shift it to the other side as the boat went through stays. That would bring all the boat's running gear, except the foresail halyard, straight to the helmsman who would be sitting where his weight does the least harm and the most good, where the little boat is widest and deepest.

The foresail halyard could be led aft, but it's a failing of full-batten sails that they're apt to need a strong pull on the luff to make them come down. It'd be a pity if the sailor, leaping forward to do this, tripped over the halyard on his way.


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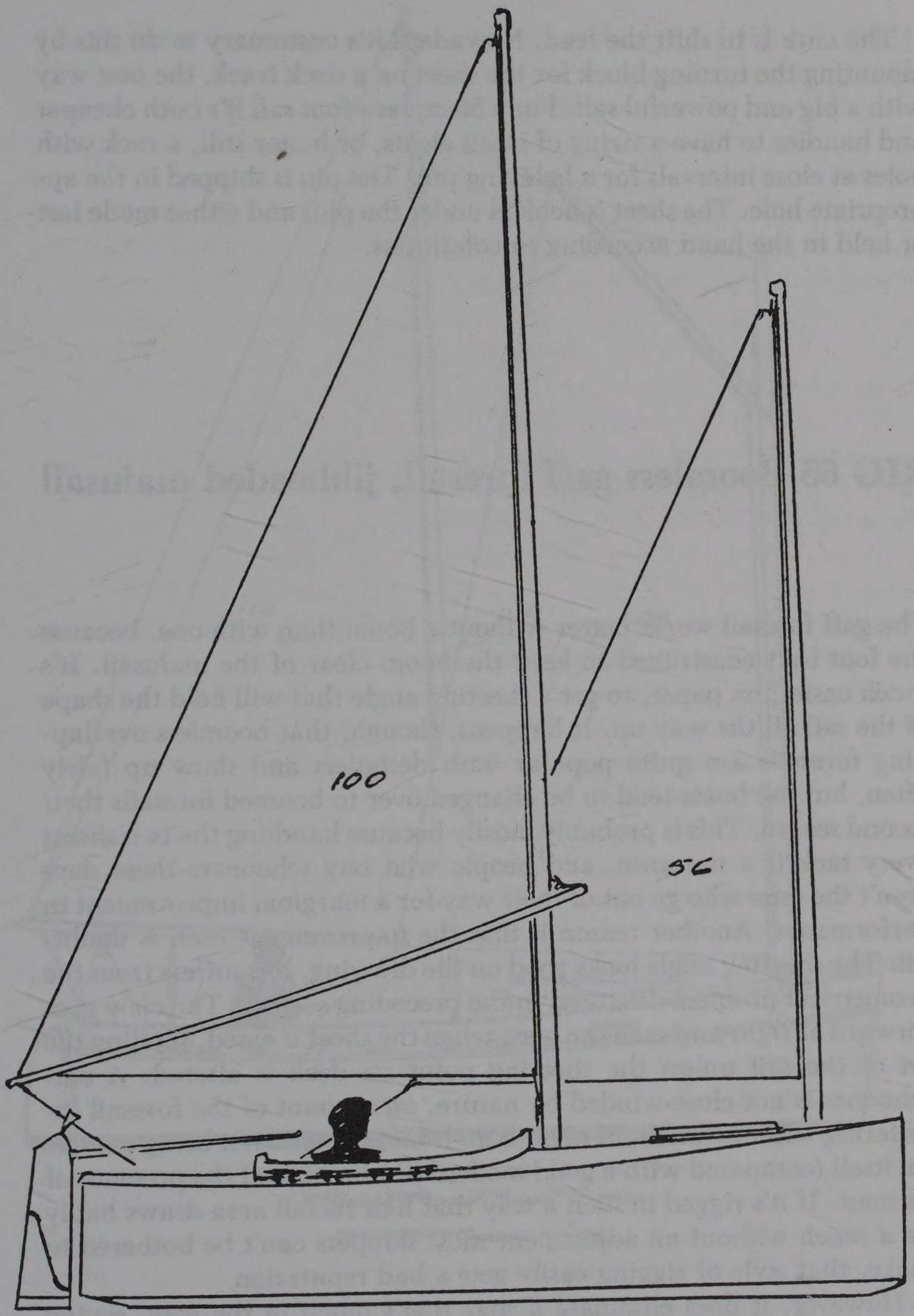
RIG 64 Jibheaded with boomless foresail and sprit-boomed mainsail

The cartoon represents a sharpie, not as wide as her high sides suggest and only 16 feet long, so that 156 square feet is a sizable rig for her. The mainmast is 25 feet long, but slender and light at the top. The boat is supposed to be very simple and cheap to build, yet still weatherly and able for her size. The cat-schooner is adopted, to begin with, because it needs no expensive standing rigging.

With a boomless foresail, the foremast can be stepped close to the mainmast. The airflow on the lee side of the mainsail gets worthwhile benefit from the draft off the foresail. The mainsail luff runs on a track to get it past the fixed block of the main boom snotter. The tracked mainsail, streamed from the wrong side of the mast from an aerodynamic point of view, needs the help of the foresail flow to give drive in proportion to its size, even though the sprit boom will keep the mainsail's head from sagging on all points of sailing.

The main boom is a wishbone, with the heel end, forward of the mast, shaped to a smooth radius to help the leech of the foresail blow around it in tacking. Before the wind this boom will make the mainsail behave itself in docile fashion. The sail can be squared all the way out, even forward of the beam, and still stand perfectly. In fact, with the wind right aft, it would pay to haul it in somewhat abaft the beam, to spill the wind across the boat and fill the foresail wing and wing on the other side. Sailed thus, the foresail would help drive the boat without having to carry and rig a whisker pole.

The foresail, probably laced up the luff, would never show a sagging luff, but it does suffer from having a spar to make eddies in the air. In addition, its sheet leads at a sharp angle to the luff. It's possible to lead the sheet to the deck at the optimum point to shape the sail close-hauled, or for any one reaching position. But as the sheet is hauled in or paid out, the clew moves at right angles to the mast. Any drastic change in sheet tension spoils the vertical angle of the sheet. For instance, say, the sheet is led properly when the boat is close-hauled. Then the sheet is started, the clew moves forward horizontally, and if the lead stays in the same place the pull of the sheet will come more along the foot and less up the leech. As a result the head of the sail will fall off. By the time the boat is off to a beam reach the top of the foresail will be luffing.

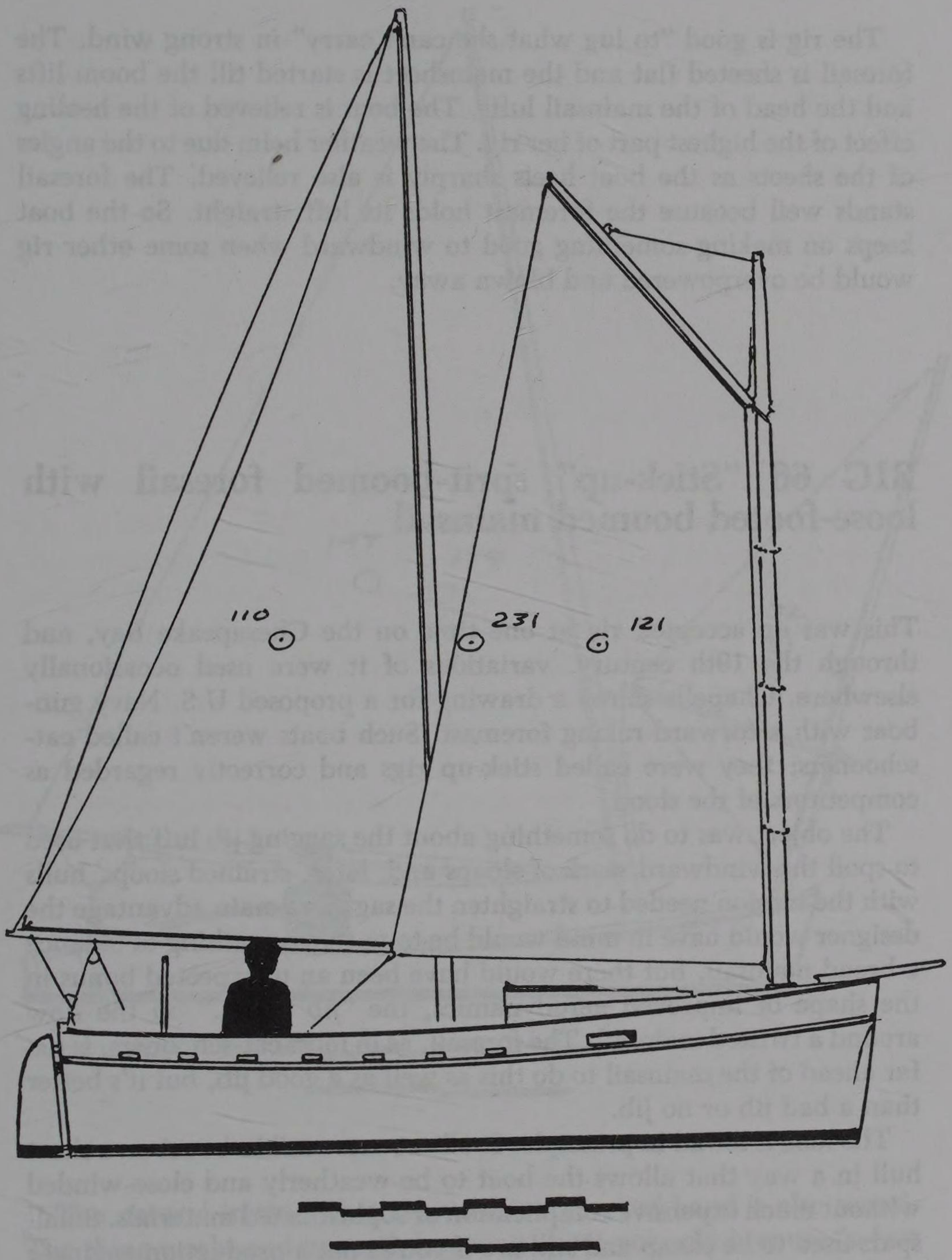

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The cure is to shift the lead. Nowadays it's customary to do this by mounting the turning block for the sheet on a deck track, the best way with a big and powerful sail. For a 56-square-foot sail it's both cheaper and handier to have a string of small cleats, or better still, a rack with holes at close intervals for a belaying pin. The pin is shipped in the appropriate hole. The sheet is hooked under the pin, and either made fast or held in the hand according to conditions.

RIG 65 Boomless gaff foresail, jibheaded mainsail

The gaff foresail works better without a boom than with one, because the foot isn't constricted to keep the boom clear of the mainsail. It's much easier, on paper, to get a sheeting angle that will hold the shape of the sail all the way up. It happens, though, that boomless overlapping foresails are quite popular with designers and show up fairly often, but the boats tend to be changed over to boomed foresails their second season. This is probably mostly because handling the two sheets every tack is a nuisance, and people who buy schooners these days aren't the ones who go out of their way for a marginal improvement in performance. Another reason is that the improvement itself is doubtful. The sheeting angle looks good on the drawing, but suffers from the geometrical problem discussed in the preceding section. The clew goes forward at right angles to the mast when the sheet is eased, spoiling the set of the sail unless the sheeting point on deck is altered. A cat-schooner is not close-winded by nature, on account of the foresail interfering with the mainsail more than it helps it, and not being powerful itself (compared with a good modern jib) because of the presence of its mast. If it's rigged in such a way that half its sail area draws badly on a reach without an adjustment most skippers can't be bothered to make, that style of rigging easily gets a bad reputation.

However, it does eliminate a spar that's much in the way, saving some money in the process since the sail is just small enough to be sheeted without either winches or purchases. The sail would be furled on the gaff, which would then be peaked up, or hoisted with both



halyards, to clear the companionway. The bundle would be handy to serve as a ridgepole for an awning that would shade the deck and allow the hatch to be open in a gentle rain.

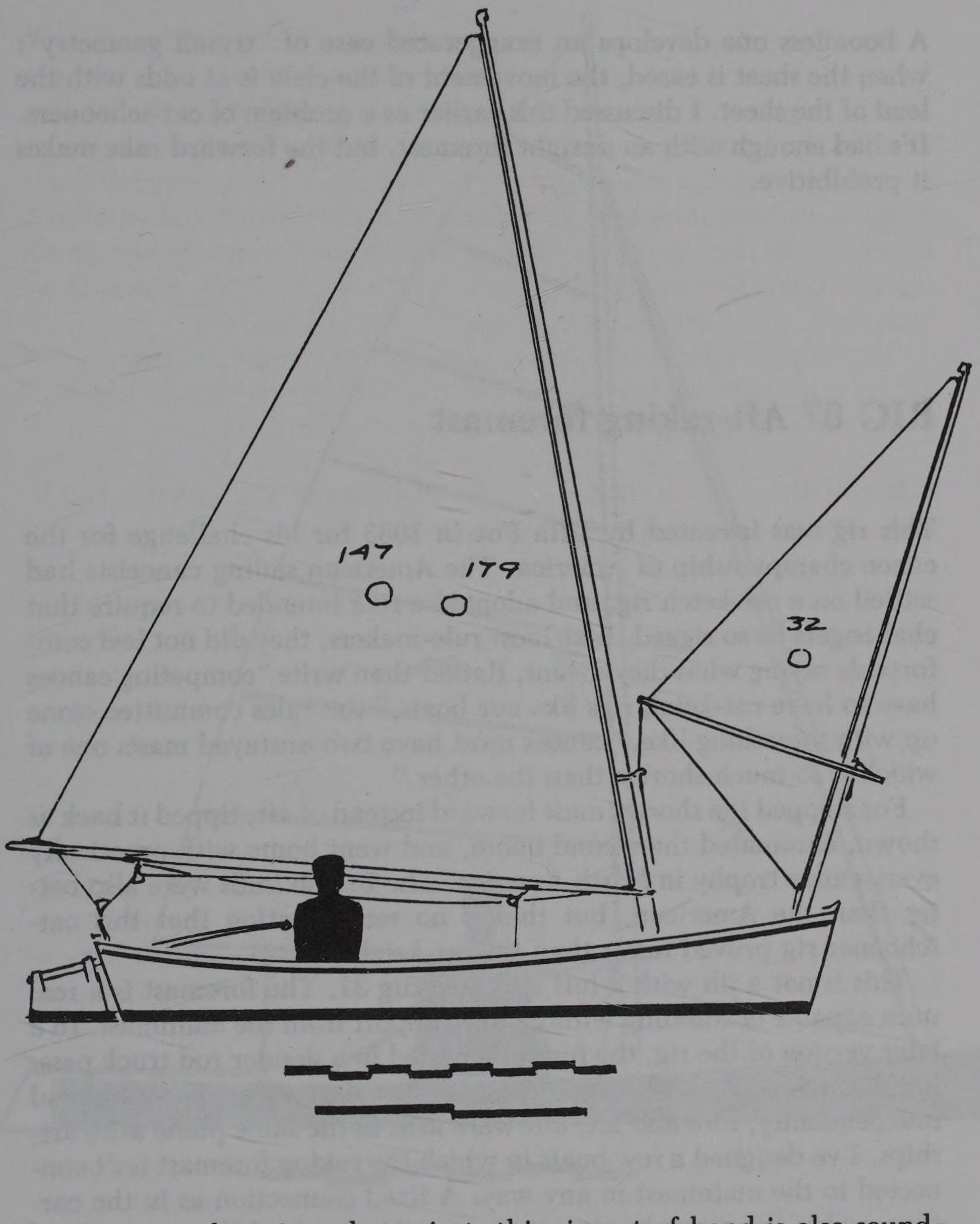
The rig is good "to lug what she can't carry" in strong wind. The foresail is sheeted flat and the mainsheet is started till the boom lifts and the head of the mainsail luffs. The boat is relieved of the heeling effect of the highest part of her rig. The weather helm due to the angles of the sheets as the boat heels sharply is also relieved. The foresail stands well because the foremast holds its luff straight. So the boat keeps on making something good to windward when some other rig would be overpowered and blown away.

RIG 66 "Stick-up" sprit-boomed foresail with loose-footed boomed mainsail

This was an accepted rig at one time on the Chesapeake Bay, and through the 19th century, variations of it were used occasionally elsewhere. Chapelle shows a drawing for a proposed U.S. Navy gunboat with a forward-raking foremast. Such boats weren't called cat-schooners; they were called stick-up rigs and correctly regarded as competitors of the sloop.

The object was to do something about the sagging jib luff that used to spoil the windward work of sloops and, later, strained sloops' hulls with the tension needed to straighten the sag. The main advantage the designer would have in mind would be to put up something to balance a broad mainsail, but there would have been an unexpected bonus in the shape of improved aerodynamics, the "jib effect," on the flow around a twisted mainsail. The foresail, as in most cat-schooners, is too far ahead of the mainsail to do this as well as a good jib, but it's better than a bad jib or no jib.

The idea is sound in principle. It allows more sail to be set on a short hull in a way that allows the boat to be weatherly and close-winded without much expensive complication or sophisticated materials. Small spars used to be cheap and still are if you're not a production engineer who has to produce 10,000 alike. If you just need one and know that it doesn't have to be "select clear Sitka spruce," a short drive will usually locate a tree that is in somebody's way. For a rig like this, it doesn't even have to be straight, though if it has a big kink the sailmaker deserves a warning and a diagram.



The natural instinct that rejects this rig out of hand is also sound. The thing works and is worth knowing about not only because "a fact should be loved for itself alone," but because once in a blue moon there might be a good reason to want this rig. But it has defects apart from bizarre looks: it's clumsy to hoist and to furl; its angle tends to depress the bow of the boat on all points of sailing; and it needs spars out of proportion to its size. The sprit boom shown is the only way to sheet it.

A boomless one develops an exaggerated case of "trysail geometry": when the sheet is eased, the movement of the clew is at odds with the lead of the sheet. I discussed this earlier as a problem of cat-schooners. It's bad enough with an upright foremast, but the forward rake makes it prohibitive.

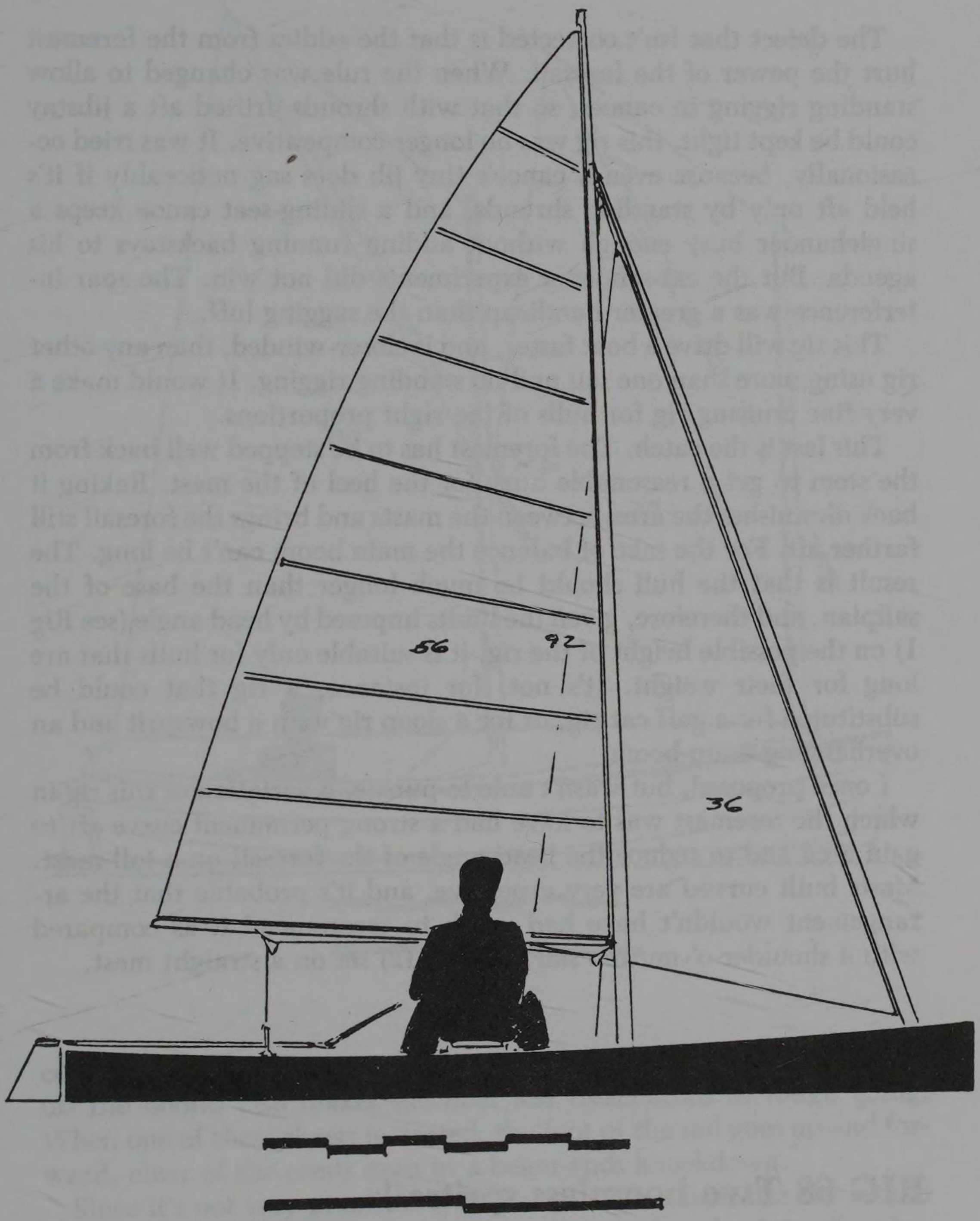
RIG 67 Aft-raking foremast

This rig was invented by Uffa Fox in 1933 for his challenge for the canoe championship of America. The American sailing canoeists had settled on a cat-ketch rig, and adopted a rule intended to require that challengers be so rigged. Like most rule-makers, they did not feel comfortable saying what they meant. Rather than write "competing canoes have to have cat-ketch rigs like our boats," the rules committee came up with something like, "canoes must have two unstayed masts one of which is so much shorter than the other."

Fox stepped the shorter mast forward instead of aft, tipped it back as shown, eliminated the second boom, and went home with practically every canoe trophy in North America. The British hulls were also better than the American, but there's no real question that this cat-schooner rig proved faster than the cat-ketches.

This is not a jib with a luff spar like Rig 31. The foremast is a real mast capable of standing without any support from the mainmast. In a later version of the rig, the foremast ended in a slender rod truck passing through a ring on the mainmast, so that the two masts could bend independently, fore and aft, but were held in the same plane athwartships. I've designed a few boats in which the raking foremast isn't connected to the mainmast in any way. A fixed connection as in the cartoon makes the masts hard to step since the two heels have to go into their partners and step scissors-fashion.

Raking the foremast corrects three of the four defects of the cat-schooner rig. Most important, it brings the foresail back where it has optimum "jib effect" (see Rig 28) to improve the power of the mainsail by smoothing out turbulence over its lower lee side. Secondly, the vertical angle of the sheets of the boomless foresail changes much less as



the sheets are eased; that is, the foresail will draw well reaching without shifting the deck lead. Thirdly, the weight of the foremast is shifted farther aft.

The defect that isn't corrected is that the eddies from the foremast hurt the power of the foresail. When the rule was changed to allow standing rigging in canoes, so that with shrouds drifted aft a jibstay could be kept tight, this rig was no longer competitive. It was tried occasionally, because even a canoe's tiny jib does sag noticeably if it's held aft only by standing shrouds, and a sliding-seat canoe keeps a singlehander busy enough without adding running backstays to his agenda. But the cat-schooner experiments did not win. The spar interference was a greater handicap than the sagging luff.

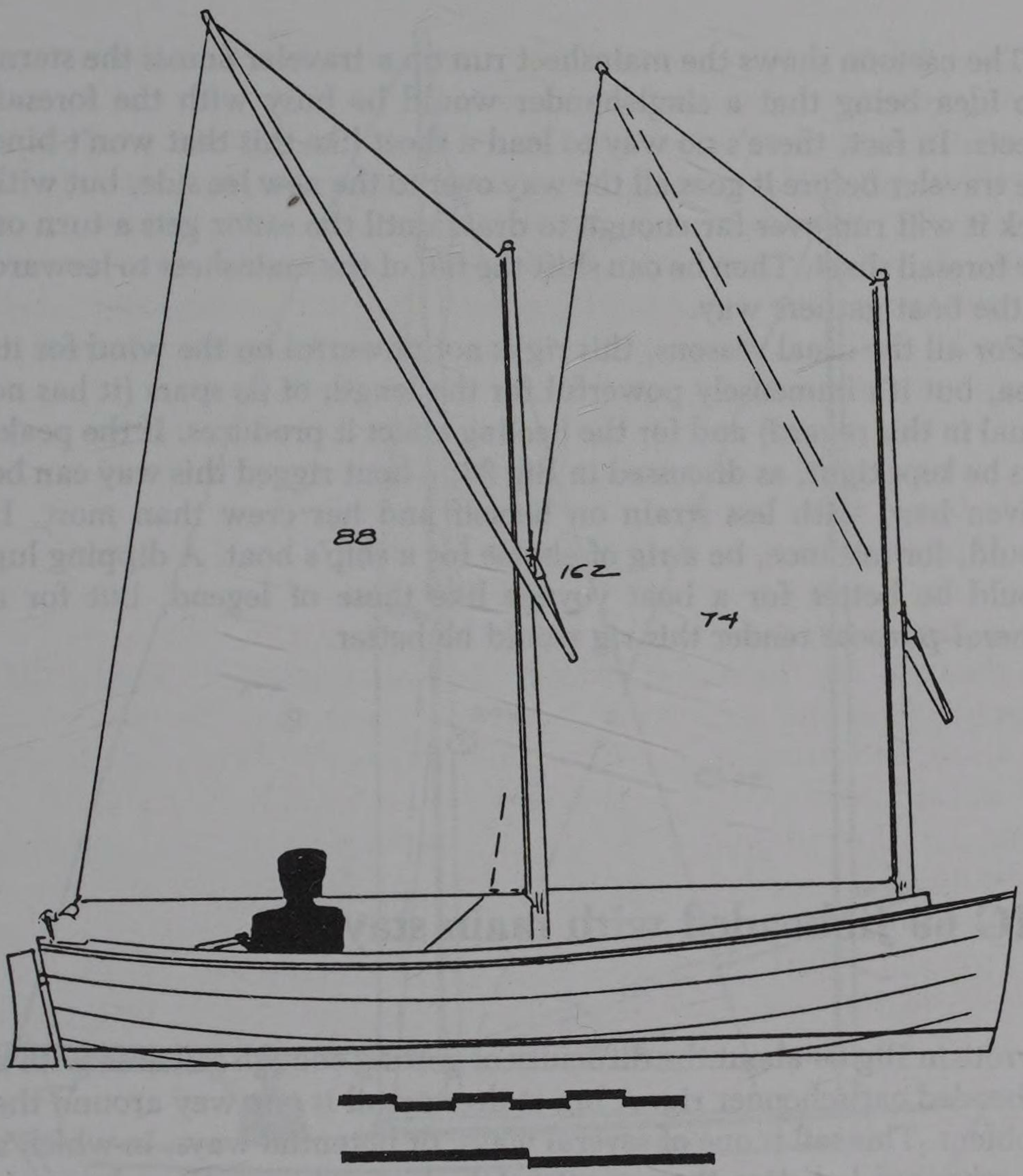
This rig will drive a boat faster, and is closer-winded, than any other rig using more than one sail and no standing rigging. It would make a very fine cruising rig for hulls of the right proportions.

This last is the catch. The foremast has to be stepped well back from the stem to get a reasonable bury for the heel of the mast. Raking it back diminishes the area between the masts and brings the foresail still farther aft. For the sake of balance the main boom can't be long. The result is that the hull should be much longer than the base of the sailplan, and therefore, given the limits imposed by head angle (see Rig 1) on the possible height of the rig, it is suitable only for hulls that are long for their weight. It's not, for instance, a rig that could be substituted for a gaff cat rig, or for a sloop rig with a bowsprit and an overhanging main boom.

I once proposed, but wasn't able to pursue, a variation of this rig in which the foremast was to have had a strong permanent curve aft to gain area and to reduce the head angle of the foresail on a tall mast. Masts built curved are very expensive, and it's probable that the arrangement wouldn't have had much to recommend it as compared with a shoulder-o'-mutton sail (see Rig 12) set on a straight mast.

RIG 68 Two boomless spritsails

This cartoon represents a daysailer or camper about 17 feet long on deck, with 162 square feet of sail, whose longest spars, the masts, are 14 feet 4 inches overall. The sprits are less than 13 feet long. Sails, spars, and all will bundle up and stow down in the boat, off the



centerline. The sails are boomless mostly to save two spars, but leaving off the booms also makes the boat less treacherous in rough going. When one of these sheets is started, the foot of the sail goes up and forward, clear of the crests even in a beam-ends knockdown.

Since it's not very practical to reef a spritsail, a boat like this would be built with a third mast step and appropriate sheet leads to allow her to be sailed as a cat with either of her masts and sails, with the other sail and mast stowed.

The stern has to be wide to sheet this mainsail properly. The alternative is to use an outrigger for the mainsheet, but outriggers are an unholy nuisance when the boat is alongside another boat or a float.

The cartoon shows the mainsheet run on a traveler across the stern, the idea being that a singlehander would be busy with the foresail sheets. In fact, there's no way to lead a sheet like this that won't bind the traveler before it goes all the way over to the new lee side, but with luck it will run over far enough to draw until the sailor gets a turn on the foresail sheet. Then he can shift the fall of the mainsheet to leeward as the boat gathers way.

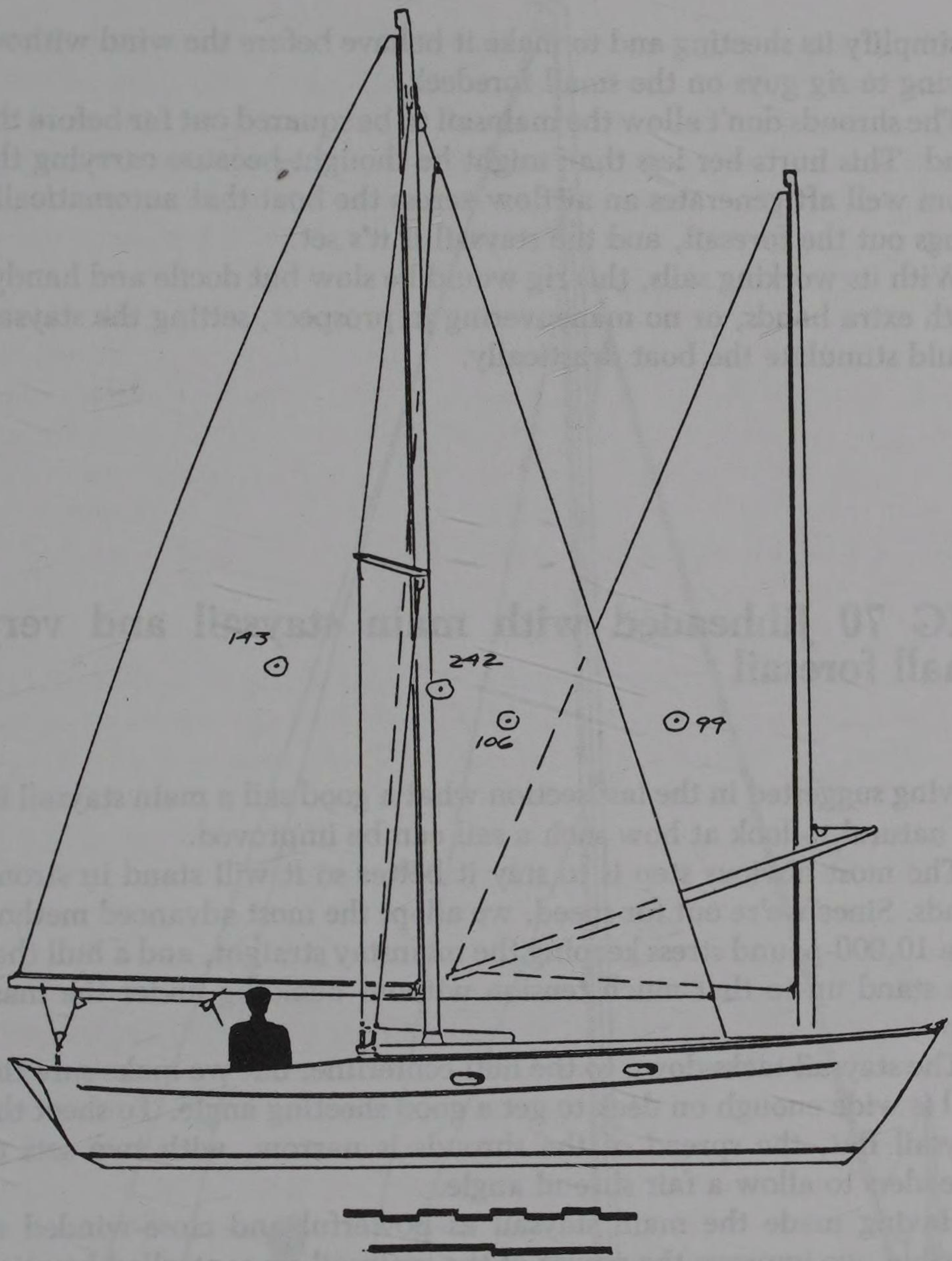
For all the usual reasons, this rig is not powerful on the wind for its area, but it's immensely powerful for the length of its spars (it has no equal in this regard) and for the heeling effect it produces. If the peaks can be kept tight, as discussed in Rig 23, a boat rigged this way can be driven hard with less strain on herself and her crew than most. It would, for instance, be a rig of choice for a ship's boat. A dipping lug would be better for a boat voyage like those of legend, but for a general-purpose tender this rig would be better.

RIG 69 Jibheaded with main staysail

I wrote in Rig 60 about the difficulty of getting enough sail area with a jibheaded cat-schooner rig. A big main staysail is one way around the problem. This sail is one of several ways, or potential ways, in which a cat-schooner is better than a cat-ketch. Not only can the schooner's main staysail be bigger and higher than a cat-ketch's mizzen staysail, but it's better placed to balance the helm.

The staysail cartooned would increase the sail area by 44 percent, but as long as the staysail can be made to stand well and hold its shape, the increase in the total power of the sailplan is much more than that. The staysail itself is a much better airfoil than the working sails, and it can be tacked down out to windward of the boat centerline to be in an optimum relationship with the mainsail as described in Rig 28. Shifting the tack to windward also gets it clear of the foresail.

To make the staysail stand, the mainmast has to be stayed as stiffly as possible. The shrouds drifted well abaft the mast are adequate for light airs, and for moderate weather if the wire is heavy enough to eliminate most of the stretch. In stronger winds the aft angle of the shrouds isn't



adequate. Backstays to the quarters would have to be added if the staysail was needed then.

The windward position of the tack of the staysail precludes sheeting it out around the shrouds. The sheet would pass inboard of the lower shroud, so the sail can't have more length on the foot than will allow the leech to clear the spreaders.

The foresail here has a sprit boom with a snotter high above the tack

to simplify its sheeting and to make it behave before the wind without having to rig guys on the small foredeck.

The shrouds don't allow the mainsail to be squared out far before the wind. This hurts her less than might be thought because carrying the boom well aft generates an airflow across the boat that automatically wings out the foresail, and the staysail if it's set.

With its working sails, this rig would be slow but docile and handy. With extra hands, or no maneuvering in prospect, setting the staysail would stimulate the boat drastically.

RIG 70 Jibheaded with main staysail and very small foresail

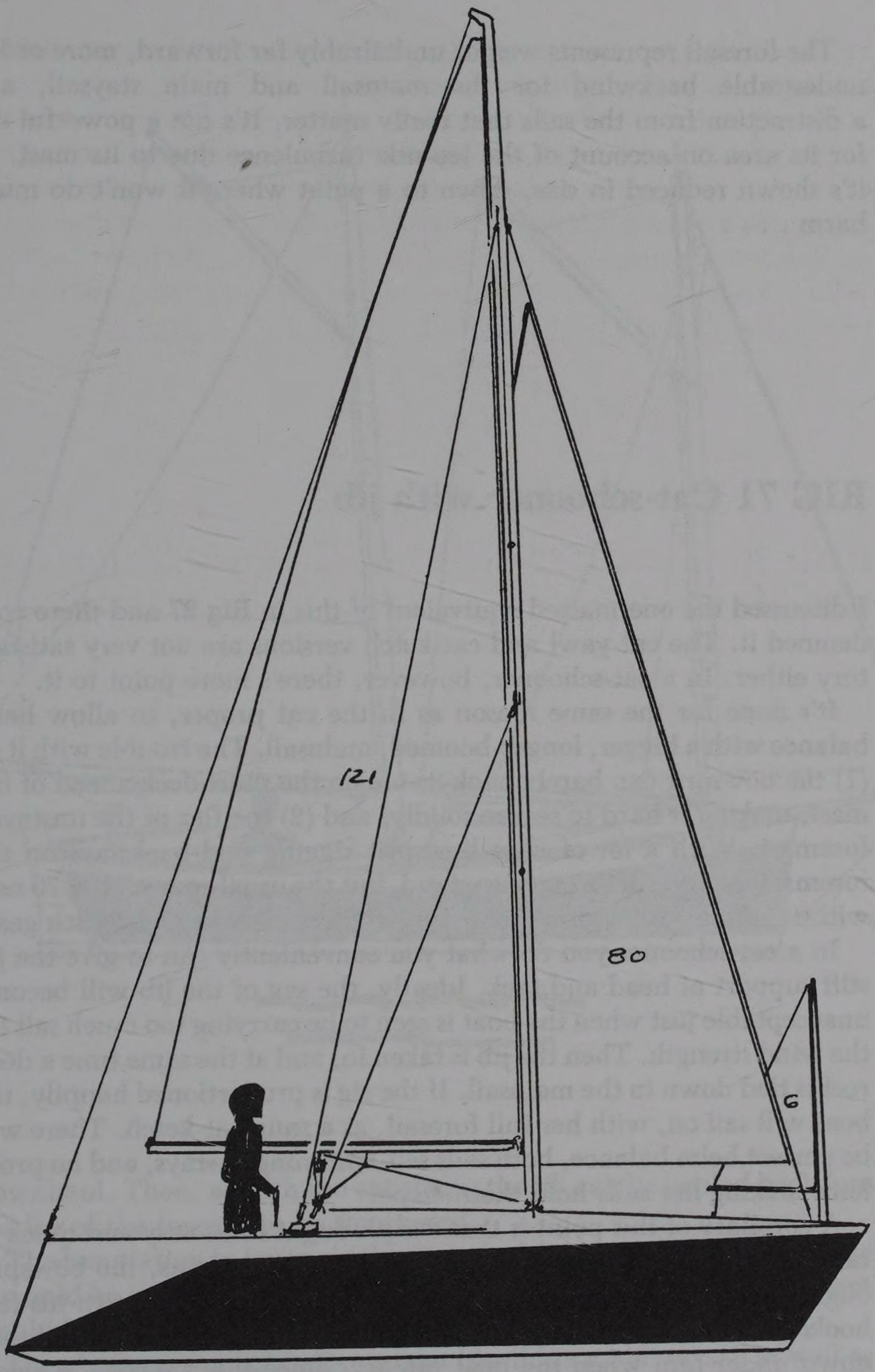
Having suggested in the last section what a good sail a main staysail is, it's natural to look at how such a sail can be improved.

The most obvious step is to stay it better so it will stand in strong winds. Since we're out for speed, we adopt the most advanced method — a 10,000-pound stress keeping the mainstay straight, and a hull that can stand up to that much tension without buckling under the mast step.

The staysail tacks down to the hull centerline, but we make sure the hull is wide enough on deck to get a good sheeting angle. To sheet the staysail flat, the spread of the shrouds is narrow, with two sets of spreaders to allow a fair shroud angle.

Having made the main staysail as powerful and close-winded as possible, we improve the power of the mainsail by controlled bending of its mast and boom, as discussed in Rig 32. Two sets of running backstays are needed to do this job well. There are simpler methods, such as having a second set of lower shrouds with some drift aft, but the backstays allow nicer adjustment.

All this is expensive, especially as it needs several high-class winches to work at its best. It also needs skill and vigilance, both to keep it adjusted for best effect and to see that it doesn't break. But if knowledgeably carried out and skillfully handled, this would be the most weatherly and close-winded schooner that ever sailed.


121
80
6

The foresail represents weight undesirably far forward, more or less undesirable backwind for the mainsail and main staysail, and a distraction from the sails that really matter. It's not a powerful sail for its area on account of the lee-side turbulence due to its mast. So it's shown reduced in size, down to a point where it won't do much harm . . . .

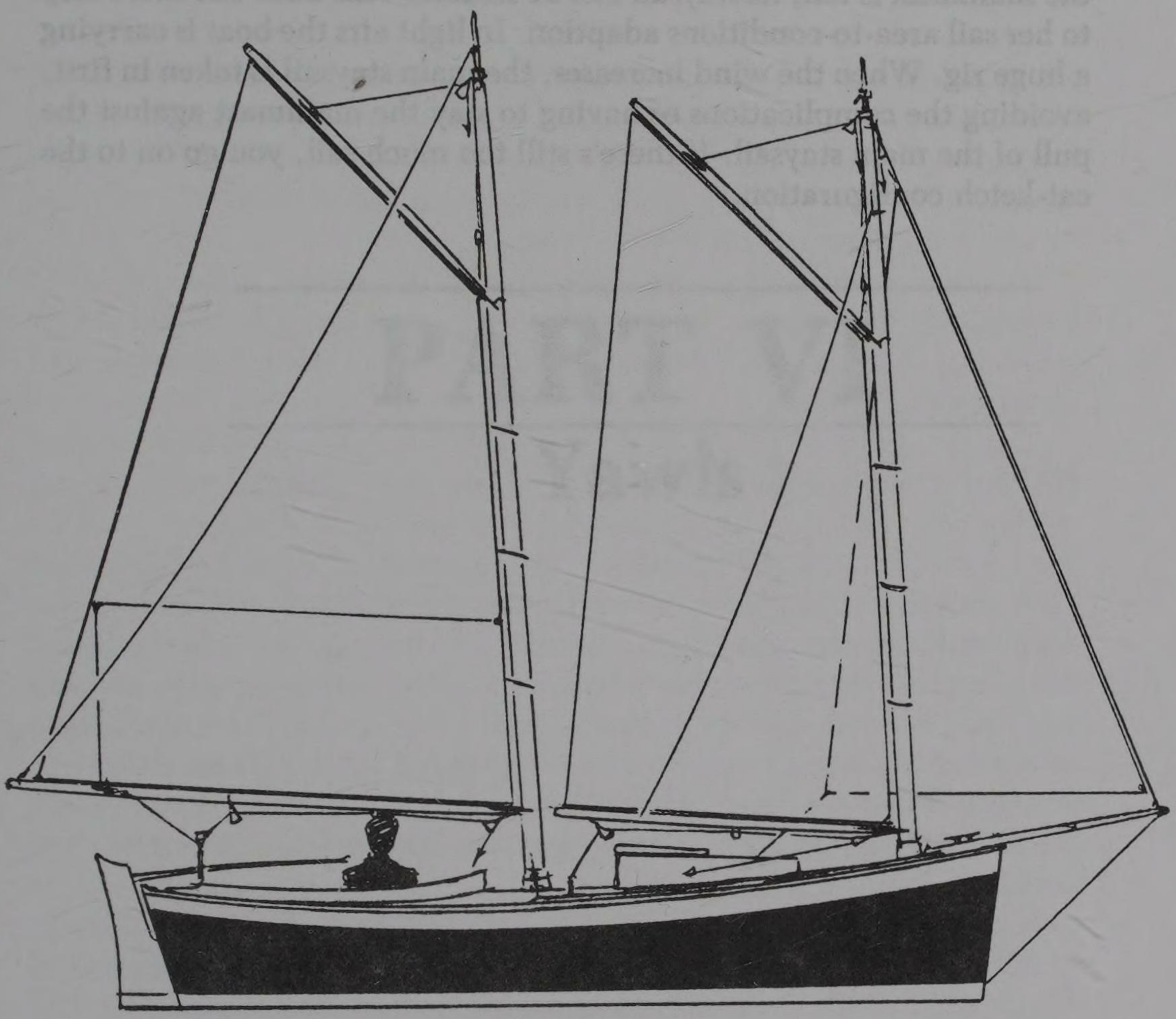
RIG 71 Cat-schooner with jib

I discussed the one-masted equivalent of this in Rig 27 and there condemned it. The cat-yawl and cat-ketch versions are not very satisfactory either. In a cat-schooner, however, there's more point to it.

It's done for the same reason as in the cat proper, to allow helm balance with a bigger, longer-boomed, mainsail. The trouble with it is: (1) the bowsprit can barely hook its toe on the short deck ahead of the mast, making it hard to secure solidly; and (2) the flex of the unstayed foremast. With a lot of wire bowsprit rigging and backstays on the foremast the jib can be made to stand, but the usual reason, Rig 70 notwithstanding, for adopting a cat-type rig is to do away with such gear.

In a cat-schooner you do what you conveniently can to give the jib stiff support at head and tack. Ideally, the sag of the jib will become unacceptable just when the boat is seen to be carrying too much sail for the wind strength. Then the jib is taken in, and at the same time a deep reef is tied down in the mainsail. If the rig is proportioned happily, the boat will sail on, with her full foresail, as a snug cat-ketch. There will be perfect helm balance, both sails self-trimming in stays, and no problems making her sails hold their shape.

A corollary of this point is that the jib ought to be easy and quick to take in. If it's hanked to a stay as the cartoon suggests, the bowsprit ought to be strong enough for a heavy man to straddle, with his feet hooked around the bobstay, in complete confidence that it won't break down under him when the boat pitches. Since that involves a heavy spar hanging on the bow of a little boat, it usually would be better to set the jib flying and haul it out to the bowsprit end with a tack



downhaul. Then, as with the cat-sloop, the jib can be hauled back into the lee of the foresail to be smothered.

The temptation to try to rig the jib to be hauled all the way aft where it would be taken into the cockpit, is best resisted. The gear to do that would have notable snarl potentiality.

There's no reason not to give a boat like this a main staysail as well as a jib, other than the cost of the extra sail and its running gear. A schooner so rigged can set a lot of sail low, and can be fast reaching.

The main staysail, being amidships, doesn't upset the balance. And as the mainmast is tall, its staysail can be sizable. This adds one more step to her sail area-to-conditions adaption. In light airs the boat is carrying a huge rig. When the wind increases, the main staysail is taken in first, avoiding the complications of having to stay the mainmast against the pull of the main staysail. If there's still too much sail, you go on to the cat-ketch configuration.

PART VI

Yawls

RIG 72 Jibheaded with three-quarter foretriangle

I was brought up to quote confidently that a yawl had her mizzen abaft the rudderpost while a ketch had hers forward of it. We played games with odd consequences of this definition and argued with people who'd been taught that the difference was whether the mizzen was forward or abaft the after end of the waterline.

This is all arbitrary. The functional difference is that a ketch depends on her mizzen for a significant part of the power that drives the boat, whereas in a yawl the mizzen serves as a balancing and maneuvering sail.

The rig shown is on typical 1930s proportions, and it had another motive. The Cruising Club rule in those years allowed yawls to set mizzen staysails with no increase in their rating. A mizzen staysail on most yawls is too small for most cruising people to bother with, but to the racers it was "free" and seconds per mile mattered to them. A great many racing boats were rigged as yawls so the rig was fashionable.

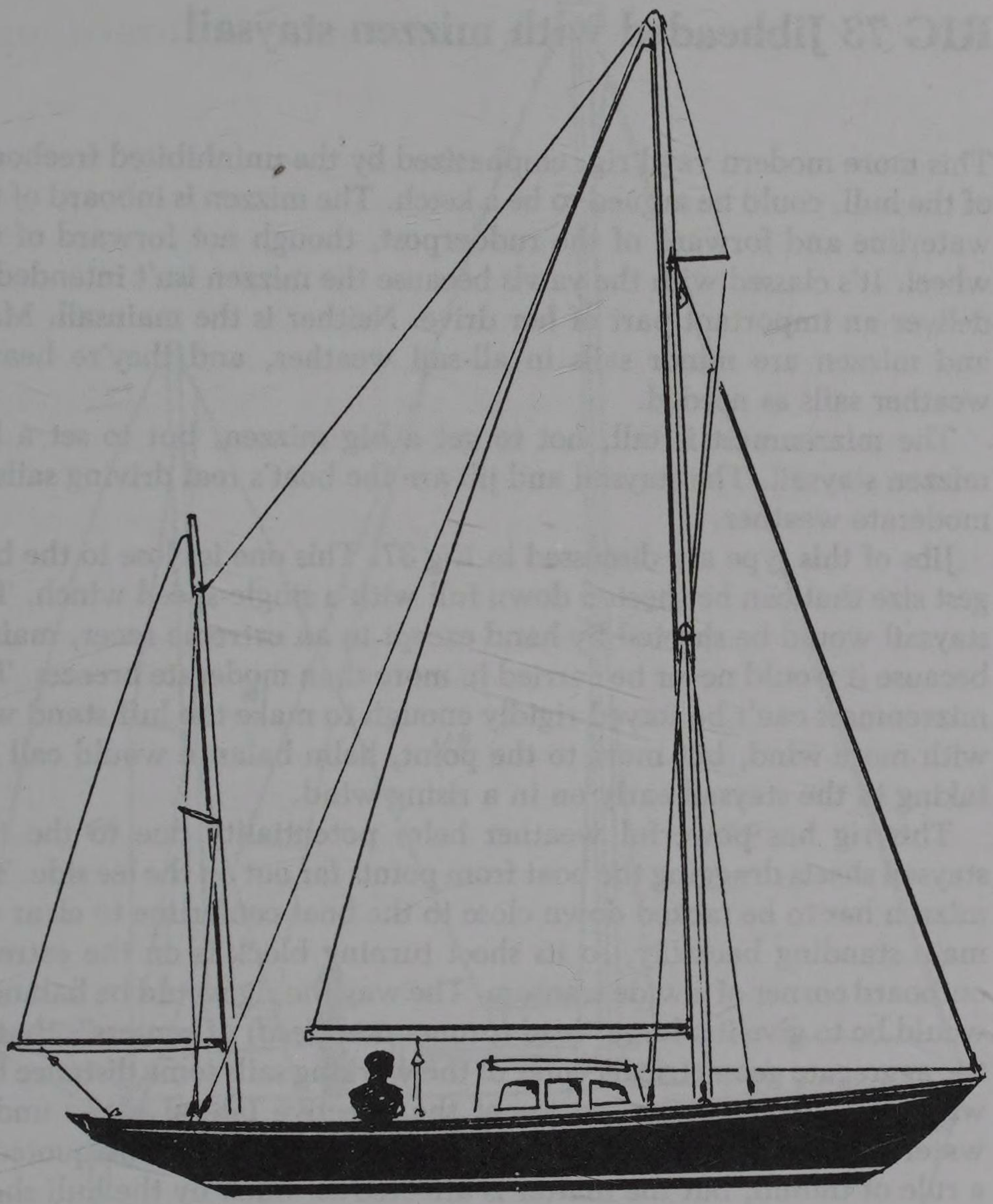
It's a good rig in any case. Mainsail and headsails can be as big and powerful as those of a sloop with full sail, more so when they both have to shorten sail because the yawl can adjust her helm balance better. In heavy weather the yawl can furl her mainsail and drive on with a big jib that's not only a fine airfoil, but has less heeling effect than the mainsail.

If the problem is heavy weather helm rather than an inability to carry sail, the mizzen can be furled without losing an important part of the driving power by reefing the mainsail or merely lugging it. The small mizzen is also handy to steady the boat on an anchor, and for heaving-to with the jib backed.

Lastly, the yawl can be a pretty rig, though if that was all, the sails, spars, and rigging would be expensive ornaments. Putting up a big flag at the stern, 17th century–style, would produce the same visual fillip more economically. Flagstaffs went out of fashion along with boomless mainsails. I'd have thought short booms might bring them back but so far they haven't.

Most yawls of the type and era represented by the cartoon had the mizzen stayed independently of the mainmast, with a pair of shrouds led well forward instead of the springstay to the main masthead. The springstay supports the mizzen better, but if the mast should break the springstay can't be reached to cut the wreckage adrift.

Except for the mizzen's effect on balance and on the arrangements



for shortening sail, a yawl's rig is designed in exactly the same way as that of a sloop — in this case the older type of three-quarter foretriangle sloop discussed in Rig 32. The jumper stays mentioned there, to transfer the pull of the jib to the standing backstay, are shown here.

RIG 73 Jibheaded with mizzen staysail

This more modern yawl rig, emphasized by the uninhibited freeboard of the hull, could be argued to be a ketch. The mizzen is inboard of the waterline and forward of the rudderpost, though not forward of the wheel. It's classed with the yawls because the mizzen isn't intended to deliver an important part of her drive. Neither is the mainsail. Main and mizzen are minor sails in all-sail weather, and they're heavy-weather sails as needed.

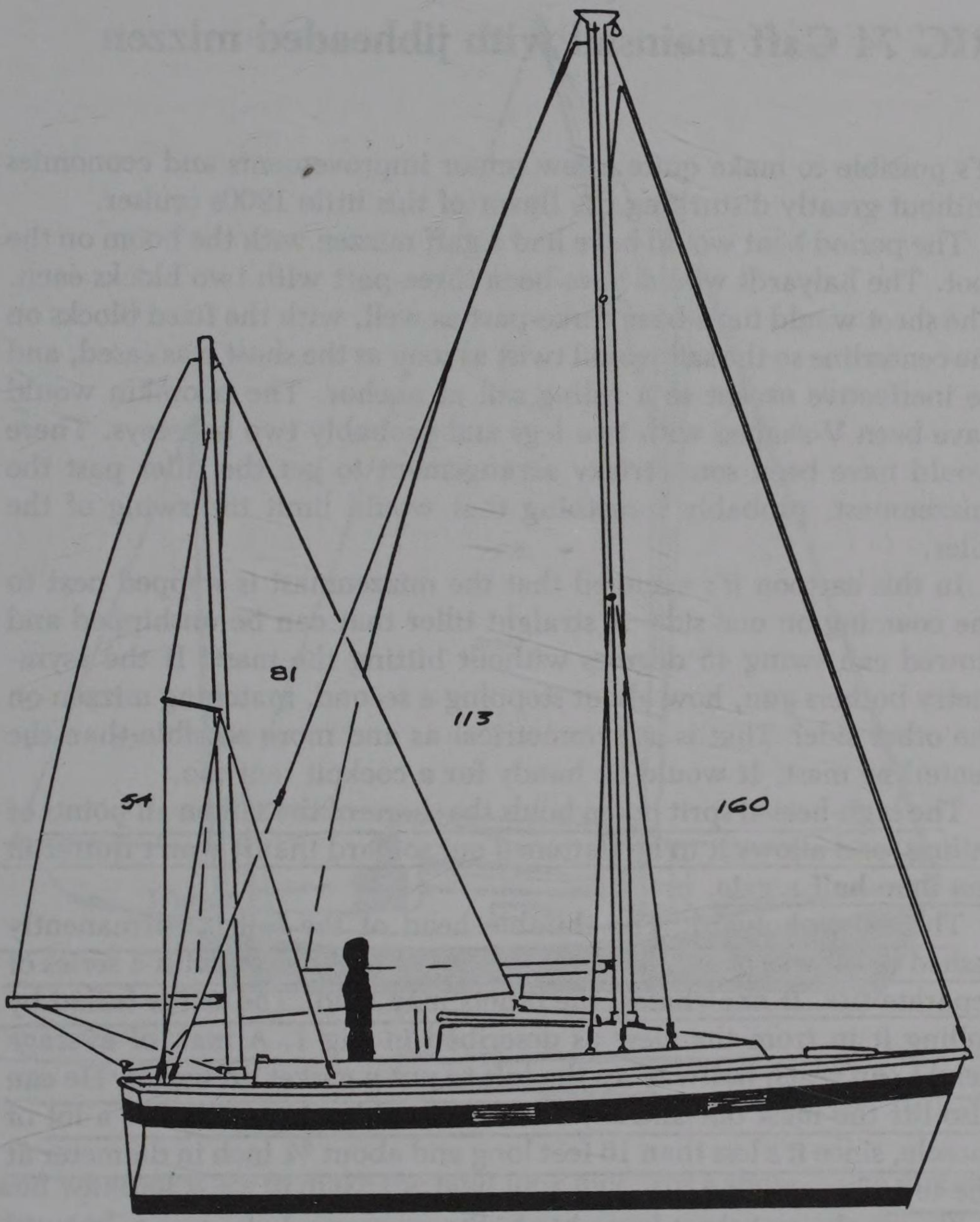
The mizzenmast is tall, not to get a big mizzen, but to set a big mizzen staysail. The staysail and jib are the boat's real driving sails in moderate weather.

Jibs of this type are discussed in Rig 37. This one is close to the biggest size that can be sheeted down full with a single-speed winch. The staysail would be sheeted by hand except in an extreme racer, mainly because it would never be carried in more than moderate breezes. The mizzenmast can't be stayed rigidly enough to make the luff stand well with more wind, but more to the point, helm balance would call for taking in the staysail early on in a rising wind.

This rig has powerful weather helm potentiality due to the two staysail sheets dragging the boat from points far out on the lee side. The mizzen has to be tacked down close to the boat centerline to clear the main standing backstay, so its sheet turning block is on the extreme outboard corner of a wide transom. The way the rig would be balanced would be to give it a large "lead (pronounced *leed*) of centers"; that is, the aggregate geometrical center of the working sails some distance forward of the geometrical center of the effective lateral plane underwater. Twelve to 15 percent of the load waterline used to be quoted as a rule of thumb, but the matter is affected so much by the hull shape and the type of keel that the rule can easily embarrass a designer. For instance, a hull with a shallow body, a long waterline, and a deep and narrow fin keel wants less lead relative to the waterline than one with a broader fin and deeper hull body.

Whatever is decided would be figured without the mizzen staysail. This would (it would be hoped) make sure that the boat wouldn't carry lee helm in light weather. About the time the staysail would start to induce so much weather helm that the rudder across the boat would be stopping her more than the staysail is pulling her, it'd be time to take it in. At that same time, the staysail would be stretching the mizzen shrouds and slacking its luff.

All this needs experience (which can be vicarious) or luck, if it's to



come out just so. When it does, this can be a fast rig over a wide range of wind strengths, if it's built strong enough to stand the tensions needed to make it work.

It's an expensive rig for obvious reasons. It also needs a numerous and skilled crew to drive it hard, though not to cruise it in a leisurely way.

RIG 74 Gaff mainsail with jibheaded mizzen

It's possible to make quite a few minor improvements and economies without greatly disturbing the flavor of this little 1900s cruiser.

The period boat would have had a gaff mizzen with the boom on the foot. The halyards would have been three-part with two blocks each. The sheet would have been three-part as well, with the fixed blocks on the centerline so the sail would twist as soon as the sheet was eased, and be ineffective except as a riding sail at anchor. The boomkin would have been V-shaped with two legs and probably two bobstays. There would have been some tricky arrangement to get the tiller past the mizzenmast, probably something that would limit the swing of the tiller.

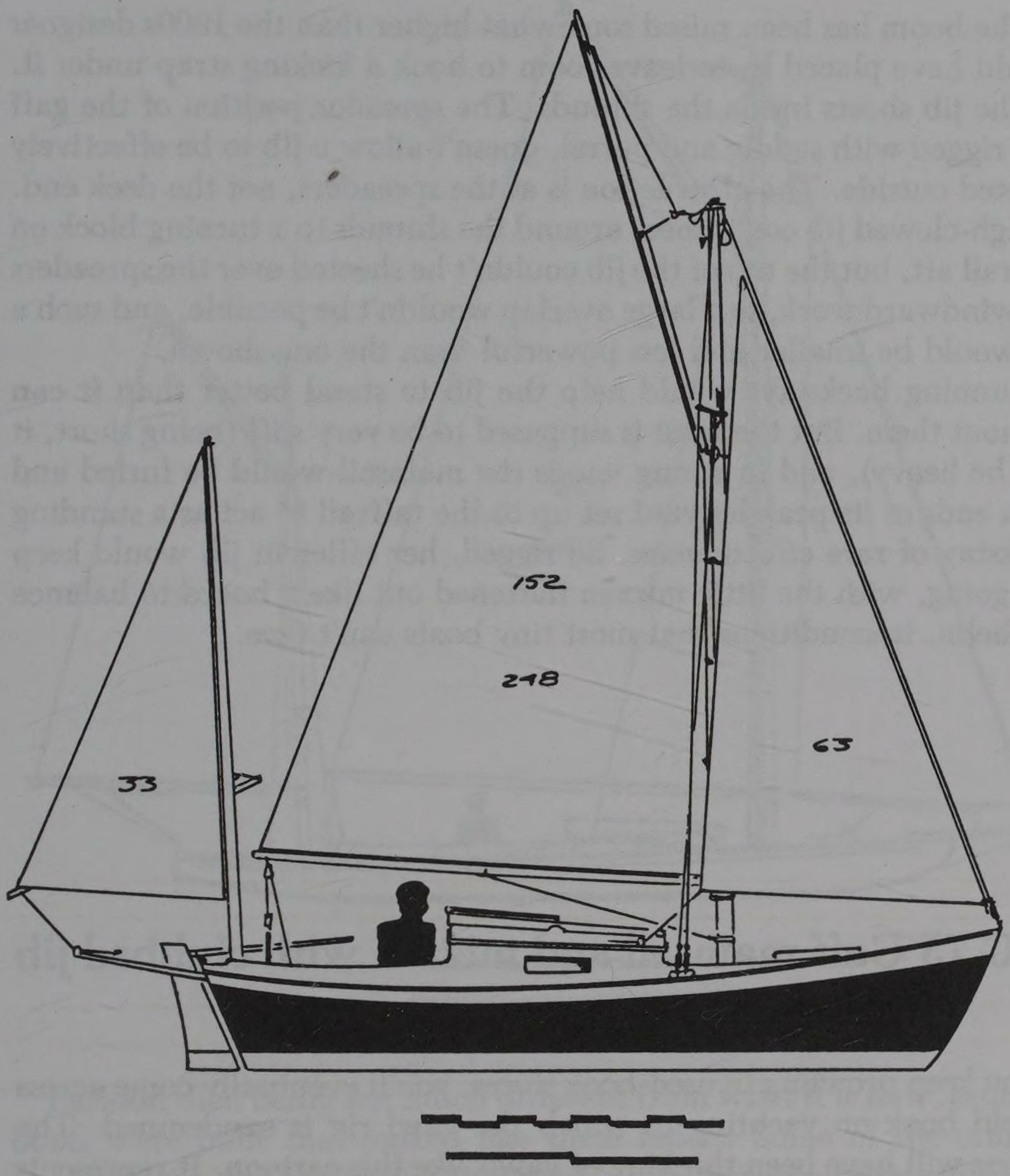
In this cartoon it's assumed that the mizzenmast is stepped next to the coaming on one side. A straight tiller that can be unshipped and stowed can swing 45 degrees without hitting the mast. If the asymmetry bothers you, how about stepping a second, matching mizzen on the other side? That is as symmetrical as and more sensible than the centerline mast. It would be handy for a cockpit tent too.

The high-heeled sprit boom holds the shape of the sail on all points of sailing, and allows it to be flattened out so hard that it won't flutter in less than half a gale.

There's no halyard. The thimble head of the sail is permanently lashed to the masthead. The luff is secured to the mast with a series of separate ties. If one chafes, the others may hold. The sail is furled by rolling it in from the clew as described in Rig 1. A man of average height can reach halfway up the luff to put a gasket around it. He can also lift the mast out and lay it on deck without putting out a lot of muscle, since it's less than 16 feet long and about ¾ inch in diameter at the top.

The single-part sheet has a big bull's-eye instead of a turning block. This is located on the end of a strong but flexible boomkin that can be slid out of its socket and stowed as fast as you can say it.

I have to dwell on this because it took all those years and scores of published designs before any yachtsman or yacht designer (some of the workboat types did know better) noticed that a 33-square-foot sail doesn't have to be treated as though it was 330 square feet. In 1907 an enlightened character wrote a letter to the editor of *Rudder* magazine to this effect. The editor was Thomas Fleming Day, a sensible though sentimental man who went to sea a lot. He said the superfluous blocks



and whatnot were to make the boat look nice "for a show." The matter dropped.

The main halyards can be single-part. The span for the peak halyard allows a lighter gaff, but the advantage is less than might be thought because it puts considerable compression stress on the gaff. You could save two eyesplices by putting the standing end of the peak halyard directly on the gaff, a third of the way up from the lower span attachment as here, with a stiff gaff tapered both ways from that point. It would also allow more margin for error in the peak angle of the gaff. As sketched here, there's too little range of adjustment above the designed angle.

The boom has been raised somewhat higher than the 1900s designer would have placed it, to leave room to hook a kicking strap under it.

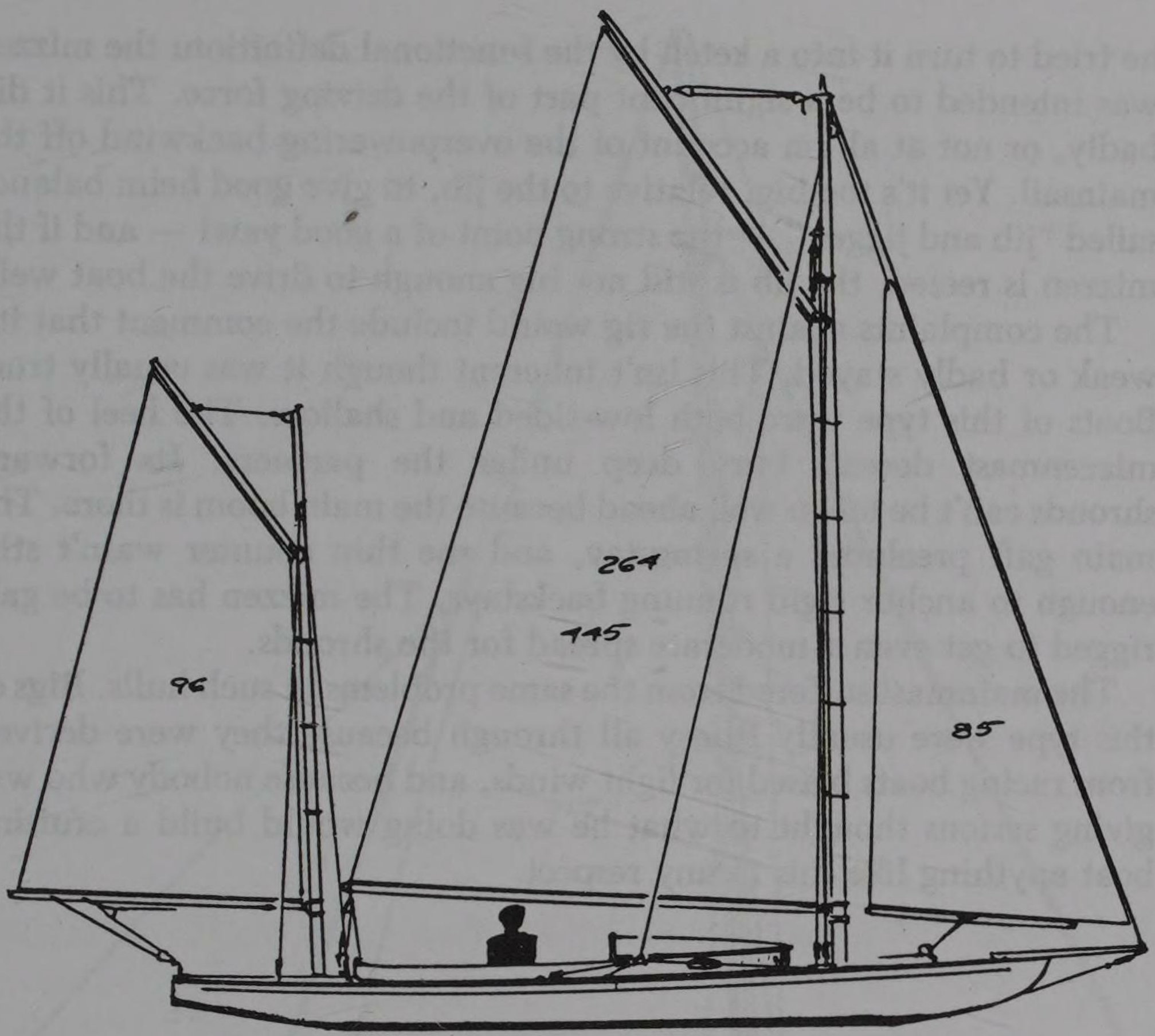
The jib sheets inside the shrouds. The spreader position of the gaff rig, rigged with saddle and parrel, doesn't allow a jib to be effectively sheeted outside. The obstruction is at the spreaders, not the deck end. A high-clewed jib could sheet around the shrouds to a turning block on the rail aft, but the top of the jib couldn't be sheeted over the spreaders for windward work, so a large overlap wouldn't be possible, and such a jib would be smaller and less powerful than the one shown.

Running backstays would help the jib to stand better than it can without them. But the mast is supposed to be very stiff (being short, it can be heavy), and in strong winds the mainsail would be furled and both ends of its peak halyard set up to the taffrail to act as a standing backstay of rare effectiveness. So rigged, her efficient jib would keep her going, with the little mizzen flattened out like a board to balance the helm, in conditions that most tiny boats can't face.

RIG 75 Gaff mainsail and mizzen with clubbed jib

If you keep prowling in used-book stores, you'll eventually come across an old book on yachting in which the yawl rig is condemned. The author will have been thinking of yawls like this cartoon. It represents a cruising version of an early-1900s racing boat, influenced by one of several rating rules that measured the waterline for "length" instead of the deck.

Gradually it was ascertained that it was possible to build a hull that would float on a short belly as little as half the length of the deck, with a long, flat scow hull carried just clear of smooth water. These boats often went very fast even for their deck length, but they would hammer themselves and their crews to bits in a seaway. They behaved best if they were sailed at a big angle of heel, to meet the seas on their bilges instead of their bottoms. Being immensely stiff, it took a huge sailplan to heel them. They were commonly rigged as gaff sloops with long main booms.



Fashion then being not much different from what it is now, cruising boats were built that looked like these racers. Some of the cruisers naturally wanted less demanding rigs than the racers and got yawls like this one.

The fundamental trouble with it is that the rig is too small and too low to heel it as much as it needs to be heeled to damp down the pounding of the flat hull. The mizzen has preempted the base length needed to set the big mainsail the hull needs. The effective sail area is even less than the nominal sail area because the mizzen — the "jigger" so-called in derision — as in any yawl, gives little thrust.

If the hull was shaped differently, with a reasonable forefoot instead of the sloping flat bottom forward, the upright sailing angle would be an advantage, but the rig still would be poorly proportioned. The designer was thinking of a yawl by the formal definition: mizzen stepped abaft the rudderstock and the after end of the waterline. But

he tried to turn it into a ketch by the functional definition: the mizzen was intended to be a significant part of the driving force. This it did badly, or not at all on account of the overpowering backwind off the mainsail. Yet it's too big, relative to the jib, to give good helm balance sailed "jib and jigger" — the strong point of a good yawl — and if the mizzen is reefed, the jib is still not big enough to drive the boat well.

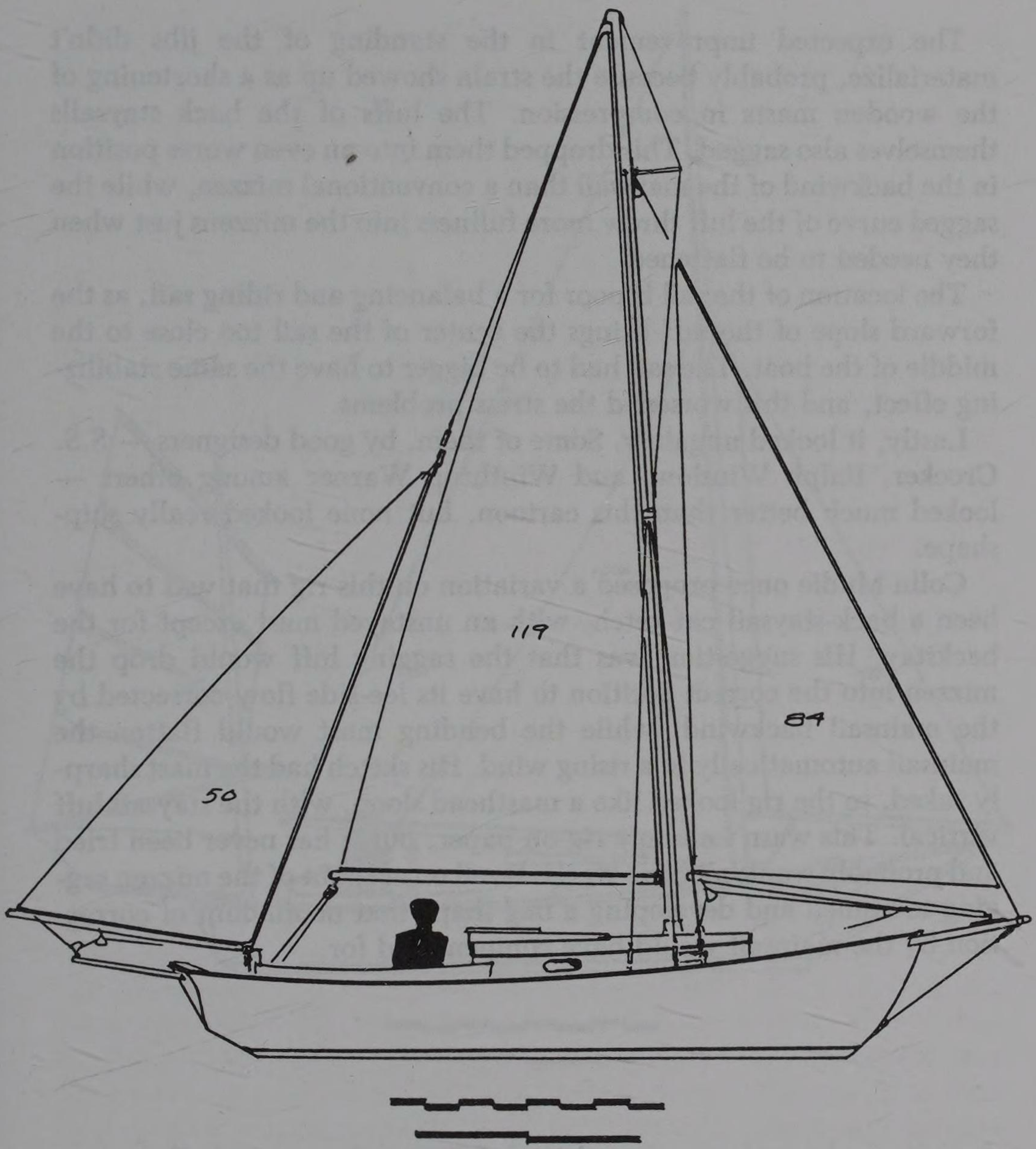
The complaints against the rig would include the comment that it's weak or badly stayed. This isn't inherent though it was usually true. Boats of this type were both low-sided and shallow. The heel of the mizzenmast doesn't bury deep under the partners. Its forward shrouds can't be taken well ahead because the main boom is there. The main gaff precludes a springstay, and the thin counter wasn't stiff enough to anchor rigid running backstays. The mizzen has to be gaff rigged to get even a moderate spread for the shrouds.

The mainmast suffered from the same problems in such hulls. Rigs of this type were usually flimsy all through because they were derived from racing boats biased for light winds, and because nobody who was giving serious thought to what he was doing would build a cruising boat anything like this in any respect.

RIG 76 Back-staysail or Foster rig

C.H.W. Foster was a notable yachtsman in the 1920s and 1930s. He was the rather rare temperamental type who liked the unusual for its own sake, and was always casting around for different approaches to standard problems. This rig is his best-known suggestion. The cartoon is a caricature of it; the drawing didn't come out well and I didn't bother to do it over, since I have no liking for the idea. The rig had a brief vogue and quite a number of boats were built with it or converted to it.

Foster's thought was that since marconi yawls had standing backstays, it would save clutter, weight, and wind resistance to set the mizzen on the backstay and eliminate the mizzenmast. The mizzen would have the clear luff of any staysail, so its aerodynamics ought to be improved. Finally, the load on the backstay would help keep the luff of the jib tight.



The idea worked after a fashion, but after a few years all the boats that had the rig abandoned it, one by one rerigging with conventional mizzenmasts.

One reason was that the sail much increased the load on the mainmast. I heard of no dismastings, but there were complaints of buckling and other signs of overload. At any rate, it became clear that the masts of back-staysail yawls had to be heavier, especially at the top where it mattered most, than those of conventional yawls.

The expected improvement in the standing of the jibs didn't materialize, probably because the strain showed up as a shortening of the wooden masts in compression. The luffs of the back staysails themselves also sagged. This dropped them into an even worse position in the backwind of the mainsail than a conventional mizzen, while the sagged curve of the luff threw more fullness into the mizzens just when they needed to be flattened.

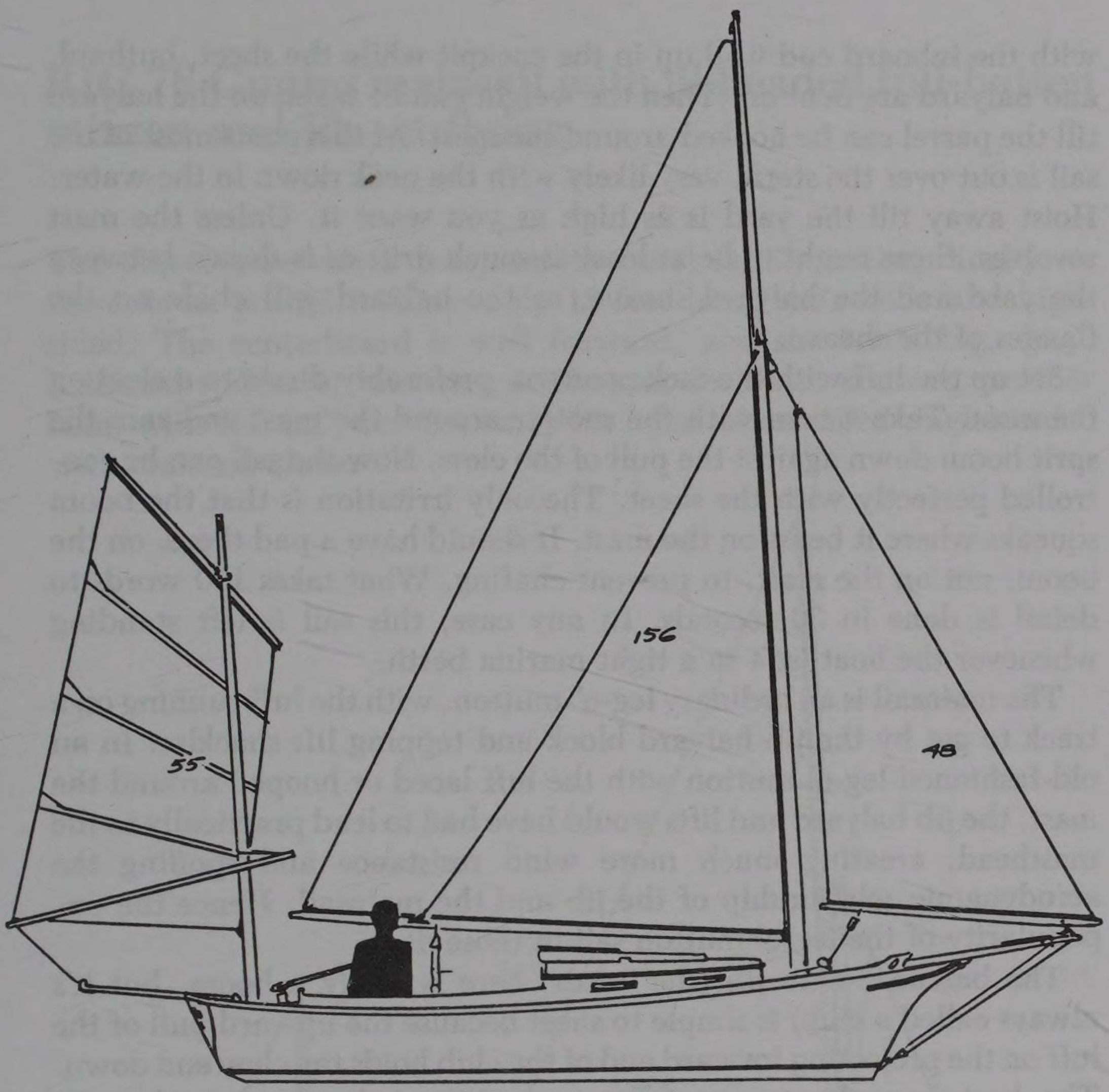
The location of the sail is poor for a balancing and riding sail, as the forward slope of the luff brings the center of the sail too close to the middle of the boat. The sail had to be bigger to have the same stabilizing effect, and this worsened the stress problems.

Lastly, it looked ungainly. Some of them, by good designers — S.S. Crocker, Ralph Winslow, and Winthrop Warner among others — looked much better than this cartoon, but none looked really shipshape.

Colin Mudie once proposed a variation on this rig that was to have been a back-staysail cat-ketch, with an unstayed mast except for the backstay. His suggestion was that the sagging luff would drop the mizzen into the correct position to have its lee-side flow corrected by the mainsail backwind, while the bending mast would flatten the mainsail automatically in a rising wind. His sketch had the mast sharply raked, so the rig looked like a masthead sloop, with the staysail luff vertical. This wasn't an ugly rig on paper, but it has never been tried and probably wouldn't have worked well on account of the mizzen sagging too much and developing a bag shape that no amount of correction by the mainsail would have compensated for.

RIG 77 Jibheaded with balanced-club jib and full-batten standing lug mizzen

Once you decide to put up with the extra first cost of a full-batten mizzen, and the mild nuisance of having to stow the battens, it makes sense to make the mizzen oversized. The bigger it is, within reason, the more positively it works as a riding sail either at anchor or for lying-to, and the sharper maneuvers can be executed with it. The full-batten sail



can be luffed without destructive slatting, so it can always be feathered when it generates too much weather helm. A 55-square-foot sail isn't much more laborious than, say, a 40-square-foot one. The battens have to be made up into a rigid bundle to be stowed, so giving the sail a yard adds nothing much to the stowage problem. The lugsail allows the mast to be shorter, not much of an advantage in a yawl but a slight improvement when it needs to be unstepped.

The lugsail is also somewhat easier to set and take in because the luff doesn't have to be secured to the mast except for hooking up the yard parrel just before hoisting. The furled sail can be laid on the counter

with the inboard end well up in the cockpit while the sheet, outhaul, and halyard are bent on. Then the weight can be taken on the halyard till the parrel can be hooked around the mast. At this point most of the sail is out over the stern, very likely with the peak down in the water. Hoist away till the yard is as high as you want it. Unless the mast revolves, there ought to be at least as much drift as is shown between the yard and the halyard sheave, or the halyard will chafe on the flanges of the sheave.

Set up the luff with the tack pendant, preferably direct to a cleat on the mast. Take a turn with the snotter around the mast and ram the sprit boom down against the pull of the clew. Now the sail can be controlled perfectly with the sheet. The only irritation is that the boom squeaks where it bears on the mast. It should have a pad there, on the boom, not on the mast, to prevent chafing. What takes 150 words to detail is done in 30 seconds. In any case, this sail is left standing whenever the boat isn't in a tight marina berth.

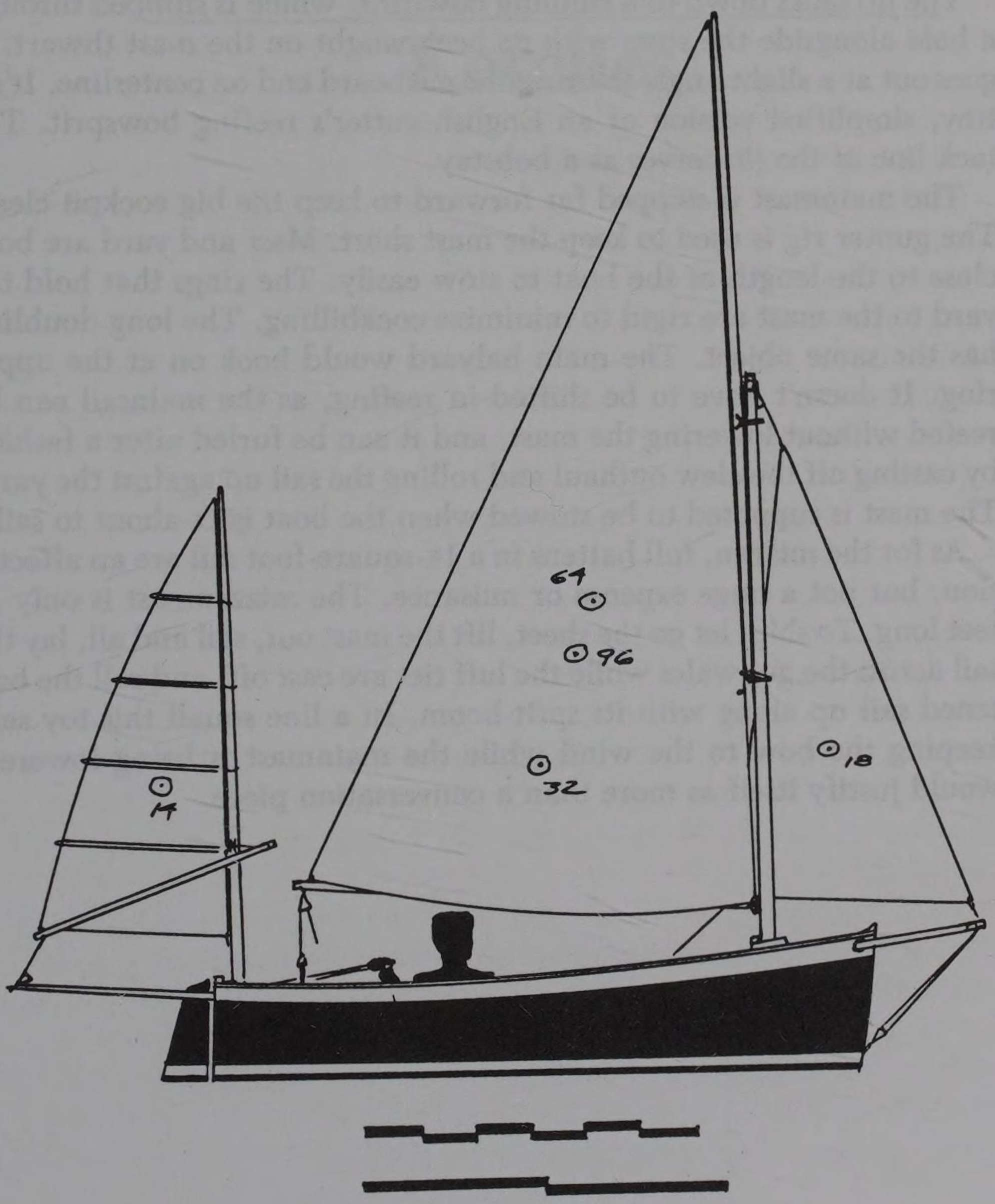
The mainsail is an ordinary leg-o'-mutton, with the luff running on a track to get by the jib halyard block and topping lift shackles. In an old-fashioned leg-o'-mutton with the luff laced or hooped around the mast, the jib halyard and lifts would have had to lead practically to the masthead, creating much more wind resistance and spoiling the aerodynamic relationship of the jib and the mainsail. Hence the unpopularity of the leg-o'-mutton sail in those days.

The balanced-club jib (the "club" here is really a boom, but it's always called a club) is simple to sheet because the upward pull of the luff on the projecting forward end of the club holds the clew end down. The sheet shown has two parts for convenience in leading it back to the cockpit, but since these sails are feather-light to sheet, a single-part sheet would suffice. These balanced sails are easily overbalanced. The pivot point shouldn't be more than one-fifth of the length of the foot from the tack and less is safer. As little as one-eighth will hold the clew down pretty well. If the sail is overbalanced, it won't feather its luff to "split the wind," won't draw well, and may backwind the mainsail.

A balanced jib is even harder to prevent from sagging than other jibs that are set flying. Set on a flexible mast, as here, it can't be carried to any advantage to windward in a strong wind. This boat would work in heavy weather with her mainsail set, mizzen set but usually feathered, and jib stowed. The jib is taken in by paying out the downhaul, which doubles as a bobstay. The sail is lowered, even into the cockpit, in the lee of the mainsail.

RIG 78 Gunter mainsail with jibheaded full-batten mizzen and jib set flying

The object here was a compact (to store) family sailing dinghy, as versatile as possible. While only 12 feet long, she's wide and high-sided. The centerboard is well forward, and she has a big, deep, balanced rudder on the stern so she can deal with a strong weather helm with full sail, but not carry lee helm when sailed singlehanded with mainsail alone.



She's a yawl to make her interesting for a group to sail, with something for everybody to do. The 18-square-foot jib can be set and sheeted by small children, yet it will help her sailing noticeably. She'd balance better if it were bigger, so the combined center of jib and mizzen would be in the same vertical plane as the center of the mainsail, but the jib works better for the benefit of the mainsail as it is.

The jib is set flying and can be taken in and set from abaft the mainmast. It's so small that the short mast can be made stiff enough for the jib to stand fairly well; that is, not bend the mast much in moderate weather. In strong winds it would be stowed, and the mizzen would be feathered for balance.

The jib tacks down to a running bowsprit, which is shipped through a hole alongside the stem with its heel caught on the mast thwart. It goes out at a slight angle to bring the outboard end on centerline. It's a tiny, simplified version of an English cutter's reefing bowsprit. The tack line of the jib serves as a bobstay.

The mainmast is stepped far forward to keep the big cockpit clear. The gunter rig is used to keep the mast short. Mast and yard are both close to the length of the boat to stow easily. The rings that hold the yard to the mast are rigid to minimize cockbilling. The long doubling has the same object. The main halyard would hook on at the upper ring. It doesn't have to be shifted in reefing, as the mainsail can be reefed without lowering the mast, and it can be furled after a fashion by casting off the clew outhaul and rolling the sail up against the yard. The mast is supposed to be stowed when the boat isn't about to sail.

As for the mizzen, full battens in a 14-square-foot sail are an affectation, but not a huge expense or nuisance. The mizzenmast is only 10 feet long. To ship, let go the sheet, lift the mast out, sail and all, lay the sail across the gunwales while the luff ties are cast off, and roll the battened sail up along with its sprit boom. In a line squall this toy sail, keeping the bow to the wind while the mainmast is being lowered, would justify itself as more than a conversation piece.

PART VII

Ketches

RIG 79 Jibheaded

Ketches have the same basic inefficiency as cat-ketches: the mizzen gives poor thrust for its size due to the backwind off the mainsail, while the mainsail and jib are too small for the boat if the mizzen is discounted. Any given hull is likely to be slower with a ketch rig than it would be if rigged otherwise.

The cartoon represents a small, leeboard sharpie. The rig is incongruous in that it's expensive (11 turnbuckles among other items) out of proportion to the hull. The expense is necessary to make the jib stand well, which it must do if the boat is expected to sail well on the wind.

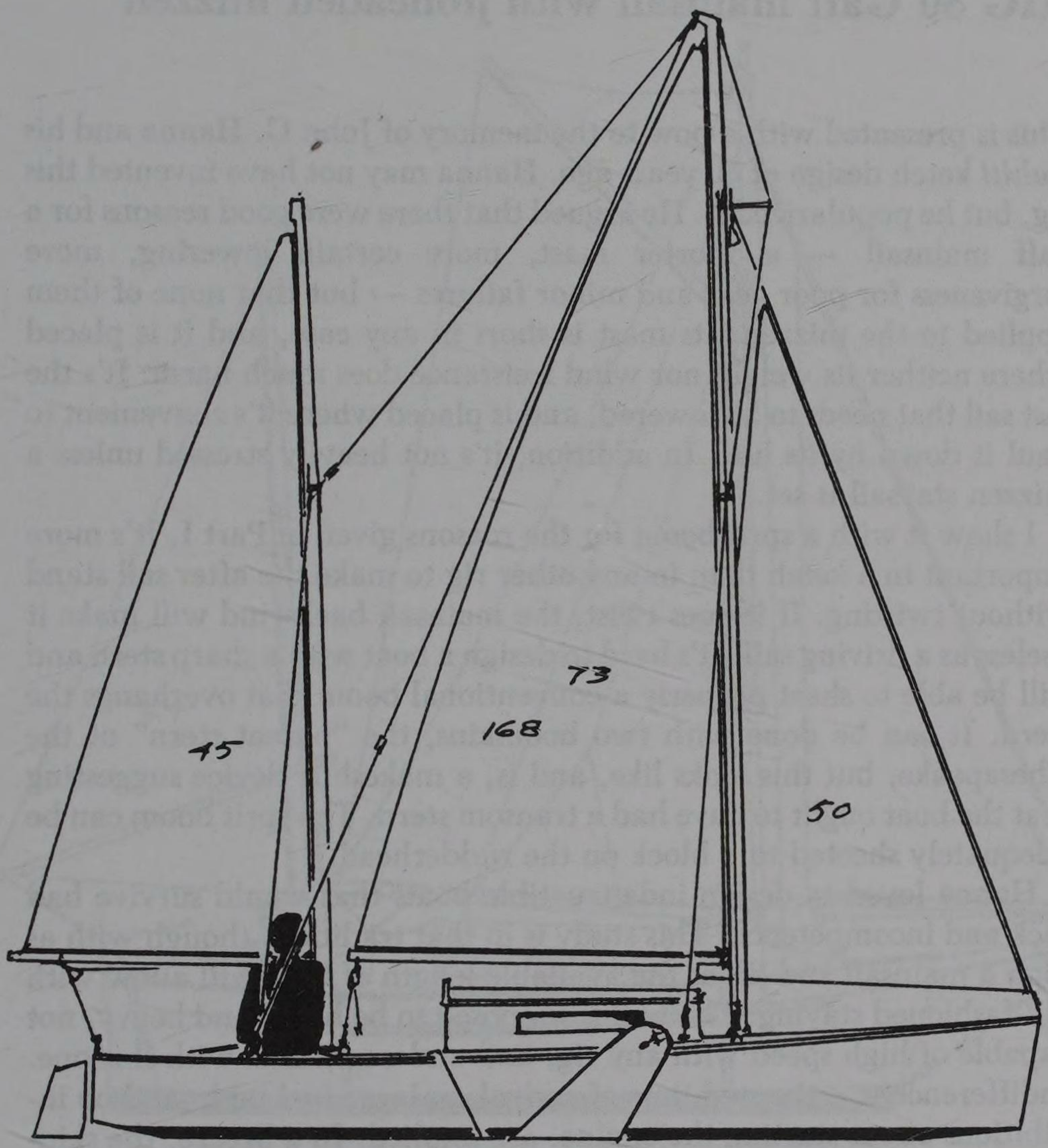
The sharpie hull is, at any rate, structurally stiff enough to stand the necessary tension, its plywood sides forming rigid girders. It would be feasible to set up this rig with the jib holding a fine airfoil and sheeted in good relationship to the mainsail. As in a sloop, the jib can be made to produce much more driving power than the same area added to the mainsail.

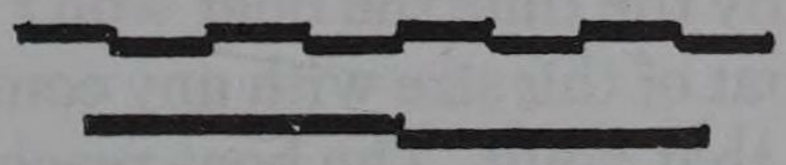
Disregarding the expense, a boat might be rigged this way because she would be faster close-hauled than rigs that have no jib, while the longest mast and the longest boom are shorter and therefore less of a handicap in bad weather than those of a sloop or yawl. The largest sail is also smaller, though in boats as small as this one, the difference isn't important.

Usually, the real reason for selecting it would be that the location of the masts was better suited to the layout of the boat than some other rig. The stayed rig might be picked because the masts can be stepped on deck. For instance, the mainmast could be stepped above, instead of through, a double berth, and the mizzen wouldn't have a thwart across the cockpit for a partner. (Without a thwart for a traveler horse for the mainsheet, the sheet lead would have to be shifted to leeward in tacking to make a mainsail this shape stand without twisting badly, but since the sail is only 73 square feet, the helmsman could do that with one hand.)

In an overpowering wind, the boat would go well with jib and mizzen if the mizzen was started a trifle to ease the weather helm.

One surprising fact about rigs like this is that they behave well with mizzen alone, including before the wind. The mainmast and rigging have a lot of windage, which tends to blow the bow off. If the rudder is powerful, the boat can be made to bear away by easing the mizzen, yet the sail is big enough to bring her to the wind if it's flattened down. She





may even be able to tack fairly reliably. There'll be a lot of leeway, but it's a handy way of keeping the boat under control without much strain on either the boat or the crew.

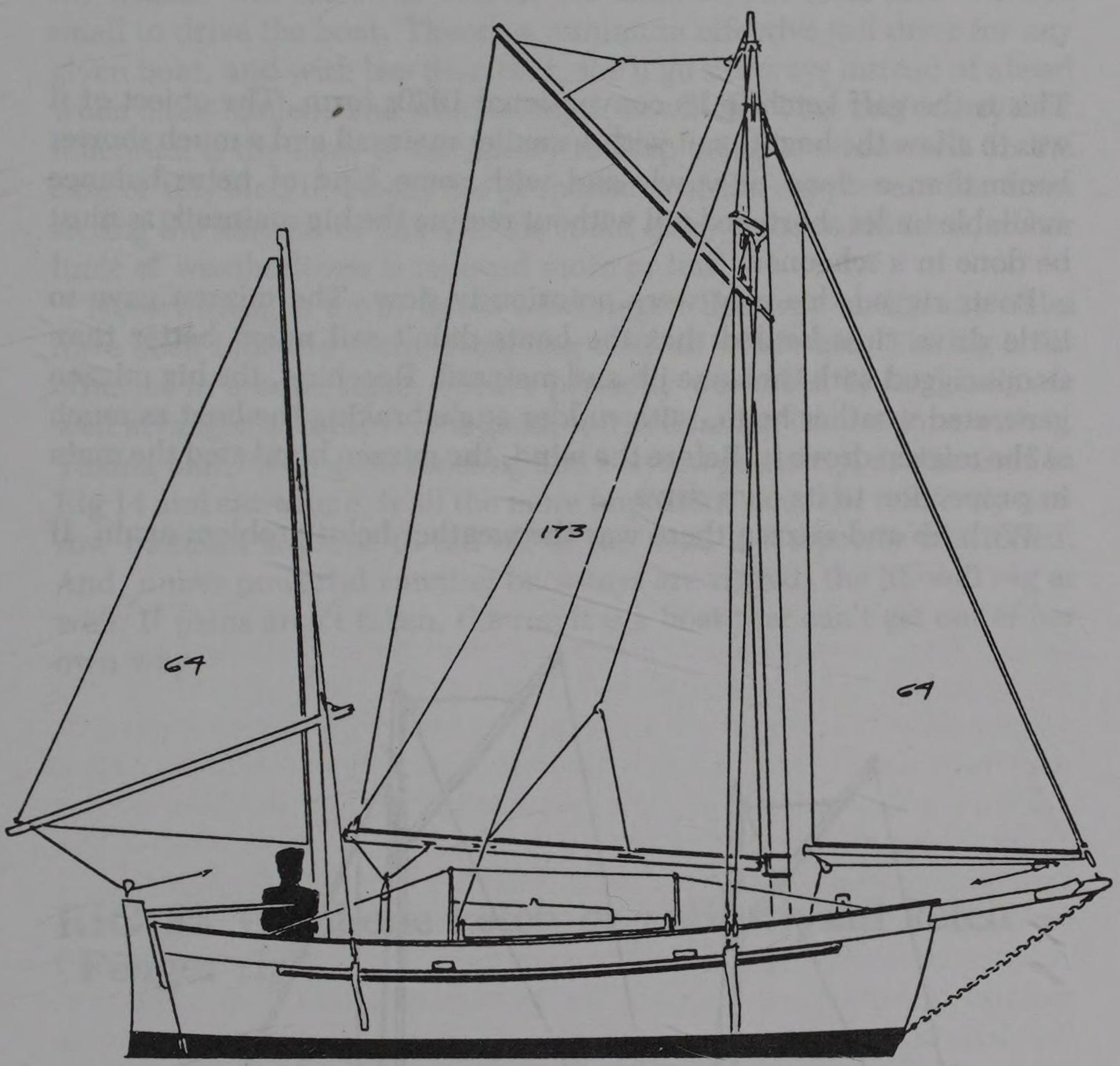
RIG 80 Gaff mainsail with jibheaded mizzen

This is presented with a bow to the memory of John G. Hanna and his *Tahiti* ketch design of 60 years ago. Hanna may not have invented this rig, but he popularized it. He argued that there were good reasons for a gaff mainsail — a shorter mast, more certain lowering, more forgiveness for poor gear and minor failures — but that none of them applied to the mizzen. Its mast is short in any case, and it is placed where neither its weight nor wind resistance does much harm. It's the last sail that needs to be lowered, and is placed where it's convenient to haul it down by its luff. In addition, it's not heavily stressed unless a mizzen staysail is set.

I show it with a sprit boom for the reasons given in Part I. It's more important in a ketch than in any other rig to make the after sail stand without twisting. If it does twist, the mainsail backwind will make it useless as a driving sail. It's hard to design a boat with a sharp stern and still be able to sheet properly a conventional boom that overhangs the stern. It can be done with two boomkins, the "patent stern" of the Chesapeake, but this looks like, and is, a makeshift device suggesting that the boat ought to have had a transom stern. The sprit boom can be adequately sheeted to a block on the rudderhead.

Hanna loved to design indestructible boats that would survive bad luck and incompetence. This study is in that tradition, though with as high a mainsail and jib as the available length of base will allow with old-fashioned staying. The hull is supposed to be bulky and heavy, not capable of high speed with any rig, and undercanvased with this one. Indifference to estimated time of arrival, or large fuel tanks and no inhibitions about starting the engine, are implied. In a breeze, the skipper smiles at the straining canvas and listens to the roar of the lee bow wave. He never reefs. By the time the boat won't carry full sail, there's a sea that will stop a boat of this size with any combination of sails. The mainsail is dropped at that point. The boat reaches or heaves-to under jib and mizzen. There's nothing about this rig to disturb the crew's tranquility. No sudden crucial decisions. The skipper of a boat like this wouldn't be likely to take desperate risks to make shelter in worsening weather. He'd be more likely to lay his course for searoom and deep water.

Backstays are shown on the mainmast. These aren't necessary for the security of the mast, but rather to put tension on the jibstay to straighten it, from a big enough angle aft to be effective without great



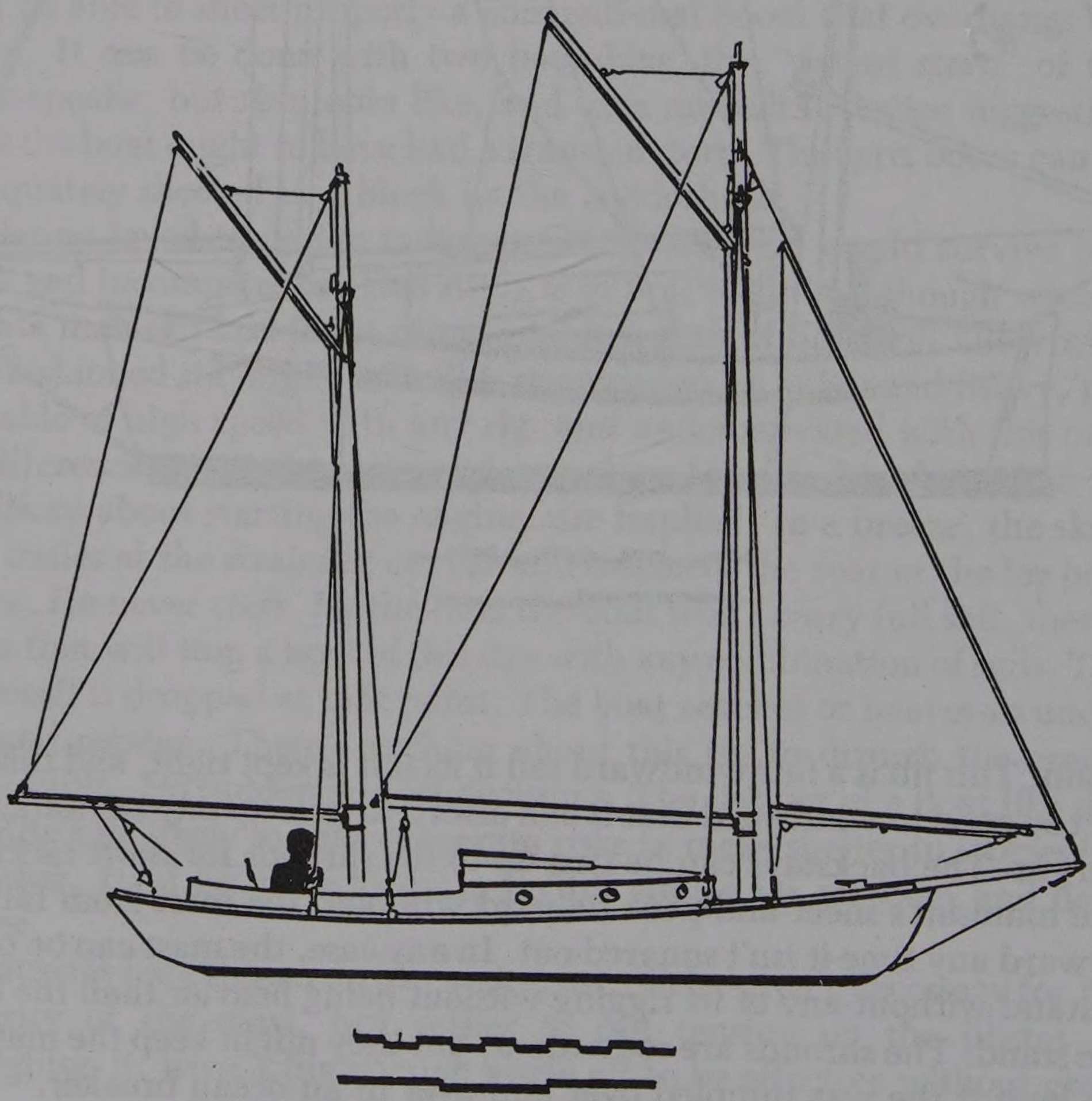
strain. This jib is a fair windward sail if its luff is kept tight, and this rig isn't so good to windward that it can afford to pass up any advantage it can get. The backstays can be tied up to the shrouds for short tacking. The mainsail's sheet and peak halyard will hold the mast from falling forward any time it isn't squared out. In any case, the mast can be built to stand without any of its rigging without being heavier than the hull can stand. The shrouds are redundant, but they might keep the mast in the boat if she was tumbled over and over in an ocean breaker.

RIG 81 Gaff

This is the gaff ketch in its conventional 1920s form. The object of it was to allow the boat to sail with a smaller mainsail and a much shorter boom than a sloop or yawl, and with some kind of helm balance available under shortened sail without reefing the big mainsail, as must be done in a schooner.

Boats rigged this way were notoriously slow. The mizzen gave so little drive close-hauled that the boats didn't sail much better than sloops rigged with the same jib and mainsail. Reaching, the big mizzen generated weather helm, with rudder angle braking the boat as much as the mizzen drove it. Before the wind, the mizzen blanketed the main in proportion to its own drive.

With jib and mizzen there was the weather helm problem again. If



the mizzen was reefed to correct the balance, the total area was too small to drive the boat. There's a minimum effective sail drive for any given boat, and with less than that, she'll go sideways instead of ahead when close-hauled. The wind strength in which a boat can't carry that much sail is the limit of her ability to keep going to windward. In the case of this kind of ketch, the proportions of the rig prevent her from setting the amount of sail that she could carry if she could set it, so her limit of weatherliness is reduced more or less.

Nevertheless, a lot of boats were rigged this way and many miles have been sailed in them, including dead to windward. The rig is inefficient in a basic sense, but it's perfectly workable. If its details are well arranged and the hull is good, spirited sailing can be done with it. Taking pains with good sheeting and halyard geometry, as discussed in Rig 14 and elsewhere, is all the more important since the relatively narrow mainsail is prone to fall off at the head if it's poorly controlled. And, unless powerful running backstays are rigged, the jib will sag as well. If pains aren't taken, the result is a boat that can't get out of her own way.

RIG 82 Wishbone ketch or main trysail ketch — "Fenger rig"

This rig has a long list of theoretical advantages. The standing mizzen staysail, a good windward sail in its own right, is the most important, and it's placed where the draft off it adds to the power of the mizzen by smoothing out the lee-side flow. The mizzen can be stiffly stayed forward, and can be stepped farther forward, which makes it easier to stay aft. The good after-staying, in turn, allows a tight mizzen stay to make the mizzen staysail luff stand straight.

The big masthead jib on the headstay, shown in the cartoon, would be the best driving sail in the rig shown. The forestay is brought well back to make it easier to pass the jib around in tacking. Most wishbone ketches had the forestay on the stem and set a working jib on it. When the mainsail was furled, such a rig could stand well in heavy weather, since the three remaining sails were set low. Most of the experiments

with the rig were done before it was possible to make as long a headstay as the one shown stand well in strong winds. The boat shown could set a storm staysail on her forestay with its clew brought well abaft the mast inside the shrouds.

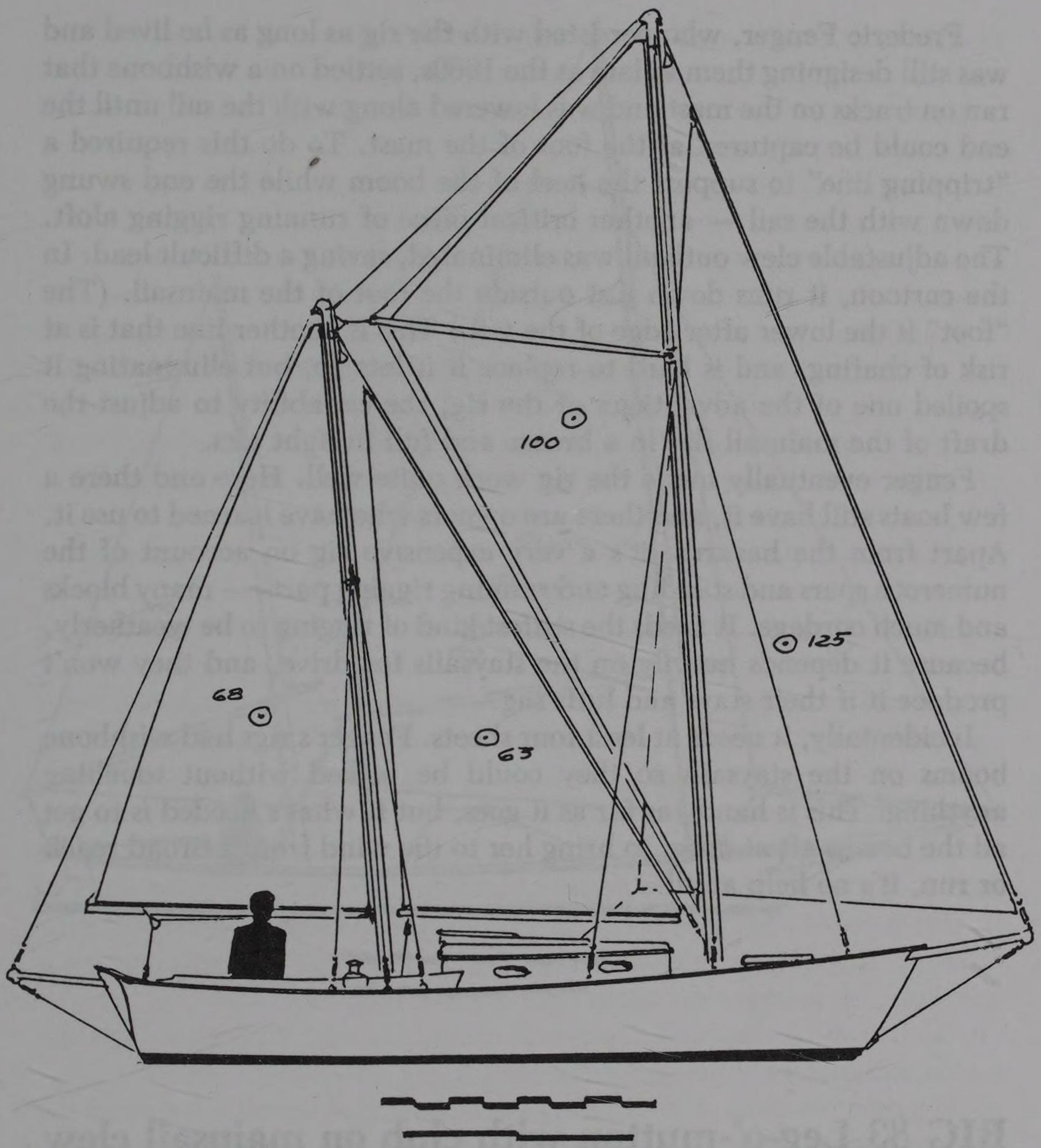
With no sail set on the mainmast, the mizzen and mizzen staysail offer a good motorsailing combination. The location of these sails more or less cancels the tendency of the windage of the mainmast rigging to blow the bow off.

The first experiments with these proportions used a boomless mainsail (or main trysail) sheeted to the mizzen head. Charles E. Nicholson rigged a big three-masted schooner that way. She and all such craft were poor performers. A boomless sail sheeted to the centerline doesn't turn the wind the way it should go. It delivers a powerful heeling effect and not much driving force. A batten across the sail to the clew was an improvement, but it made the sail stand too flat in light airs and bend too much in a breeze.

About 1932 Jasper Morgan designed what would now be called a "maxi-boat" named *Vamarie*. Her main trysail clew was held out by a wishbone boom (most people called it a gaff since it was aloft) with curved arms that didn't cut the shape of the sail. *Vamarie* wasn't the first boat rigged this way, but she was a spectacular success, first to finish in a long string of ocean races. She was fast because she was big and fine-lined, drew about 10 feet of water with a high ballast ratio, had no propeller in her early years, and was sailed hard and skillfully.

Her success led others to try the rig, but there were no more winners. Most of the boats built with the rig were eventually converted to yawls because the drawbacks of the main trysail were never overcome. The most obvious of these was the sheet lead high aloft, where a jam at the block couldn't be cleared quickly.

The next problem was what to do with the wishbone boom when the mainsail was taken in. In *Vamarie* it was left where it was, supported by a standing topping lift to the masthead. It was actually two booms, each with its own gooseneck on the mast, connected by a yoke at the clew end. To lower all this wasn't practical. Besides, at first glance it looked rather neat when the boom was sheeted tight to the mizzen masthead. There was an impression that the two masts and the boom formed some kind of girder. In fact, there was always some play. The biggest boat ever built with the rig was dismasted when her main trysail sheet chafed and let go. The wishbone swung forward and bent the spreaders; then it broke a vang with which the crew were trying to control it. The tail of the vang whipped around the top of the mizzen-



mast with enough slack to allow the boom to crash back and forth on the roll until the top of the mast broke off. It then flailed the broken masthead into the main rigging — to make it short, the whole rig fell down, wrecking the deck.

Some rigs had the boom pivoted to stow vertically down the mast with a running topping lift. It had to pass the mizzen stay in lowering, at least a momentary hazard.

Frederic Fenger, who persisted with the rig as long as he lived and was still designing them as late as the 1960s, settled on a wishbone that ran on tracks on the mast and was lowered along with the sail until the end could be captured at the foot of the mast. To do this required a "tripping line" to support the heel of the boom while the end swung down with the sail — another critical piece of running rigging aloft. The adjustable clew outhaul was eliminated, saving a difficult lead. In the cartoon, it runs down just outside the foot of the mainsail. (The "foot" is the lower after edge of the sail.) This is another line that is at risk of chafing, and is hard to replace if it lets go, but eliminating it spoiled one of the advantages of the rig, the capability to adjust the draft of the mainsail flat in a breeze and full in light airs.

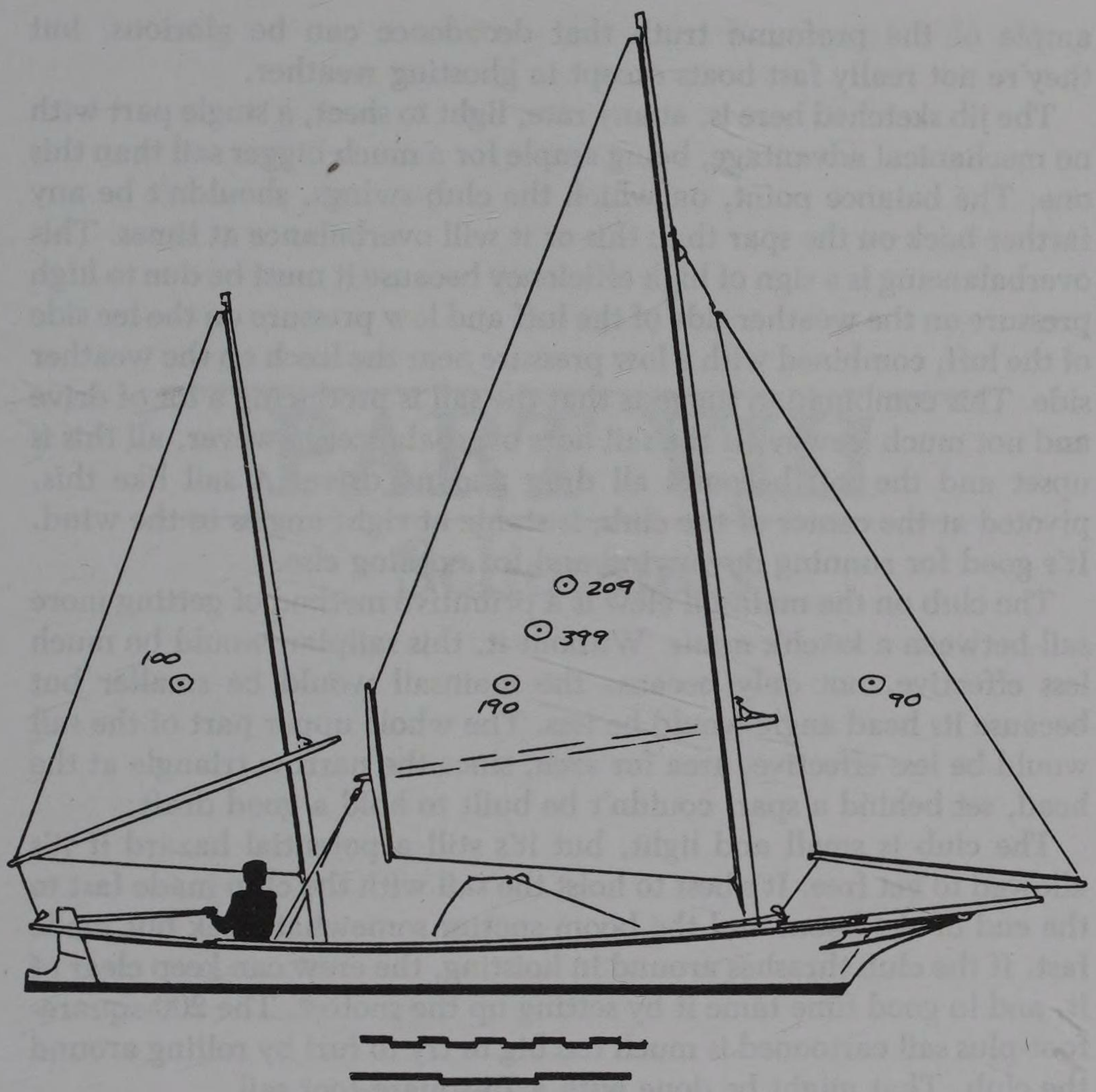
Fenger eventually made the rig work quite well. Here and there a few boats still have it, and there are owners who have learned to use it. Apart from the hazards, it's a very expensive rig on account of the numerous spars and standing and running rigging parts — many blocks and much cordage. It needs the stiffest kind of rigging to be weatherly, because it depends heavily on the staysails for drive, and they won't produce it if their stays and luffs sag.

Incidentally, it needs at least four sheets. Fenger's rigs had wishbone booms on the staysails so they could be tacked without touching anything. This is handy as far as it goes, but if what's needed is to get all the booms aft at once, to bring her to the wind from a broad reach or run, it's no help at all.

RIG 83 Leg-o'-mutton with club on mainsail clew and balanced-club jib

This Chesapeake-log-canoe type had a cat-ketch for an ancestor. In that ancestor, the mizzen was part of the system for reducing sail. She had a third mast step, well aft of the mainmast step here. Either mast could be stepped there, reducing from two sails, to one large sail, to one smaller sail.

The jib was a later addition: anything to get a little more sail in a calm. If you must set a staysail-type sail on an unstayed mast (which is



by way of being a contradiction in terms), the balanced-club sail is best. The angle of the halyard and the way the stress is distributed along the club allow the sail to maintain a useful shape with less tension than any other sail set flying. However, it still needs more than the bendy mast can hold in wind of any strength. A jib like this does more harm than good, to windward, in even a moderate breeze. It's taken in and the mizzen feathered by setting up hard on its snotter and starting its sheet, to keep the steering balanced.

The racing log canoes do carry their jibs in a breeze, but they have some staying, and, in any case, are out more for spectacle than speed. The big ones, with multiple hiking boards and trick topsails, are an ex-

ample of the profound truth that decadence can be glorious, but they're not really fast boats except in ghosting weather.

The jib sketched here is, at any rate, light to sheet, a single part with no mechanical advantage, being ample for a much bigger sail than this one. The balance point, on which the club swings, shouldn't be any farther back on the spar than this or it will overbalance at times. This overbalancing is a sign of high efficiency because it must be due to high pressure on the weather side of the luff and low pressure on the lee side of the luff, combined with a low pressure near the leech on the weather side. This combination suggests that the sail is producing a lot of drive and not much leeway. If the sail does overbalance, however, all this is upset and the sail becomes all drag and no drive. A sail like this, pivoted at the center of the club, is stable at right angles to the wind. It's good for running downwind and for nothing else.

The club on the mainsail clew is a primitive method of getting more sail between a ketch's masts. Without it, this sailplan would be much less effective, not only because the mainsail would be smaller but because its head angle would be less. The whole upper part of the sail would be less effective, area for area, since the narrow triangle at the head, set behind a spar, couldn't be built to hold a good draft.

The club is small and light, but it's still a potential hazard if it's allowed to get free. It's best to hoist the sail with the club made fast to the end of the boom and the boom snotter somewhat slack but made fast. If the club thrashes around in hoisting, the crew can keep clear of it, and in good time tame it by setting up the snotter. The 200-square-foot-plus sail cartooned is much too big to try to furl by rolling around the club. That might be done with a 75-square-foot sail.

This is a cheap rig for its power. Eight spars, counting bowsprit and boomkin, cost something, but there's a big economy in running rigging, both cordage and blocks, over the usual ketch of this area. There's no standing rigging at all, which means not only no turnbuckles, terminals, tangs, or wire, but no chainplates or complications of hull and deck structure to carry the stresses. It doesn't even need travelers or horses. Compare this with the wishbone ketch, Rig 82.

The rig works best in hulls that are long for their weight. This is true of all multi-masted rigs to some extent, but especially so if you're trying to keep it simple.

PART VIII

Schooners

RIG 84 Baldheaded gaff rig

Early schooners were like the cat-schooner discussed in Rig 71. The original ancester of the breed was a cat-schooner with two spritsails, or even lateens if you go back far enough.

The "modern," 1890s rig of this cartoon was part of a 100-year evolution that eventually improved the rig out of existence, as I'll show in a couple of later essays.

The traditional advantages of the rig, as it developed, were, first, that the largest sail was aft where it could be hoisted first and lowered last without making the vessel charge around her anchor. This heavy sail could be left standing for long periods in moderate weather, and didn't have to be furled every time the anchor was let go: important to a coaster who had to anchor frequently and was usually shorthanded.

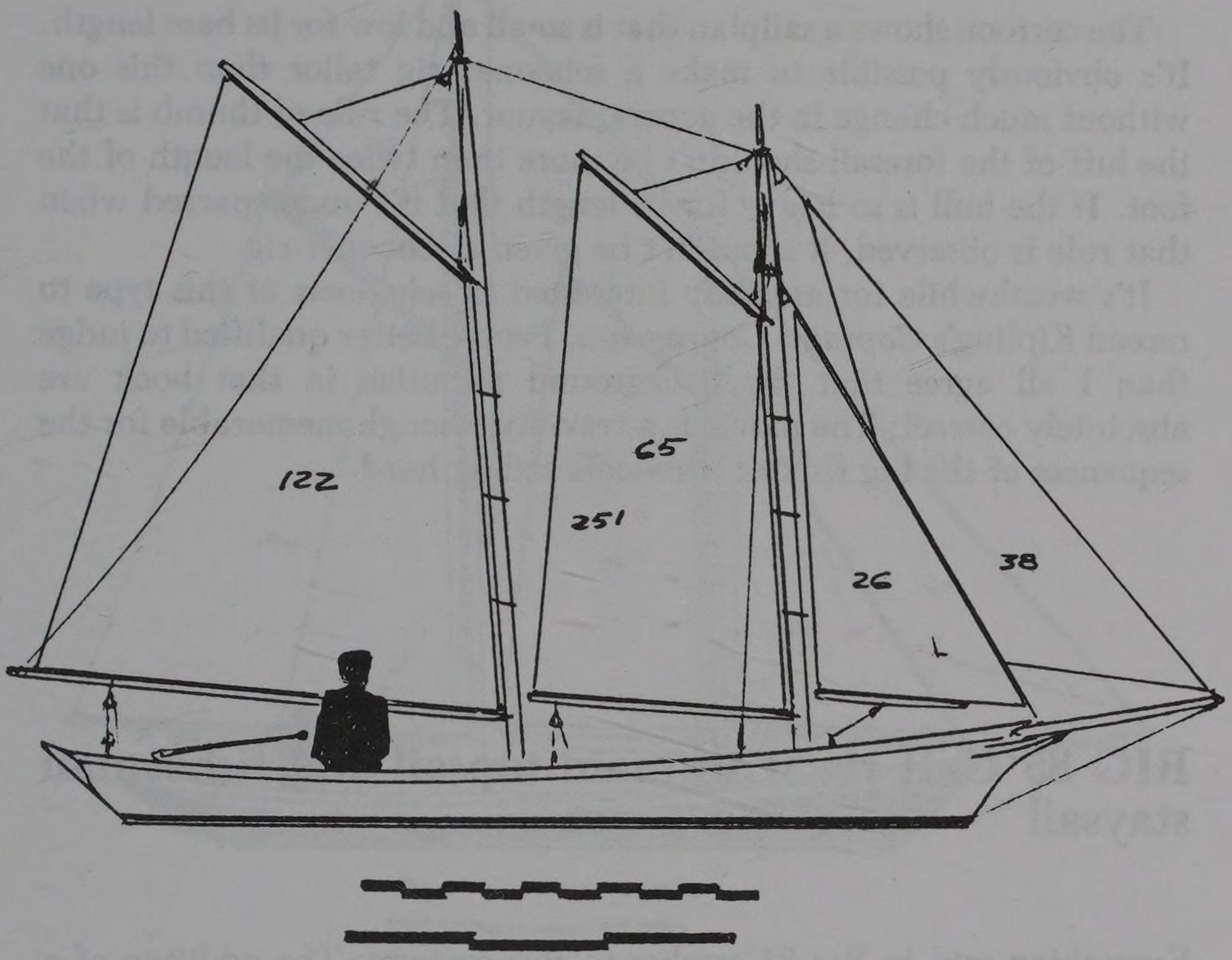
Second, the sails are progressively smaller and closer together as you go forward. This is aerodynamically good. The flow off each sail, if they're all set right, sheeted right, and can be made to hold their shape, smooths out the airflow along the lee side of the next sail aft. That's the reason for the two headsails. A single jib to the bowsprit end would be too far from the foresail to help its airflow much. So the small forestaysail is set as a leading-edge slat for the foresail, and the jib is added for its own sake.

In heavy weather, the jib is furled since the rig isn't stiff enough to keep its luff tight. The forestaysail continues to have a good effect on the foresail. A deep reef is pulled down in the mainsail. The result is a snug rig, well balanced, good for maneuvering since there are still sails at each end of the boat, imposing little strain on the hull.

In a gale the schooner lies under her foresail, sheeted flat and reefed if necessary, with her helm lashed down hard. She'll usually lie steadily and make a square drift. The furled mainsail has some effect as a riding sail.

A schooner's mainsail has the same requirements as that of a sloop, gaff, jibheaded, or whatever, though it's not as powerful because the foresail isn't as well shaped or well located to help it as is a sloop's jib.

The foresail is the weak link. Its boom is usually shorter than it should be for the height of the sail. If a schooner is to be even respectably close-winded, and if she's to be really good on a reach, the foresail sheet has to be effective in holding the boom down. The traveler horse should be extra-long, with adjustable stops, and no part of the sheet should lead over to the weather side. In the cartoon the foresail is only



65 square feet. I didn't have the heart to take the sheet in to the foremast as I'd do in a bigger schooner. With this little sail it'd be best to have the standing end of the sheet on the horse, and shift the fall to a cleat on the lee side for each tack. Reaching, the foresail should have guys and kicking straps ready when needed, whatever it takes to pull the boom down, because that's what it takes to flatten the head of the sail. And if the head sags, the schooner is dead.

As for the headsails, again they're like a sloop's or cutter's, but easier to stay and sheet because they're smaller, which is one reason for having a schooner instead of a cutter. It's usually not hard to get the forestay and the jib's luff set up tight enough for good windward work. Since a schooner's foresail isn't effective before the wind, the foremast shrouds can be brought well aft, or the running backstays can be set up to a point that will allow the close-hauled foresail to clear them.

A schooner's foremast ought to be at least as big in diameter as the mainmast, regardless of the relative lengths, and it should have a long step or otherwise be designed to stand the compression put on it in tightening the headsail luffs.

The cartoon shows a sailplan that is small and low for its base length. It's obviously possible to make a schooner rig taller than this one without much change in the general layout. The rule of thumb is that the luff of the foresail shouldn't be more than twice the length of the foot. If the hull is so heavy for its length that it's undersparred when that rule is observed, it shouldn't be given a schooner rig.

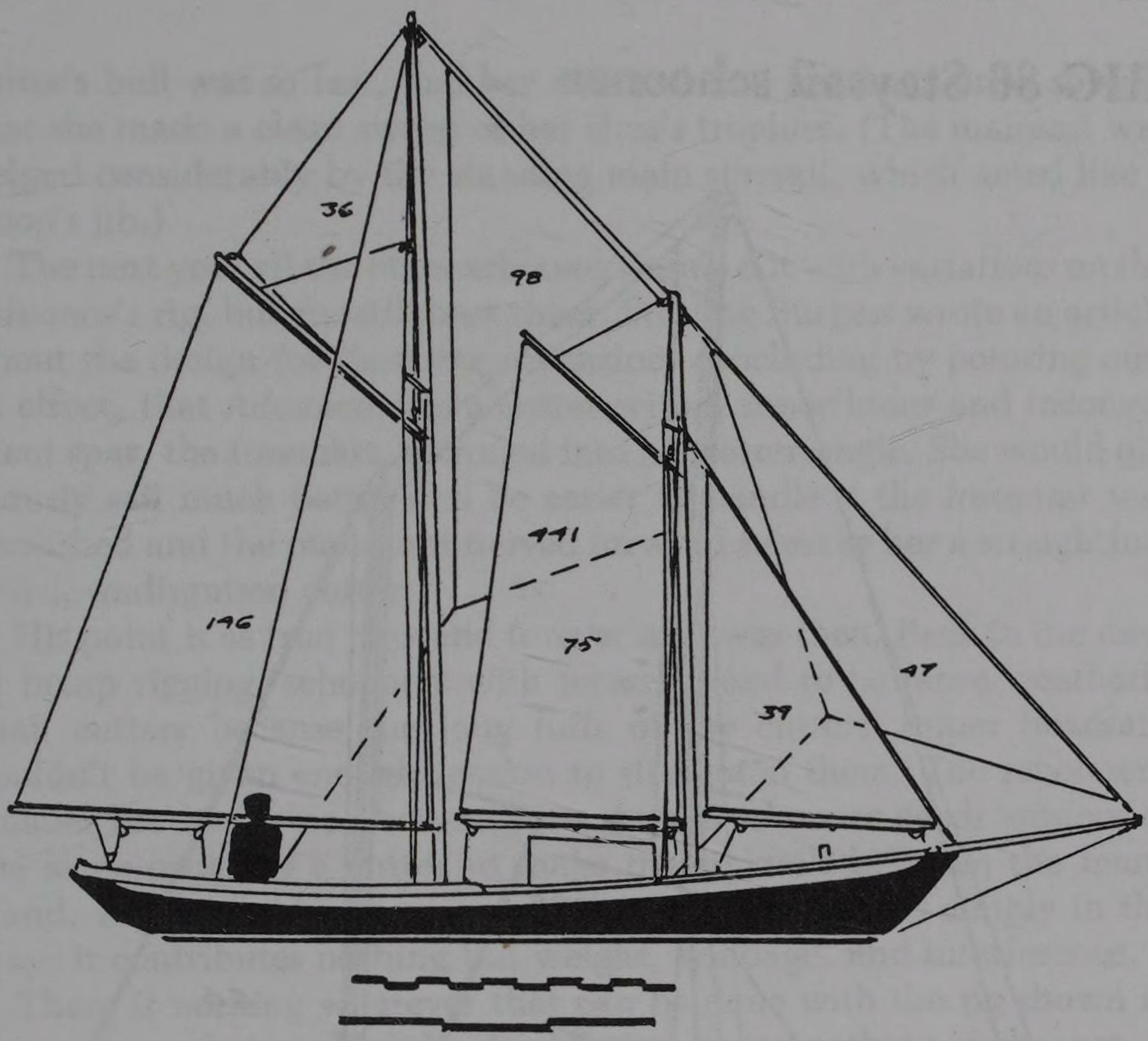
It's worthwhile for anybody interested in schooners of this type to reread Kipling's *Captains Courageous*. People better qualified to judge than I all agree that the background minutiae in that book are absolutely correct. The movie is a travesty, though memorable for the sequences of the big fishing schooners sailing hard.

RIG 85 Gaff rig with main topsail and fisherman staysail

Everything said in Rig 84 applies to this cartoon. The addition of a main gaff topsail is simplified in this small boat by the use of a pole mast. It's an affectation since there's no advantage over a jibheaded sail that would set much better and save four parts aloft: the main peak and throat halyards, and the topsail sheet and tack downhaul.

The fisherman staysail is a bad sail that shouldn't be used except for historical reasons. If the head, set flying between the mastheads, can't be kept tight, the sail will fall into a bag shape that produces a tremendous heeling effect and no propulsion to speak of, even on a reach. To keep it tight calls for backstays led at least as far aft as the one shown, and throws a compression stress on the mast and its step that may strain the hull, and always requires a heavy mast with its weight carried high.

It takes an exceptionally skilled sailmaker to cut a fisherman staysail that doesn't go out of shape between peak, throat, and tack. The sheet has no control over this part of the sail since the three corners are all held on centerline. It can be done, but usually isn't. Again, if it isn't, that part of the sail will be all heel and no drive. Taking the tack downhaul over to the lee rail mitigates the problem with the forward upper part of the sail, but makes it impossible to sheet the other half of



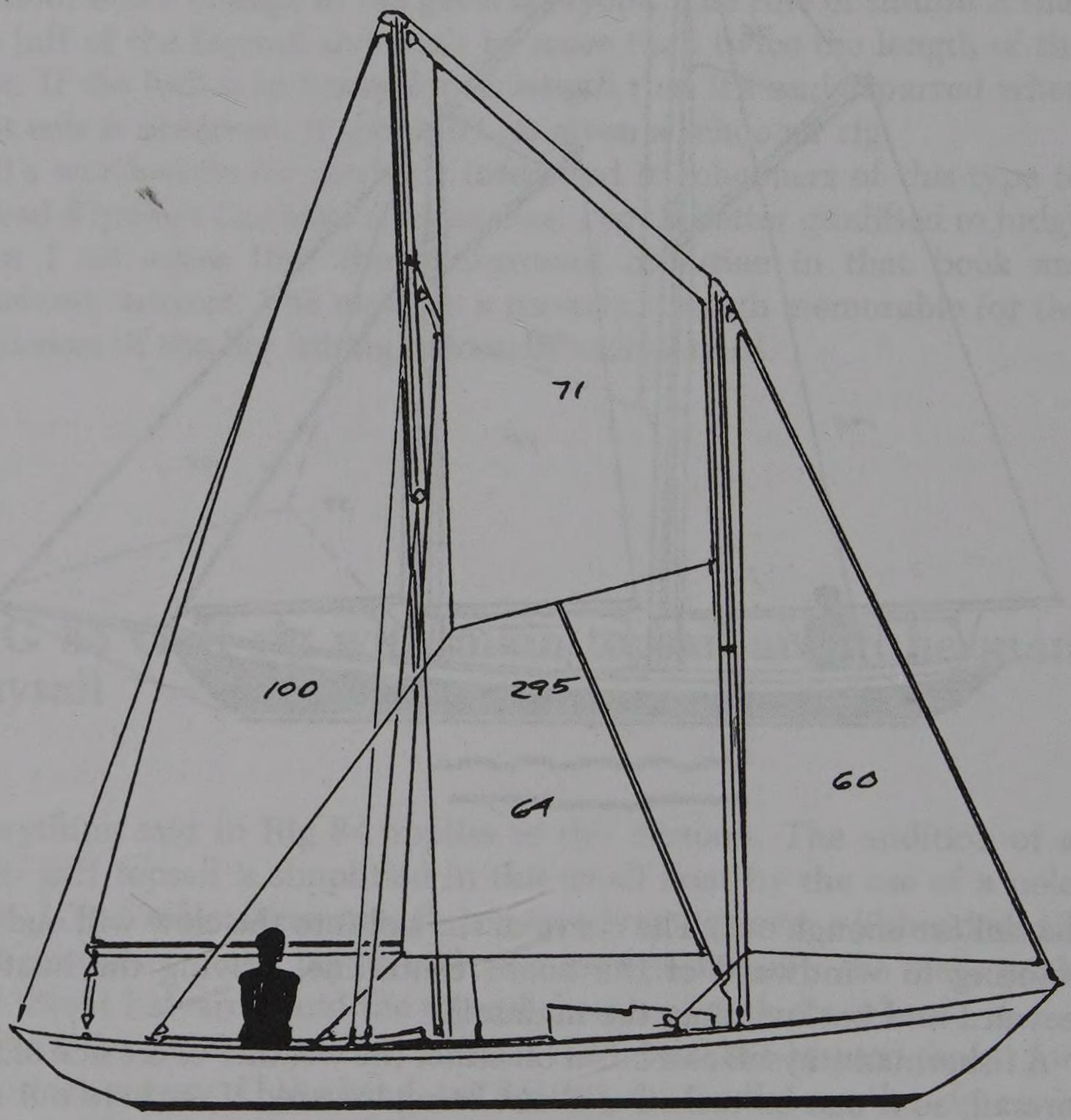
the sail far enough out. The curve of the sail into the clew will end up pointing to windward of the boat's centerline, driving the boat to leeward and backwinding the mainsail.

A fisherman staysail can be set on either the weather or lee side of the foresail, so it can be tacked without being lowered if, as here but not usually, there's no standing rigging in the way. The sheet has to be shifted over. In *Captains Courageous*, Harvey put the *We're Here*'s fore gaff through her staysail by tacking her accidentally.

This sail persisted, and still persists, because it's universal with sailors to dislike empty spaces inside the perimeter bounded by spars and rigging. The wishbone ketch, Rig 82, is another manifestation of this instinct. It's not unsound but a good many of its temptations are.

A main topmast staysail, triangular and tacked to the deck, is a good sail in light airs. It's simpler to set as well as more effective than the fisherman. It doesn't work in strong winds because the long luff sags, but no matter how badly it sets it's still better than a fisherman staysail at its best. Improving a main topmast staysail's support leads to the end caricatured in Rig 70.

RIG 86 Staysail schooner



The origin of this rig was thus: In 1925 John Lawrence had Burgess, Swasey, and Paine design a vessel called the *Advance* to race in a certain schooner class. He suggested that the foresail be eliminated so that better staying could be arranged for a tall mainmast and for the headsails. Starling Burgess modeled an exceptionally fast hull. He and Frank Paine, L. Francis Herreshoff, and others all had a field day sketching sails that could be set around the stays between the masts. The Ratseys managed to build a sail with the outline of a fisherman staysail, but so ingeniously cut that it did not kill the boat's sailing. *Ad-*

vance's hull was so fast, and her mainsail and headsails drew so well that she made a clean sweep of her class's trophies. (The mainsail was helped considerably by the standing main staysail, which acted like a sloop's jib.)

The next year all the other schooners came out with variations on the *Advance*'s rig, but she still beat them. Starling Burgess wrote an article about the design for *Yachting* magazine, concluding by pointing out, in effect, that *Advance* was a cutter with a superfluous and inconvenient spar, the foremast, intruded into her foretriangle. She would obviously sail much better and be easier to handle if the foremast was abolished and the mainmast moved forward to make her a straightforward, undisguised cutter.

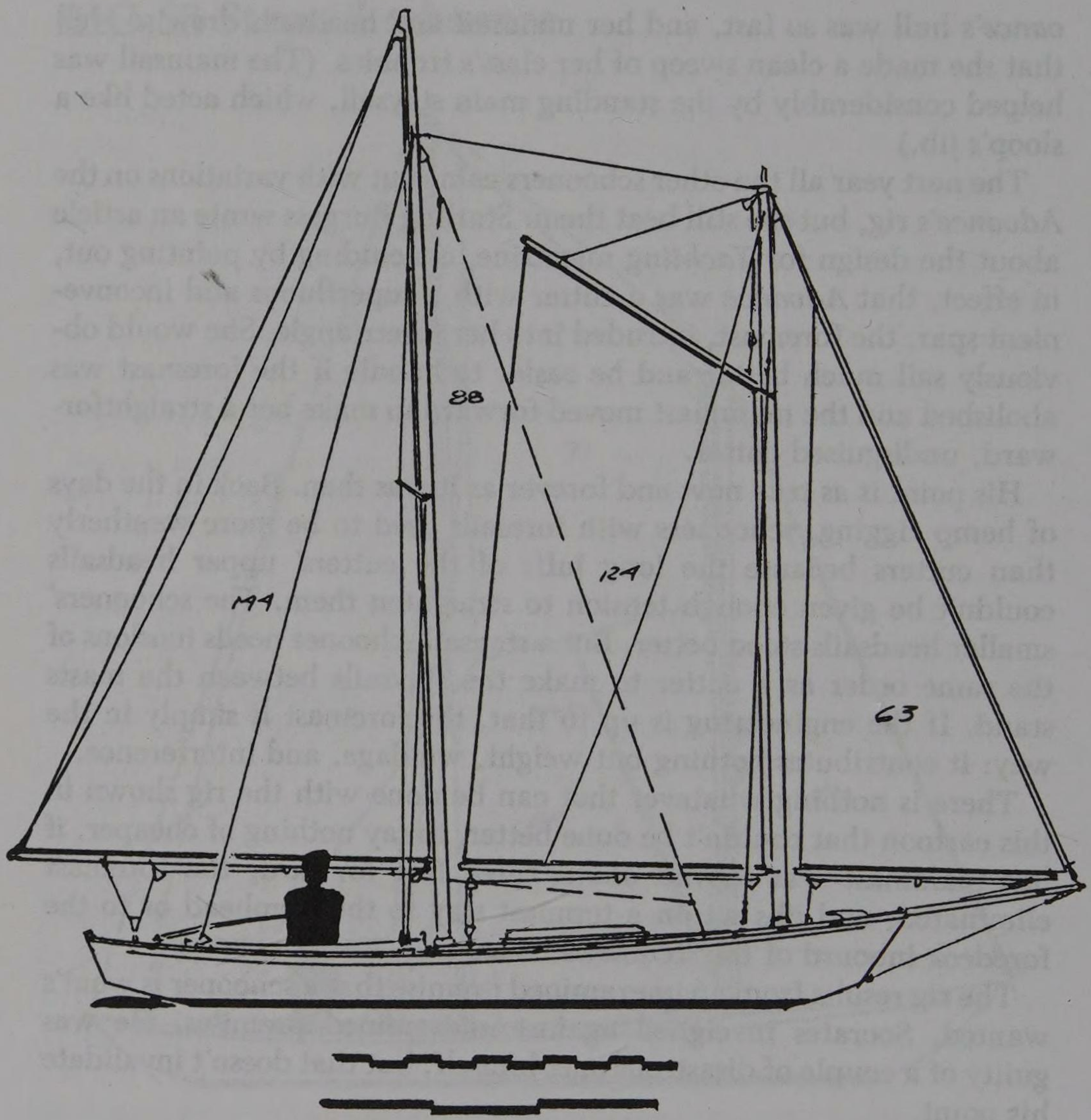
His point is as true now and forever as it was then. Back in the days of hemp rigging, schooners with foresails used to be more weatherly than cutters because the long luffs of the cutters' upper headsails couldn't be given enough tension to straighten them. The schooners' smaller headsails stood better. But a staysail schooner needs tensions of the same order as a cutter to make the staysails between the masts stand. If the engineering is up to that, the foremast is simply in the way: it contributes nothing but weight, windage, and interference.

There is nothing whatever that can be done with the rig shown in this cartoon that couldn't be done better, to say nothing of cheaper, if her mainmast was moved about three feet forward, the foremast eliminated, and jibs set on a topmast stay to the stemhead or to the foredeck inboard of the stemhead.

The rig results from an unexamined premise that a schooner is what's wanted. Socrates inveighed against unexamined premises. He was guilty of a couple of disastrous ones himself, but that doesn't invalidate his point.

RIG 87 Jibheaded mainsail with gaff foresail and single jib with club

This looks like the cat-schooner with a jib discussed in Rig 71, but it's derived from an opposite process. It's an example of "convergent evolution." In the cat-schooner the mast was in the eyes of the boat to begin with, and as more sail was wanted a makeshift jib was added.



This one started with a conventionally proportioned schooner that needed a tall rig because it was wide for its length. Giving it a tall jibheaded mainsail with a boom overhanging the stern was the first step. It was also given a main staysail for long tacks in light weather, an immensely powerful, driving sail as long as it can be made to hold its shape.

Making the foresail taller made it too long in the hoist for the length of its boom. The taller and narrower a schooner's foresail is, the harder it is to keep the top from sagging off and spoiling not only its own power and ability to look high on the wind, but the action of sails set abaft it.

The tall foremast was therefore moved forward so the foreboom could be longer. In boats with sharp bows there's an early limit to this process because the foremast shrouds can't be given enough spread to be effective, but the cartoon represents a scow schooner with a wide bow transom. The square bow not only forms an outrigger for the shrouds but also makes space for a long traveler horse for the jibsheet, so the boomed, self-trimming jib is practical.

This jib is about as big as a single jib ought to be, relative to the foresail. If it were longer on the foot its axis would be too far from the foresail to have much good effect on the drive of the foresail. At one time many schooners were rigged with boomed jibs that were very long on the foot. The original rig of the *America* is typical. It was a good enough rig to have won the America's Cup, but boats that had it were improved by rerigging with the foretriangle split between two sails, the inner one close to the foresail.

A small foretriangle, as in this cartoon, needs less rigging tension to stand well; hence, less strain on hull and spars. The jib tension is transferred to the mainmast along a springstay by running backstays on the mainmast. The backstays are needed anyway to set up the main staysail; if that didn't exist, the small drift of the main shrouds would be enough to keep the mast from falling forward, and it would make sense to put the backstays on the foremast.

The amount of rigging is somewhat out of keeping with the cheap scow hull, but the intention here was to make the boat fast and close-winded beyond what most people would expect from her looks. For that, the jib has to stand well in strong winds and the main staysail has to do the same, at least in moderate weather. Neither of them will stand without effective staying. Besides, the shallow-hulled scow has a problem getting enough bury for her masts if they're unstayed or casually stayed.

RIG 88 Jibheaded with boomless foresail

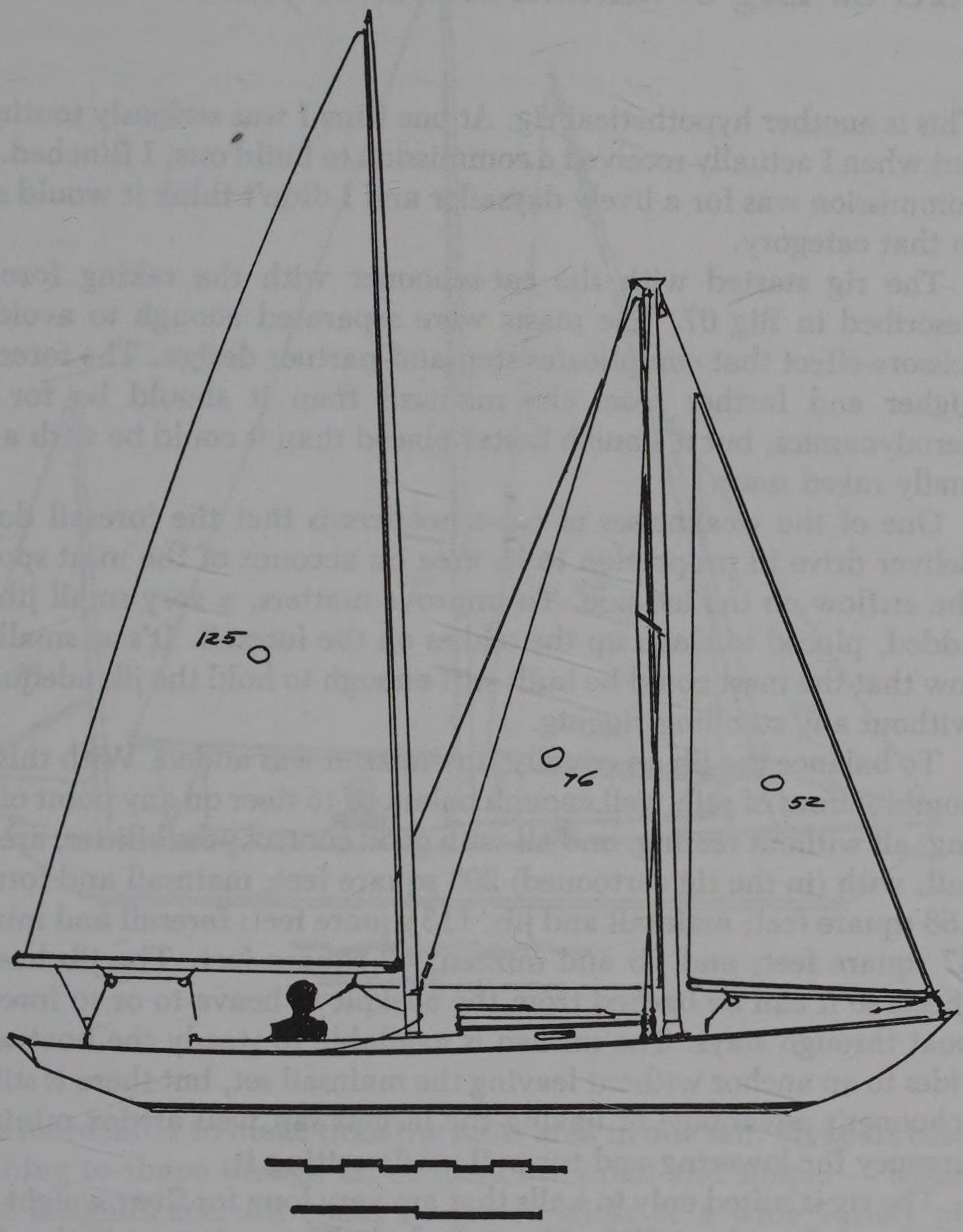
Once the marconi rig was well established, there were trials of schooners with marconi foresails. The incentive, besides fashion, was that the triangular foresail allowed better staying geometry, so the

headsails stood better. The single halyard and light hoist were minor items. But the rig was never satisfactory. The foresail was always designed with a boom on the foot. Some of the applicable racing rules of the time actually prohibited overlapping, boomless foresails in schooners. (Earlier, some racing schooners had set foresails with conventional forebooms, but with a loose-footed overlap of the foresail beyond the end of the foreboom past the mainmast; such a schooner had *three* foresail sheets. The rule was meant to reduce the crew needed to be competitive.) With a boom that had to clear the mainmast, the foresail was too narrow to stand well and had too small a head angle to be a good driving shape in three dimensions, or else it was simply too small to be a useful driving sail. Most such schooners were eventually converted to gaff or staysail rig.

Disregarding racing, a boomless overlapping foresail looks attractive in theory. It can have good proportions, and, at first glance, good sheeting geometry. The staying is simplified because such a foresail can pass under a standing backstay in tacking as easily, much more easily in fact, as a boomless jib can pass over an inner forestay. The standing backstay that holds the luff of the jib can lead low where it doesn't have to be backed by another stay on the mainmast. In the cartoon (which is hypothetical — this combination, to my knowledge, has never been tried) I've indicated a completely unstayed mainmast to make the point that in this rig only the foremast has to stand stiffly. The set of the mainsail isn't hurt by a bend in its mast.

Every so often a schooner is built with a boomless overlapping foresail, usually a gaff sail in imitation of the Tancook whalers, one of the few working schooner types to use it. It's noticeable that they usually have a boomed foresail before they're very old. Handling the sail in tacking is a nuisance, and the sail isn't as easy to sheet properly as it seems. The vertical luff of the sail causes the correct sheeting point on deck to vary much more drastically as the sheet is started off to a reach than does the same point for a jib with its sloping luff and high clew relative to the luff. Unless continual adjustments are made to the deck lead, a foresail like this will either have a tight leech close-hauled or a slack one reaching.

This foresail isn't a powerful sail. It looks something like a genoa jib, but there's no comparison in aerodynamic efficiency because the mast spoils the flow on the lee side. Simply because it isn't producing as much power, it's lighter to sheet down and has less tendency to produce weather helm than a genoa. In addition, it doesn't need any great rigging tension to stand well, but its drive is disappointing.



In fact, this rig is a legitimate schooner, with the advantages and drawbacks discussed in Rigs 84 and 87. The attempted modernization trades the simplified running rigging of the leg-o'-mutton sails for the short masts of the gaff rig. The improvement in the sailing of the boat is negligible. What's missing is the nostalgia that is the usual and best reason for rigging a small boat as a schooner.

RIG 89 Leg-o'-mutton schooner-yawl

This is another hypothetical rig. At one time I was seriously touting it, but when I actually received a commission to build one, I flinched. The commission was for a lively daysailer and I didn't think it would shine in that category.

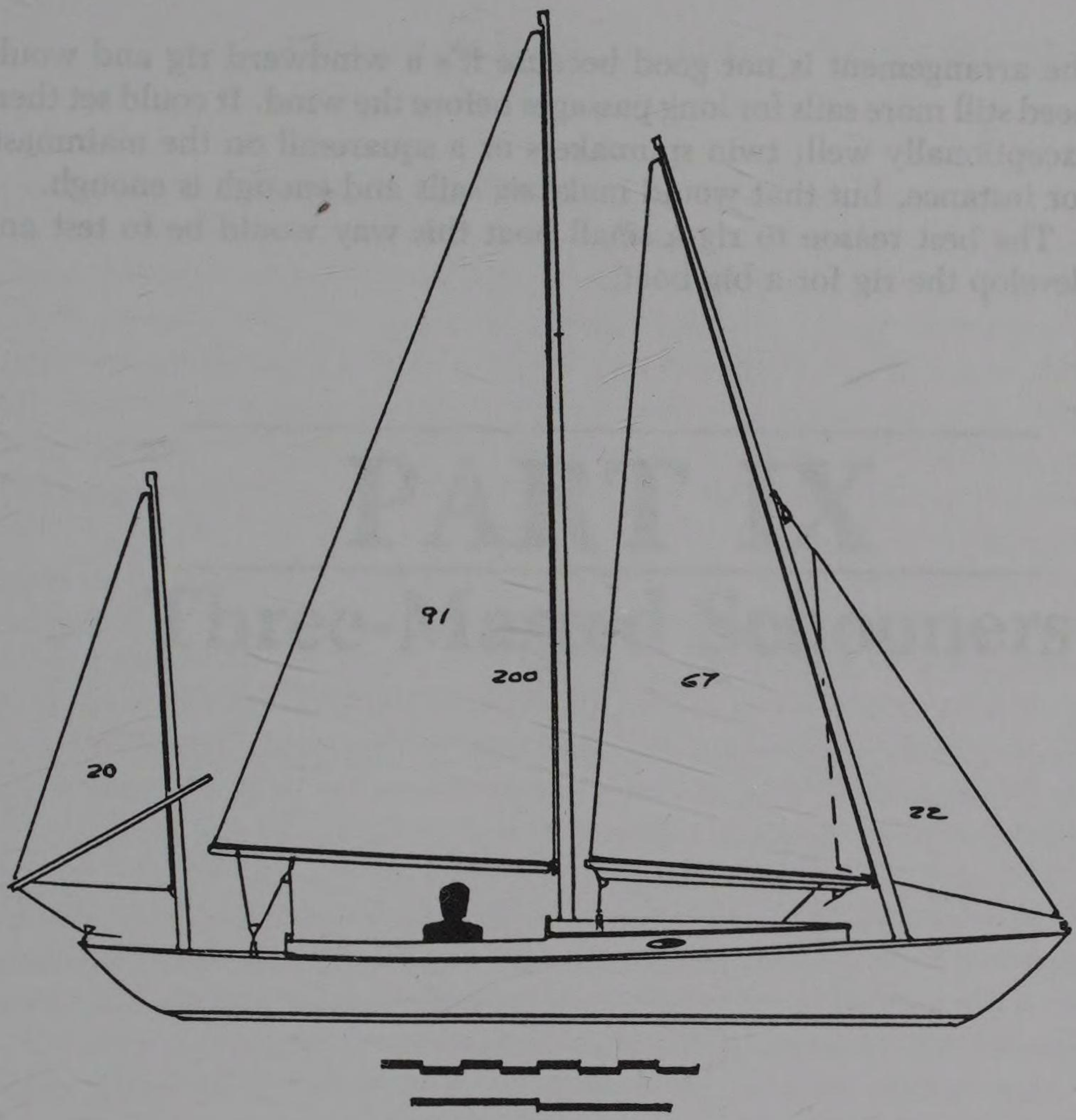
The rig started with the cat-schooner with the raking foremast described in Rig 67. The masts were separated enough to avoid the scissors-effect that complicates step-and-partner design. The foresail is higher and farther from the mainsail than it should be for best aerodynamics, but it's much better placed than it could be with a normally raked mast.

One of the weaknesses of cat-schooners is that the foresail doesn't deliver drive in proportion to its area on account of the mast spoiling the airflow on the lee side. To improve matters, a very small jib was added, placed to clean up the eddies on the foresail. It's so small and low that the mast could be built stiff enough to hold the jib adequately without any standing rigging.

To balance the jib an equally tiny mizzen was added. With this, the combinations of sail, well enough balanced to steer on any point of sailing, all without reefing, and all with good control possibilities, are: full sail, with (in the rig cartooned) 200 square feet; mainsail and foresail, 158 square feet; mainsail and jib, 113 square feet; foresail and mizzen, 87 square feet; and jib and mizzen, 42 square feet. The jib has two sheets so it can be backed from the cockpit to heave-to or to force the boat through stays. The mizzen is available to steady the boat as she rides to an anchor without leaving the mainsail set, but there is still the schooner's advantage of having the largest sail well aft for minimum urgency for lowering and turmoil while setting it.

The rig is suited only to hulls that are very long for their weight. The cartoon is for a boat 25 feet long on deck. The mainmast is about that long and couldn't be much taller without the sail's becoming too narrow to work well without battens and more complex sheeting. The effective sail area is even less than the nominal area because the mizzen is good only for balance and control. But considering the amenities it offers in worsening weather, and the fact that it will work with the most primitive materials, the rig looks remarkably efficient. The man I finally talked out of building it was an academic aerodynamicist who was fascinated by the interplay of all these sails.

It's rather expensive, mainly because 200 square feet of area in four



sails is more labor to make than the same area in one sail. Six spars cost something to shape though all of them are small and simple — some almost insignificant. All could be grown sticks of a wide variety of species. In many localities suitable trees for the fore- and mainmasts, let alone the toothpicks for the rest, are to be had for the asking if only a couple are needed. They don't even have to be straight to work tolerably well in this rig. The boat still could be sailed, under control, if either foremast or mainmast broke.

The objection to the rig is that it has too many sheets. These are mostly "self-trimming," it's true, meaning that the boat can go through stays without handling them, but that's no help if it's a jibe rather than a tack that's in prospect. For daysailing the rig would only be good for something like a troop of sea scouts. Again, for a long-distance cruiser

the arrangement is not good because it's a windward rig and would need still more sails for long passages before the wind. It could set them exceptionally well; twin spinnakers or a squaresail on the mainmast, for instance, but that would make six sails and enough is enough.

The best reason to rig a small boat this way would be to test and develop the rig for a big boat.

PART IX

Three-Masted Schooners

RIG 90 Gaff sails with topsails — "coaster"

It's legitimate to speak of all pleasure boats as toys (keeping in mind that toys are a serious matter to people who depend on them for a living), but there's a real distinction between a recreational vehicle and a conversation piece. A three-masted schooner, 30 feet long on deck, with fore and main booms 6 feet 9 inches long and 20-square-foot topsails, is a conversation piece, created solely because of its amusing resemblance to a big old coal carrier. The challenge is to make it sail as well as possible, since the fun will be spoiled if it has to be towed on all occasions.

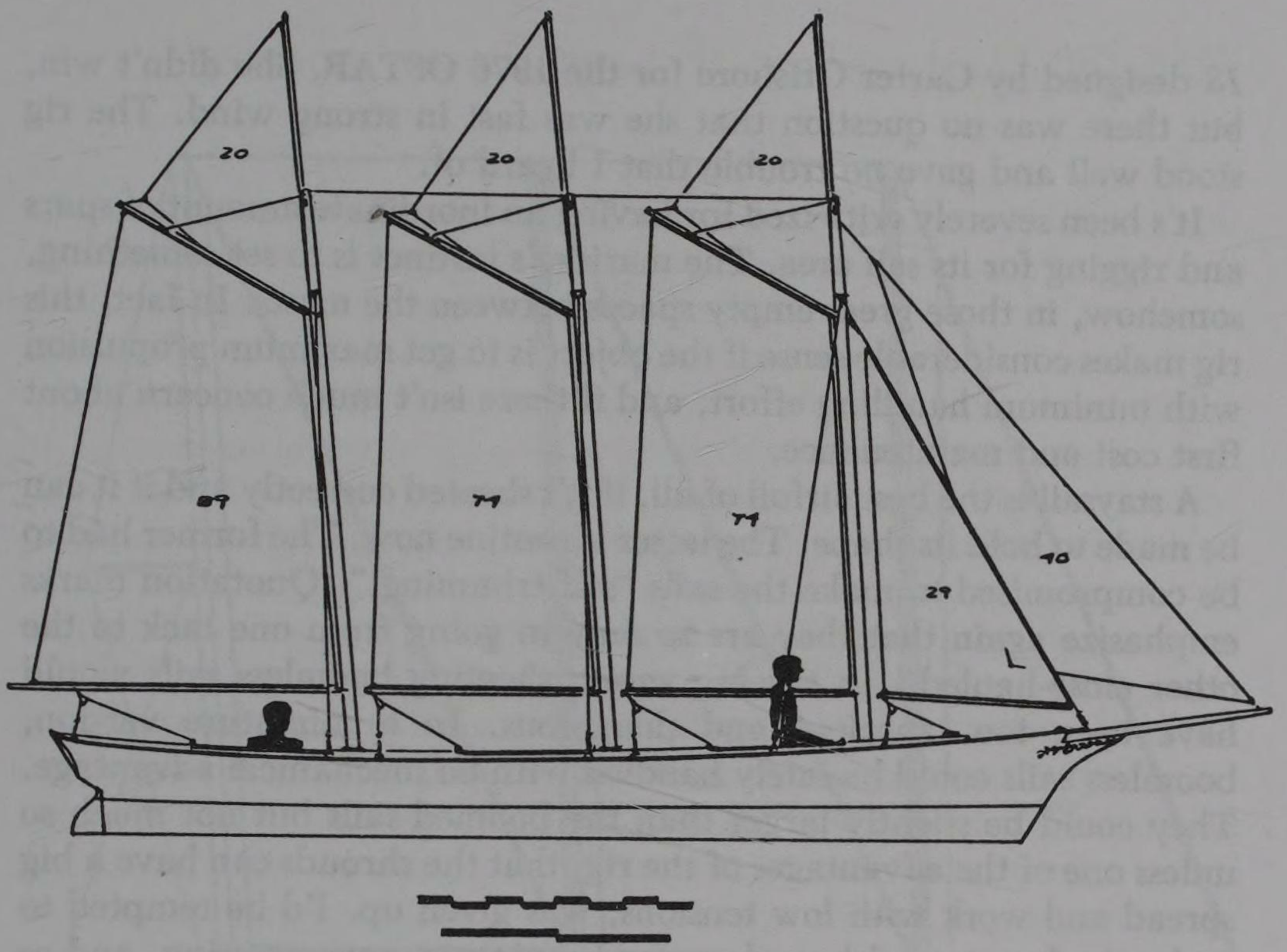
There are two basic ways of approaching it. One is to build an exact scale model of a big schooner complete with redundant rigging. That will be cute and possibly instructive, though I have my doubts about the instruction even in full-sized replicas and restorations because it can't reproduce the social and economic background. The other way, which happens to suit my own temperament, is to study how much simplification is possible without totally losing the visual effect.

The only pieces of standing rigging that are essential for this rig are the shroud/backstays of the foremast that are needed to put tension on the luffs of the jib and forestaysail. Main- and mizzenmasts could easily be made to stand unstayed, but one shroud on the side of each is used to stand for the massive multiple shrouds of the coaster.

The springstays between the mastheads keep the shroud tension and the pull of the sheets from pulling the masts aft. They add realism to the game of sailing the toy coaster by calling for taking in the fore and main topsails each time she tacks. In the full-sized vessels they'd be hauled over the stay with the halyard left fast, but that calls for a man aloft on each mast — not very practical at this scale.

In the proposal there are no topmasts. The topsails have yards on their luffs, held in line with the masts by tension on the tack downhaul. The object is to support the luffs of the topsails against sagging, yet to be able to lower them to the deck quickly. This is impractical with fidded topmasts, and even with pole masts if the lower sails are hooped around the masts, as they would be in a boat like this for appearance' sake. The topsail yards are a nuisance to stow, but they save windage when the topsails aren't set.

The lower sails are ordinary gaff sails with single-part halyards and two-part sheets. Not much mechanical advantage is needed when the largest sail is 89 square feet. The jib has two single-part sheets, and



needs no winches, since the sail is only 40 square feet. Three people could sail her but she would have them jumping at times.

This boat is supposed to be just under 30 feet long on deck, about 5 feet beam, wall-sided and almost flat-bottomed like the big schooners, but with a centerboard alongside the mainmast. The centerboard is not out of keeping with the type, but it would be much larger in relative area than would be practical in the full-sized vessel. A boat like this wouldn't be very close-winded, though she might tack through eight points by starving the mizzen. With a good full, in a freshening breeze, her sailing would be far from contemptible.

RIG 91 Staysails

I didn't include the two-masted version of this rig because I don't know of an example. The three-masted rig appeared in the 120-foot *Vendredi*

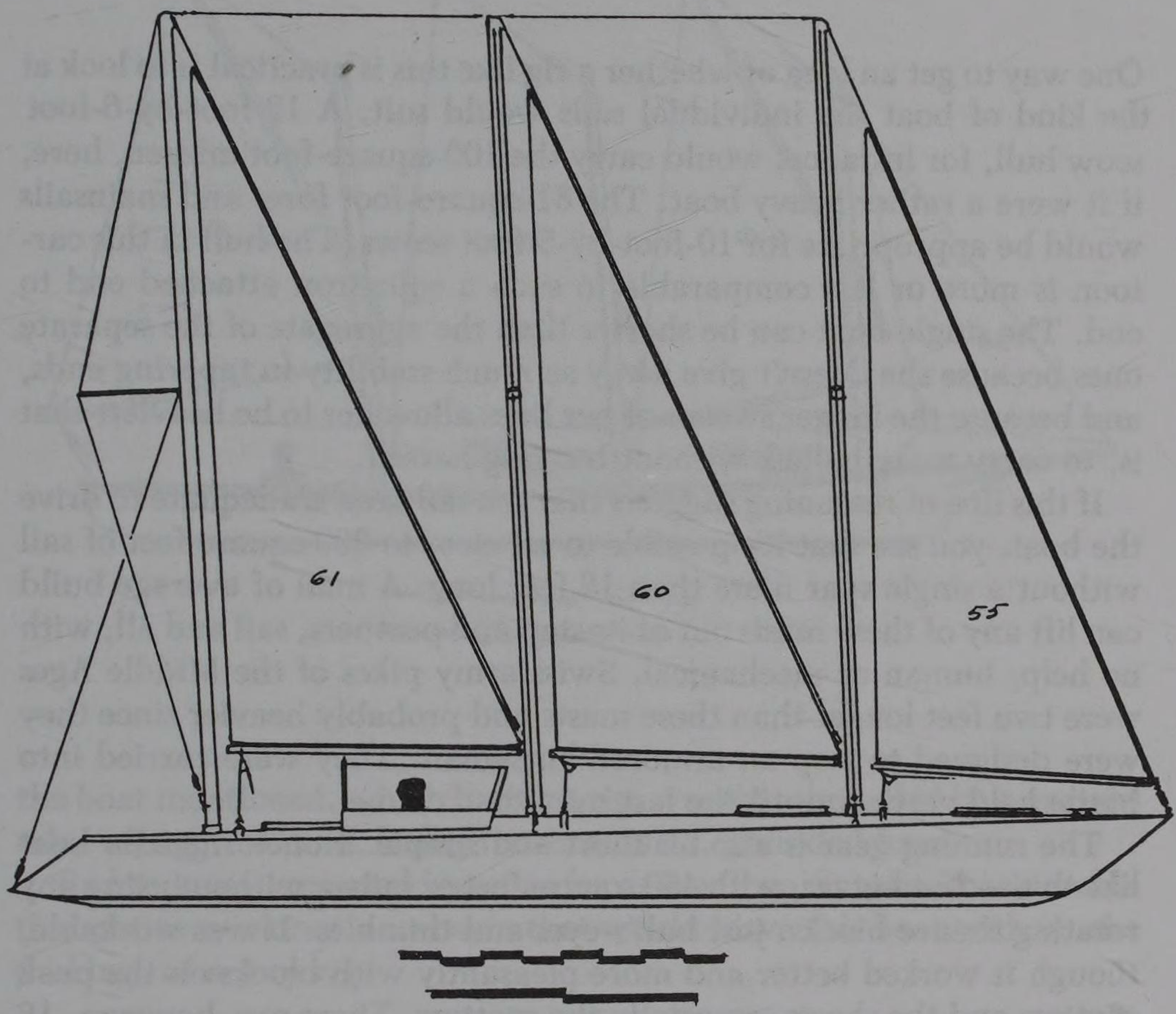
13 designed by Carter Offshore for the 1976 OSTAR. She didn't win, but there was no question that she was fast in strong wind. The rig stood well and gave no trouble that I heard of.

It's been severely criticized for having an inordinate amount of spars and rigging for its sail area. The mariner's instinct is to set something, somehow, in those great empty spaces between the masts. In fact, this rig makes considerable sense if the object is to get maximum propulsion with minimum handling effort, and if there isn't much concern about first cost and maintenance.

A staysail is the best airfoil of all, if it's sheeted correctly and if it can be made to hold its shape. The latter is routine now. The former had to be compromised to make the sails "self-trimming." (Quotation marks emphasize again that they are so only in going from one tack to the other close-hauled.) In the big vessel, sheeting boomless sails would have been too laborious and dangerous. In a miniature version, boomless sails could be safely handled with no mechanical advantage. They could be slightly larger than the boomed sails but not much so unless one of the advantages of the rig, that the shrouds can have a big spread and work with low tensions, was given up. I'd be tempted to make the forestaysail boomless, for heaving-to, maneuvering, and as insurance against missing stays. It could be set on a roller for furling. If it is, the forestay should be incorporated into the luff of the sail. No roller-furling sail should have a separate stay anywhere near it, because in the worst possible circumstances the sail will thrash enough to roll the stay into itself, jam, throw the boat out of control, and blow itself to pieces. I'm not entirely convinced that sails that roll into a mast recess are immune to this kind of catastrophe.

However that may be, these boomed sails can be sheeted well close-hauled and out to a beam reach if the traveler horses are long enough. If the boat isn't wide enough, relative to the length of the booms, to get wide angles from the masts, the sheets can be taken well inboard of the ends of the booms. This reduces the mechanical advantage, but besides allowing the sails to be sheeted effectively on a broader reach, the in-board position reduces the tendency of the booms to bend up, the wrong way, in strong winds.

When I saw the preliminary design for *Vendredi 13*, I suggested to Carter that if the staysails were balanced-club types, the sheeting geometry could be both simpler and more effective (see Rigs 77 and 83). He answered courteously that there were already too many features of the rig with which he wasn't sure what he was doing. It might have worked, though it would have been hard to get enough



halyard tension to make a sail of that type stand in heavy weather. There would have had to have been slack jackstays run down the pivot axes of the sails to keep them under control while they were hoisted and lowered. While on the huge scale of that vessel jackstays might have chafed the sails, in a miniature I'd be tempted to try them.

The criticism of the rig is valid. It does have an enormous amount of wind resistance, which is certain to hurt performance, especially under reduced sail. But it's not clear that the superior drive of the sails, compared with Rig 93, for instance, doesn't more than compensate for this. The real point is that having decided to drive the boat with staysails for better or worse, this rig doesn't waste manpower or money, or create still more wind resistance, by inserting ineffective sails of other types.

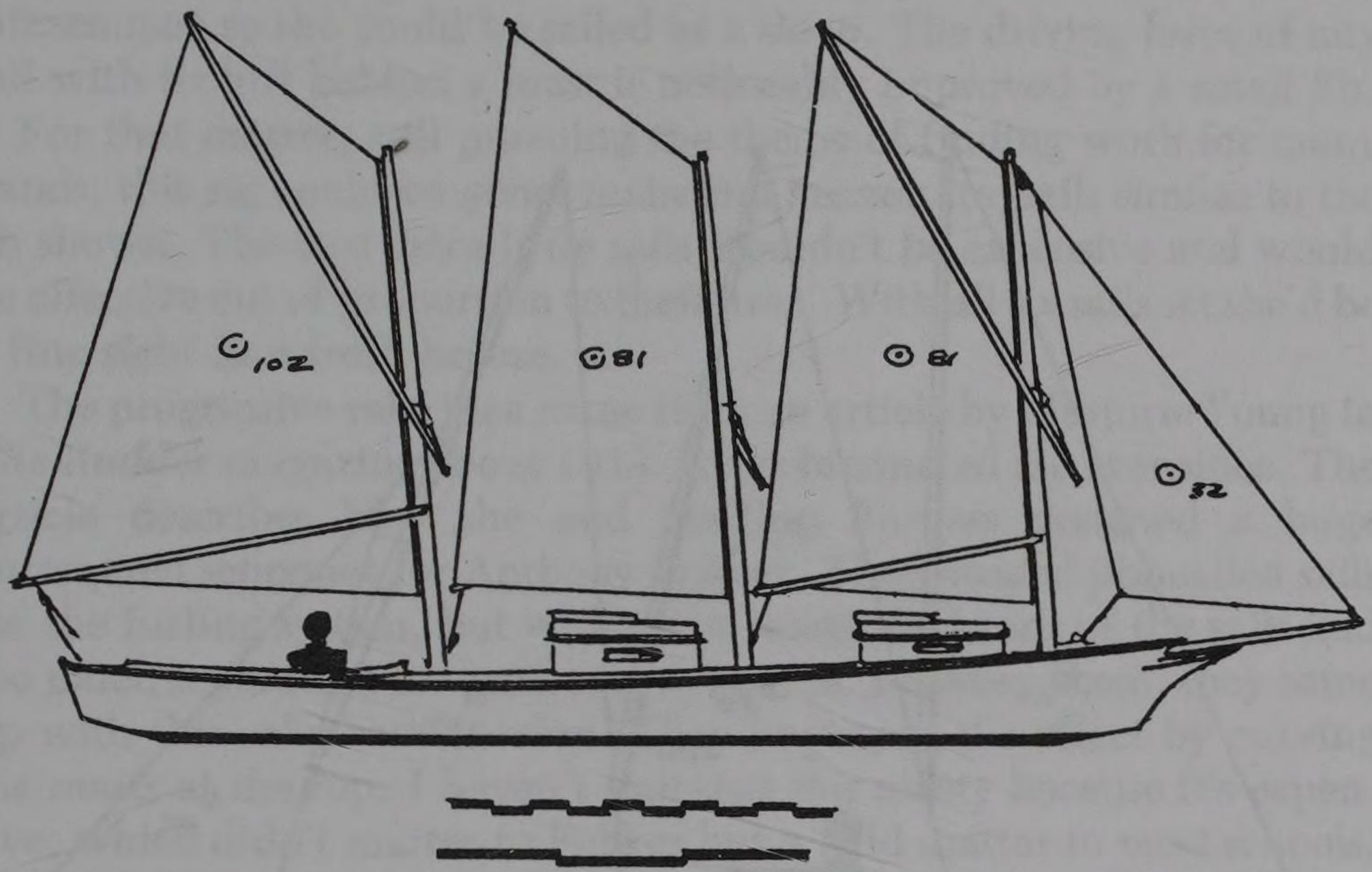
RIG 92 Spritsails

One way to get an idea of whether a rig like this is practical is to look at the kind of boat the individual sails would suit. A 12-foot-by-6-foot scow hull, for instance, would carry the 100-square-foot mizzen, here, if it were a rather heavy boat. The 81-square-foot fore- and mainsails would be appropriate for 10-foot-by-5-foot scows. The hull in this cartoon is more or less comparable to such a squadron attached end to end. The single boat can be shorter than the aggregate of the separate ones because she doesn't give away so much stability in tapering ends, and because the longer sweeps of her lines allow her to be heavier; that is, to carry more ballast without burying herself.

If this line of reasoning suggests that the sail area is adequate to drive the boat, you see that it's possible to set close to 300 square feet of sail without a single spar more than 16 feet long. A man of average build can lift any of these masts out of its step and partners, sail and all, with no help, human or mechanical. Swiss army pikes of the Middle Ages were two feet longer than these masts and probably heavier since they were designed to stop an armored horseman. They were carried into battle held vertical until the last minute.

The running gear is also all short and simple. I once rigged a boat like this — but bigger, with 450 square feet of sail — without using any rotating sheave blocks, just bull's-eyes and thimbles. It was workable, though it worked better and more pleasantly with blocks on the peak snotters and the sheets, especially the snotters. There are, however, 16 separate pieces of running rigging, 19 if halyards are used, including 5 sheets. The rig is not one a singlehander would pitch on. It could be converted in short order to a two-masted cat-schooner by leaving the mainmast ashore, stepping the mizzen in its place, and leaving off the jib. That would be a good singlehanded rig, but with too little area for the hull in most weather.

The comparison with the three little boats is misleading in some ways. If the small boats sailed one behind the other, the foremost one would outsail the others close-hauled since they'd be fighting her backwind. Held together, the speed would be that of the last boat. But it's expected that a 30-foot boat should be able to outsail three 10-foot boats. This one would do so, but she won't sail with a 30-footer that is able to carry a higher and less cut-up rig. The three-master would go very fast in strong wind because her rig has both weight and area set low where they don't have much heeling effect. One of the failings of

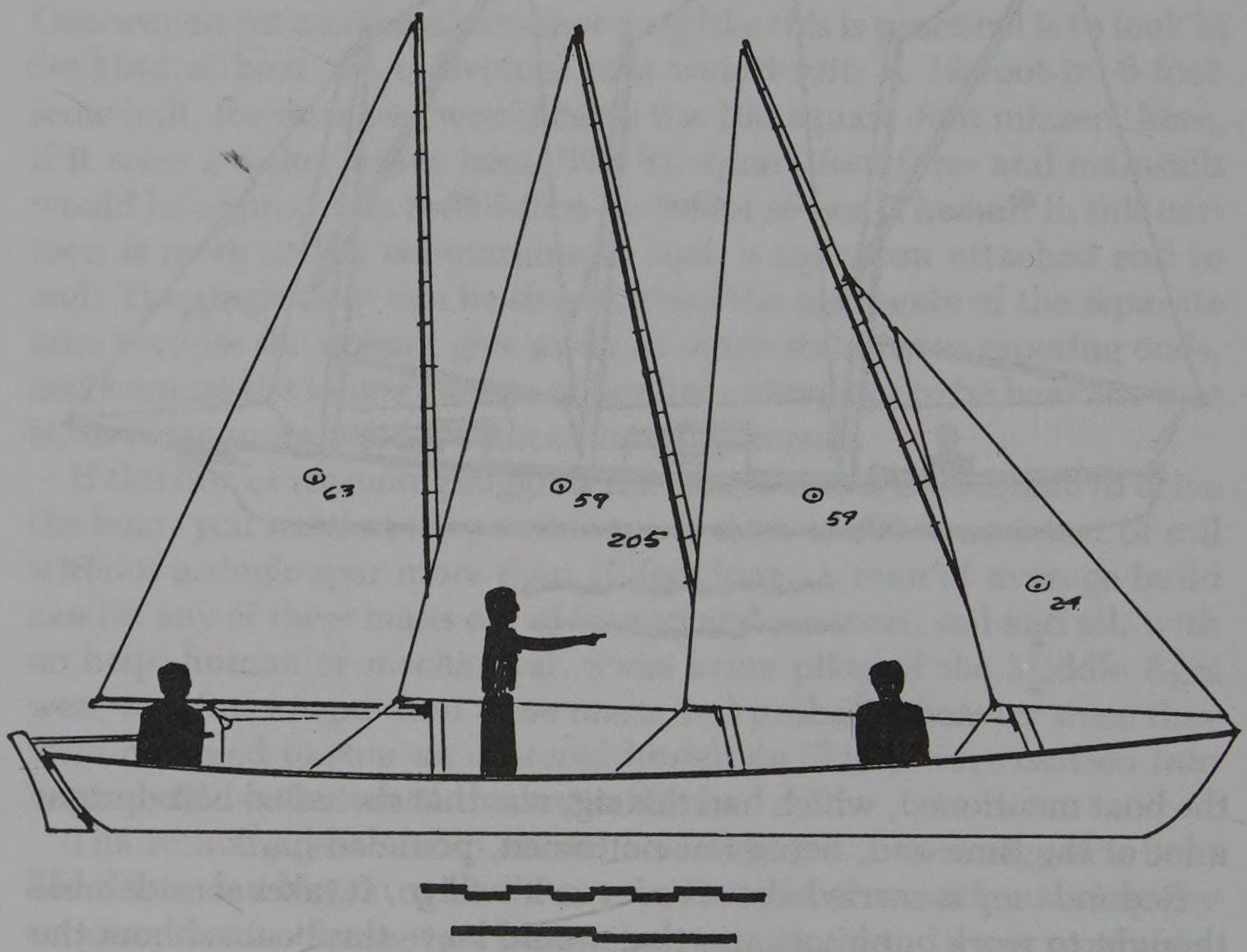


the boat mentioned, which had this rig, was that she sailed bolt upright a lot of the time and, being flat-bottomed, pounded hard.

Redundancy is carried about as far as it will go. It takes considerable thought to work out a scenario that would leave this boat without the makings of a jury rig.

RIG 93 Leg-o'-mutton

Boats designed to row usually need low rigs, being long for their breadth and weight. A slender 27½-foot whaleboat pulling six or eight oars and meant for a school or camp so she'd never be shorthanded looks unaffected with three masts. A real whaleboat usually had a gaff cat or sloop rig with a long boom and a short mast, but for an inexperienced crew the rig here is better because it creates more employ-



ment, so to speak. Again for the inexperienced, the boat isn't likely to capsize as one eight-foot boom won't trip her in a knockdown. This rig is hard to improve on for sailing in an open boat in strong, squally winds.

There's no running rigging aloft except for the jib halyard. The sails are furled by rolling them in to the masts. The masts themselves are all under 20 feet long overall and slender at the top. And with no standing rigging, the masts can be lifted out of their steps and laid flat by two or three youngsters. The masts are independent of each other, so the mainmast alone could be struck down to clear the middle of the boat for some oarsmen. If it happened that she needed to be sailed short-handed, the mizzenmast, with its boomed sail, could be put in the mainmast step. But since it's too small for the boat even with no crew

weight, it might be worthwhile to have a halyard block ready on the mizzenmast so she could be sailed as a sloop. The driving force of any sail with its luff behind a mast is noticeably improved by a small jib.

For that matter, still pursuing the theme of finding work for many hands, this rig could be given main and mizzen staysails similar to the jib shown. The two extra little sails wouldn't be expensive and would be effective out of proportion to their area. With all six sails set she'd be a fine sight in a fresh breeze.

The progressive rake idea came from an article by Marjorie Young in *The Rudder* magazine about 1943. It has fascinated me ever since. The article describes how she and Starling Burgess designed a huge automated schooner for Anthony Fokker. They needed jibheaded sails for the furling system, but with three masts the heads of the sails had too much separation for good aerodynamics. Between them, they came up with this rake combination. They improved the effect by curving the masts at the top. I haven't imitated this nicety because it's expensive, which didn't matter to Fokker but would matter to most schools. Incidentally, among other innovations, the ship was to have had inflatable booms that could be deflated and rolled up along with the sails. Fokker's death stopped this entrancing project.

The rake has other advantages besides bringing the sails into better relationship with each other. The weight of the foremast is brought back out of the extreme bow. More important, the foresail, and to a lesser extent the mainsail, have much better shapes for boomless sheeting. The high clews, relative to the luffs, need less change in the vertical angles of the sheets as the sail is slacked away. With these small sails it would be easy to shift the sheet leads, but in principle the less that has to be done, the better.

The rig is exceptionally well suited to an open boat because it doesn't depend on high tensions to work. The jib, and the other staysails if there are any, are so small and short on the luff that they're not much of a problem. If they did sag unacceptably in a blow, the rake is again useful. A crude running backstay could be rigged to this foremast practically at right angles to the mast. It would tighten up the jib without throwing a heavy compression stress on the mast and its step. As far as the three large sails are concerned, the mastheads can whip several feet out of line without spoiling their action.

Fokker was delighted with the Burgess-Young design because he liked novelty, and liked startling conservative people. I have the same bias, even to the bizarre. But this rig in the cartoon is technically conservative to the point of reaction. It's shipshape and seamanlike, as well

as handsome. It's very specialized, suitable only for a rare type of hull, but in a suitable hull, it's in the recreational vehicle class, not the toy class.

PART X

Square Rigs

RIG 94 Boomless with a luff strut

The basic advantage of the square rig is that it's stable before the wind and can go from one jibe to the other without any urgent adjustments. A square-rigger can be driven hard off the wind with less chance of getting into trouble than any kind of fore-and-after.

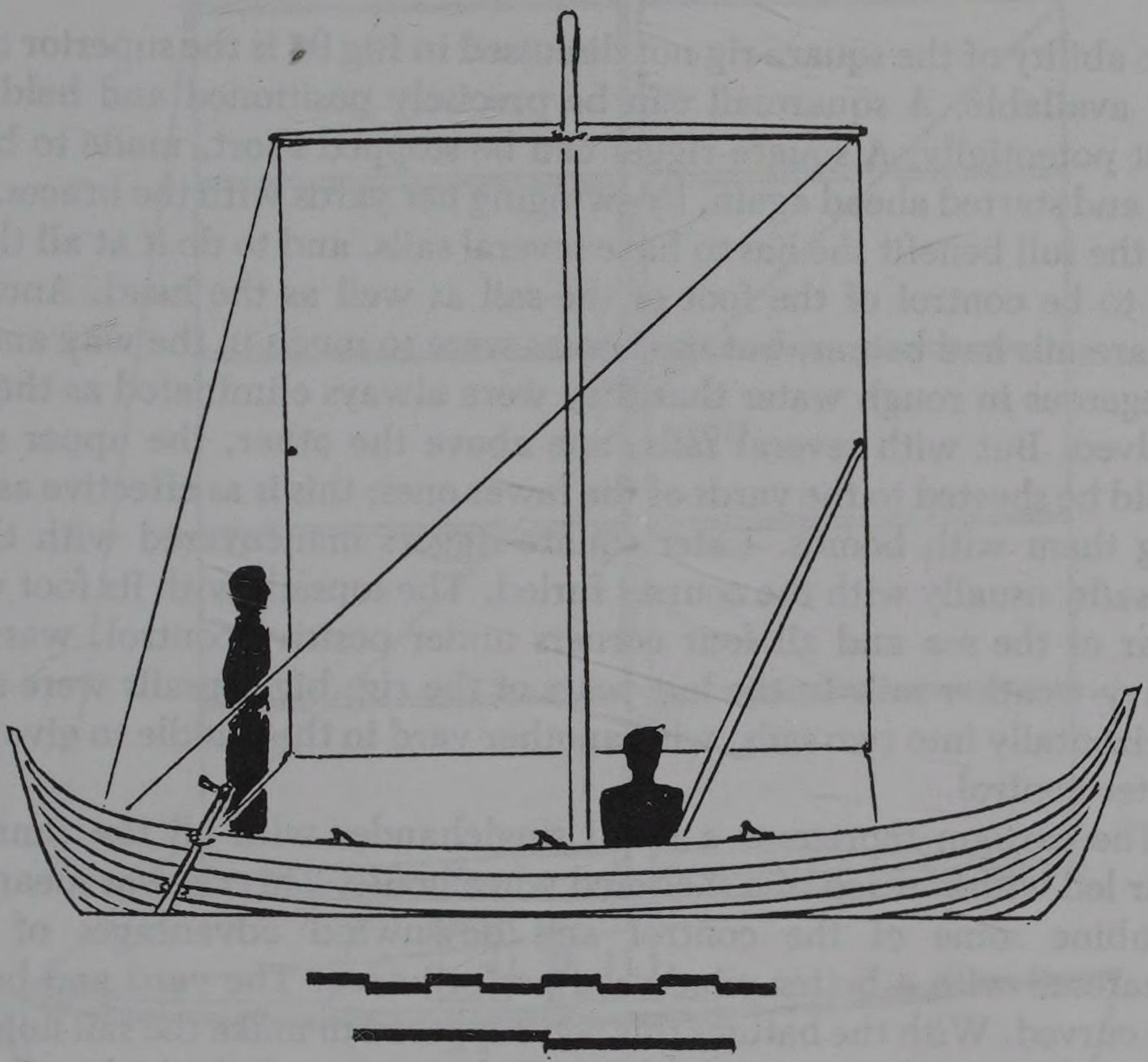
By stable, I don't mean that there's a self-steering effect. There isn't. But the sail itself isn't trying to twist itself up and goosewing as fore-and-aft sails do. Having the thrust of the sail more or less symmetrical over the boat's centerline doesn't hurt steering. Squaresails aren't likely to trip the boat in a roll as a long guyed-out boom can do. And a squaresail doesn't have as much tendency to make the boat bury her bow as most fore-and-aft sails, though it isn't as good as a staysail in that respect.

A squaresail set on an unstayed mast, as in this cartoon, can be an effective windward sail. The fact that it comes aback in tacking is less of a handicap than might be thought, for the yard can be swung very quickly and the sail is aback only for an instant. It's likely that a big overlapping jib, which has to be dragged around the mast and perhaps over an inner forestay as well, has more tendency to stop a boat in stays.

A squaresail that's meant to be used for beating ought to be cut with all its fullness in the middle of the sail, flat at both edges. If both edges are cut like the luff of a fore-and-aft sail, the one that's acting as a leech for the moment will be curled in a way that's bad for the efficiency of the sail. A flat luff does less harm if the sail is carefully trimmed.

To tack a squaresail, two braces and two sheets have to be handled. Despite appearances, the sail is not balanced when it's trimmed for close-hauled sailing. It takes a strong pull on the weather brace to keep the yard from swinging across the bow, and when the yard is braced sharp-up for beating, that brace comes aft at such a fine angle with the yard that it can take all the power in the world to hold it. If it gets away, the boat has to make a sharp dogleg to leeward, sometimes having to head almost straight before the wind to recover control of the sail. In a narrow-sterned boat, as here, a set of outriggers for the braces would help.

Still close-hauled, the corner of the sail serving as tack is brought down as far outboard as possible on the forward weather quarter. The object is to make the sail set as much like a dipping lug as possible. This can't be done well because the balanced yard won't tighten the luff,



which sags badly. The Viking spar shown supporting the luff is called a fore girt in England;* the translator of *The Viking Ships* calls it a sprit. Bjorn Landstrom calls it "beitass." The sockets for it can be seen in the Gokstad ship. The luff still sags above and below it.

Squaresails, much like this, used to be common as downwind sails in fore-and-aft-rigged cruisers. They were considered easier to control than a spinnaker, and were less prone to chafe than squared-out fore-and-aft mainsails. The shrouds of the fore-and-after prevent bracing the yard much. It was sometimes hoisted on the forestay to get it out clear of the shrouds, but if it was left set for a long time, the movements of the yard had a dangerous way of chafing or fatiguing the stay. The best description of how to handle a squaresail for this purpose is in Claud Worth's *Yacht Cruising*..

*"I learn from John Leather that the English name is 'FOREGIRT,' often rendered as 'VARGORD'. P.C.B."

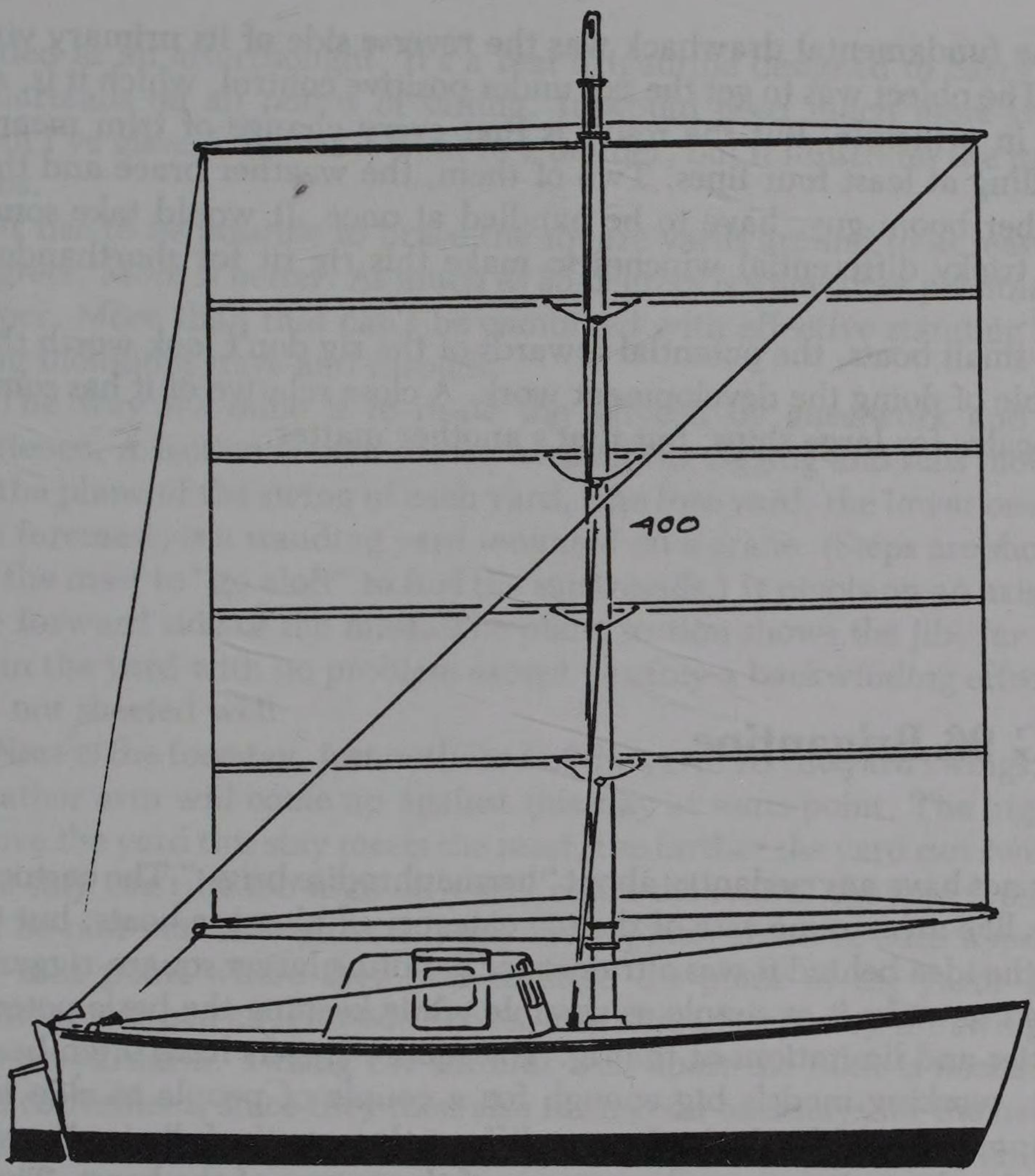
RIG 95 Full battens with boom on the foot

One ability of the square rig not discussed in Rig 94 is the superior control available. A squaresail can be precisely positioned and held, at least potentially. A square-rigger can be stopped short, made to back up, and started ahead again, by swinging her yards with the braces. To get the full benefit she has to have several sails, and to do it at all there has to be control of the foot of the sail as well as the head. Ancient squaresails had booms, but the booms were so much in the way and so dangerous in rough water that they were always eliminated as the rig evolved. But with several sails, one above the other, the upper sails could be sheeted to the yards of the lower ones; this is as effective as fitting them with booms. Later square-riggers maneuvered with their topsails, usually with the courses furled. The topsail, with its foot well clear of the sea and all four corners under positive control, was the heavy-weather sail. In the last years of the rig, big topsails were split horizontally into two sails, with another yard in the middle to give still better control.

The cartoon represents a small singlehander with all the running gear led within reach of a sheltered wheelhouse. This rig was meant to combine some of the control and downwind advantages of the squaresail with a better windward performance. The yard and boom are curved. With the battens this was supposed to make the sail hold an airfoil shape without much tension. With the mast on the high-pressure side of the sail and all the other spars lying along the airflow, it seemed that this sail would have great power. It would need exact adjustment to do its best, being the sharp-edged curved plate discussed in "Crude Aerodynamics," but the means to adjust it were provided.

With downhauls on the battens, the height and area could be varied without stopping the boat, as in a Chinese lug. The curved boom's lee end is not far outboard if the sail is braced around to any extent, so it's not the tripping hazard a straight boom is. The boom could be topped up if necessary, producing proportions similar to the topsail set over a furled course. With the sail fully lowered, and braced well fore and aft, the wind resistance at anchor is small.

With the single sail there's no means of making her lie head to wind; hence, she's intended to lie stern to the wind, either to her anchor or to a drogue. Even disregarding the use of the engine this is workable in theory. Certainly at sea, lying bow downwind eliminates strain on the rudder and gives better control of the drift. In getting underway from



an anchor, there is instant steerageway. The anchor might be let go from the bow, sailing to the exact spot selected, stopping the boat short on that spot, and backing her down to set the anchor.

Trouble with the rig came in two categories. One type was due to inexperience with it. The stress on the weather brace is surprisingly heavy, which not only made the sail hard to control but made it apt to get out of control, especially when braced sharp-up to sail close-hauled. There were some other problems of that order that would be overcome if any development was done.

The fundamental drawback was the reverse side of its primary virtue. The object was to get the sail under positive control, which it is, at least in principle. But the result is that every change of trim means handling at least four lines. Two of them, the weather brace and the weather boom guy, have to be handled at once. It would take some very tricky differential winches to make this rig fit for shorthanded work.

In small boats, the potential rewards of the rig don't look worth the trouble of doing the development work. A close relative of it has some advocates for large ships, but that's another matter.

RIG 96 Brigantine

Let's not have any pedantry about "hermaphrodite brigs." The cartoon looks like an extreme case of the toy category of pleasure boats, but in fact the idea behind it was a trainer for handling larger square-riggers. I tried to make it as simple as possible while keeping the basic potentialities and limitations of the rig. Toy square-riggers have often been built, working models big enough for a couple of people to ride in. Their gear has had to be laid out so differently from the full-sized vessel that they haven't conveyed any sense of the nature of the beast. They couldn't carry enough hands to work all the parts of the rigging at once, or even in a realistic sequence, and furling a topgallant by standing up and reaching for it is too easy.

Here, the fore-and-aft sails have been kept as straightforward as is consistent with most of the maneuvers the full-sized ship might attempt. The jibheaded mainsail is conventional, symbolizing two or three sails set on standing gaffs and furled with brails.

The single jib is set flying. It's boomless, with two sheets, to stand in for the several similar headsails of the ship.

The main topmast staysail is a bad sail, as noted in Rig 85, but it's the best arrangement available to give some idea of the uses and problems of sails set between the masts without multiplying the gear beyond what can be worked by the hands the little boat can carry.

This is not a staysail schooner with a couple of downwind squaresails

added as an afterthought. It's a real brigantine designed to carry her squaresails on all points of sailing. It would need much more study than I've given it before it went to a builder, but it illustrates the problems.

It has to be possible to brace the square yards around to at least 30 degrees. More is better. As much as 35 degrees is sometimes possible on paper. More than that can't be combined with effective standing rigging including stays and shrouds.

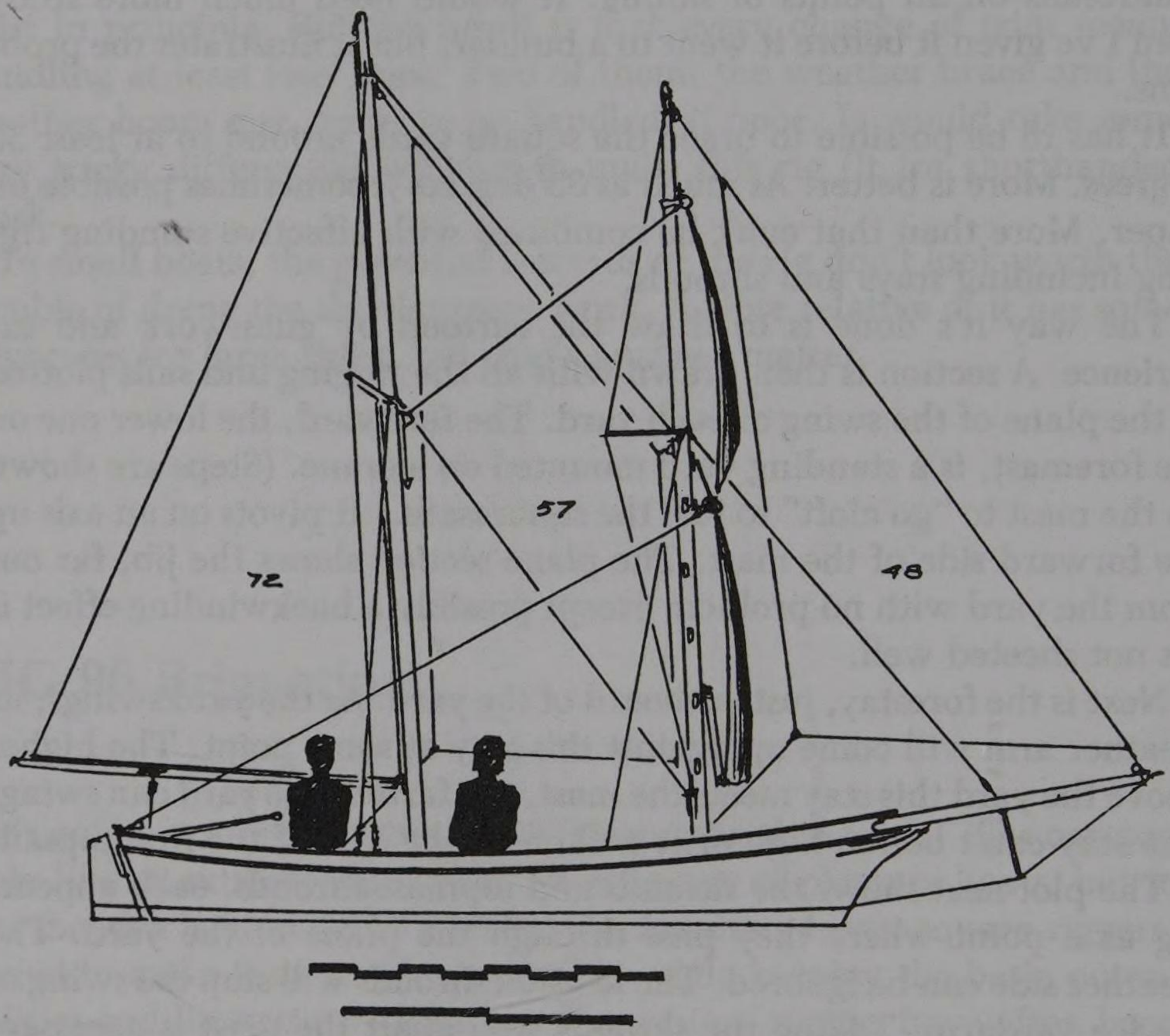
The way it's done is to draw the cartoon by guesswork and experience. A section is then drawn with all the rigging and sails plotted in the plane of the swing of each yard. The fore yard, the lower one on the foremast, is a standing yard mounted on a crane. (Steps are shown on the mast to "go aloft" to furl the squaresails.) It pivots on an axis up the forward side of the mast. The plane section shows the jib, far out from the yard with no problem except possibly a backwinding effect if it's not sheeted well.

Next is the forestay, just outboard of the yard. As the yard swings, its weather arm will come up against this stay at some point. The higher above the yard this stay meets the mast, the farther the yard can swing. The stay can't be too high or it will chafe the foot of the fore topsail.

The plot next shows the shrouds and topmast shrouds, each appearing as a point where they pass through the plane of the yard. The weather side can be ignored. The lee-side shrouds will stop the swing of the lee yardarm. Taking the shrouds well abaft the mast is necessary and convenient, since they then also form good backstays for the headsails. The drift aft of the shrouds is limited by their function as lateral support for the mast. They appear in the head-on view to have a wide spread, but the cross-section will show that if they're brought far aft, the stress on the mast at right angles to the line between the forestay and the shrouds, which is diagonally aft from the forward quarter, finds the mast much less advantageously stayed than the view from straight forward suggests.

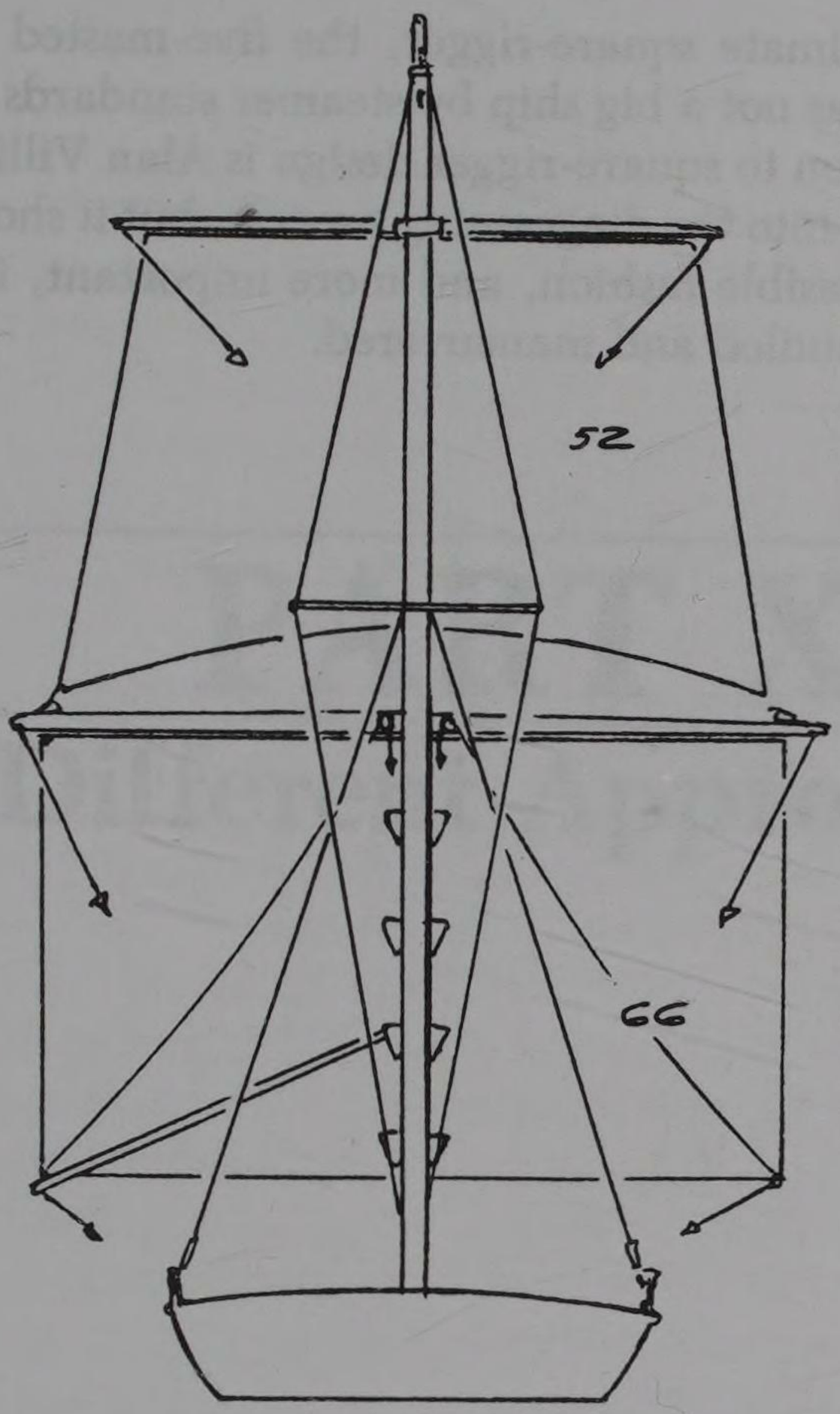
There's some margin when plotting the swing of the yard against the shrouds, because the lee shrouds will be more or less slack.

Next the diagram shows the braces, leading from the yardarms to the after quarters of the deck. The angle the weather brace makes with the yard when braced sharp-up for close-hauled sailing has to be taken into account in deciding how much mechanical advantage is needed to work the braces. The mainstaysail is plotted to make sure it's clear of the lee brace. That brace will be slack, the stress being all on the weather brace.



The topsail yard is plotted in the same way. This yard travels up and down its mast. It's lowered as far as it will go to furl the topsail, and its braces have to have a lead that will allow them to work through the full travel of the yard. In the rig shown in the cartoon, it's likely that the brace lead will turn out to cut into the leech of the main topmast staysail. If so, the staysail will have to be made narrower and lower at the head.

The topsail yard turns on a collar around the topmast. Its pivot axis is the centerline of the mast. This means that it needs less clearance for the headstay and more for the lee shroud. The swing of the topsail yard



should be plotted at each end of its vertical travel, but if the topsail is furled it can swing independently of the fore yard.

The fore-and-aft mainsail also has to be shown on these sections. A common maneuver will be to back the squaresails to stop the boat, while keeping her bow up to the wind and preventing her from gathering sternway by sheeting the mainsail flat. That means that the lee yardarms will be out on the lee bow. The lee braces must clear the close-hauled mainsail in that condition.

I've carried this no further than I had to, to show how complicated it is. The plotting process has to be repeated with each squaresail, up to

30 of them in the ultimate square-rigger, the five-masted *Preussen*, which, by the way, was not a big ship by steamer standards. The best book for an introduction to square-rigger design is Alan Villiers's *Way of a Ship*. It doesn't go into the diagraming process, but it shows all the gear in the clearest possible fashion, and more important, it explains how the ships were handled and maneuvered.

PART XI

Different Approaches

RIG 97 Kite sail

The usual limit on the amount of sail, that is, the driving power that a boat can carry, is the heeling force of the rig. The inevitable evolution of any sailing type has been toward more stability, more power to carry sail. Examples are the sandbagger with her live and shifting ballast, the canoes with crews out on outriggers to windward, and the catamaran with her feet wide apart. So is the 600-year change in the shape of Viking craft from the narrow, slack-bilged Nydam and Sutton Hoo ships to the beamy, flat-floored Gokstad ship.

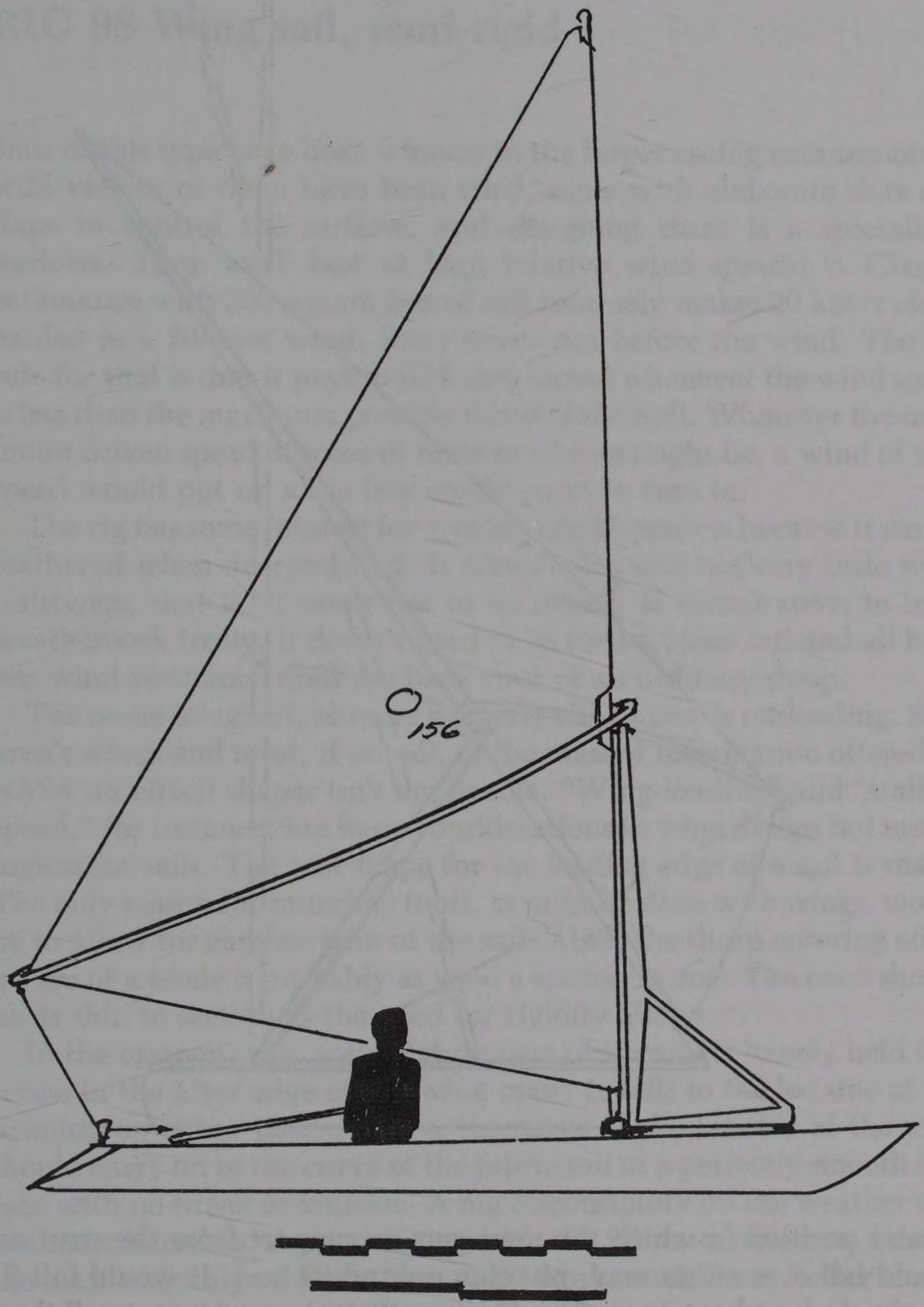
The opposite approach is by way of a sailplan that has less heeling effect; this is less studied because it's much harder to accomplish. The sloping lateen yard, raking masts, and staysails with sloping luffs all have an upward component in their drive that lessens heeling. Unless the slope is exaggerated, the effect isn't dramatic.

From time to time somebody tries to build a kite sail, one in which the aggregate vector of forces generated by the sail passes through the boat's center of gravity or lateral plane. In theory, such a sail has no heeling effect. One built in the 1930s came so close that the small hull sailed upright in a gale of wind that finally blew the rig away in pieces. The catch was that to meet the geometrical requirements, the sail had to be so small and low that the boat was helpless in light airs. The rig was also complicated to handle, expensive to build, and hard to stow. Nobody managed to build a practical one until the special case of the free sail came along (see Rig 5). It works by a combination of live ballast and aerodynamic lift that can't be duplicated above a certain very small size of rig.

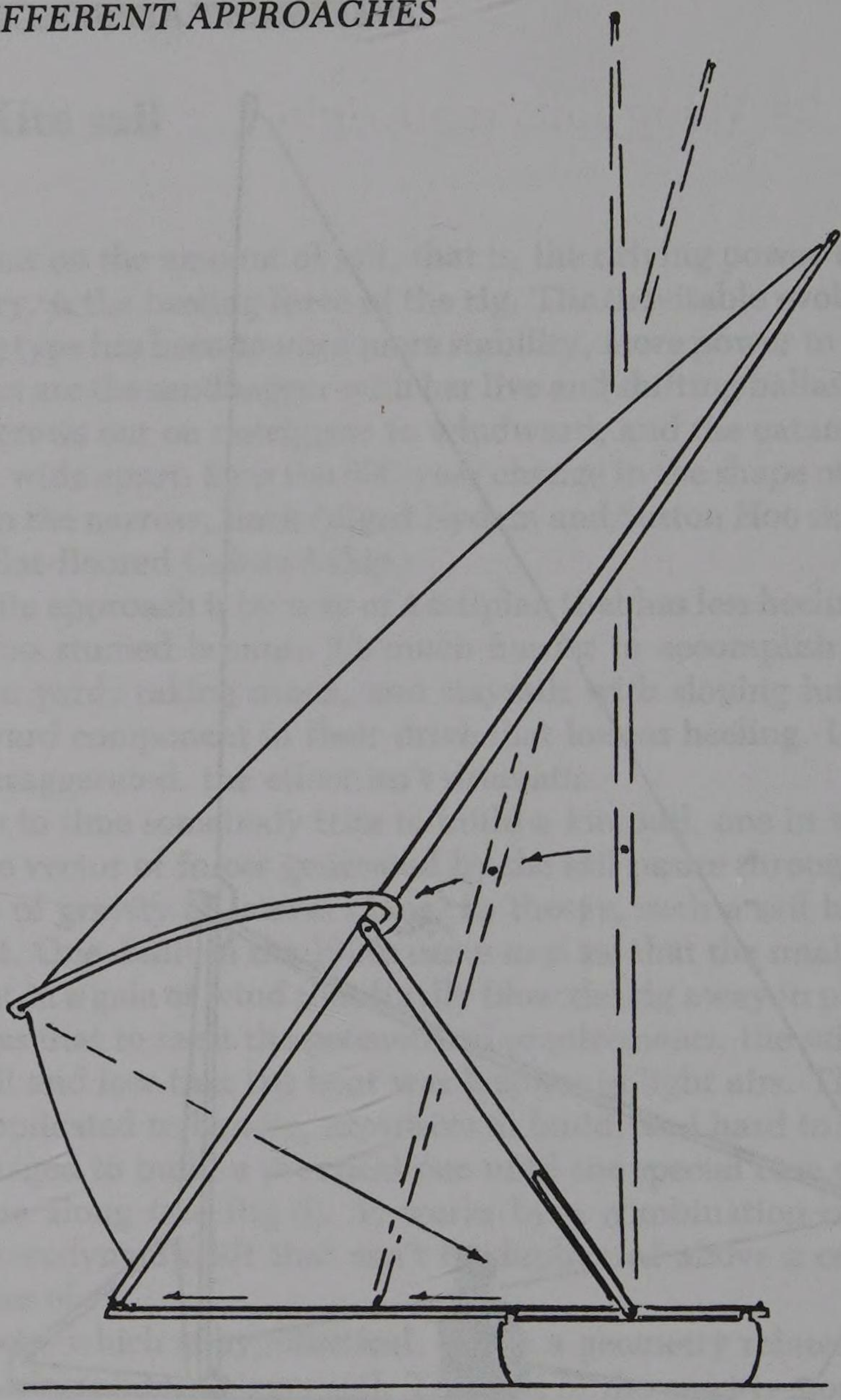
This cartoon, which is hypothetical, shows a geometry related to a free sail but adapted to a bigger sail. The heel of the mast is mounted on an athwartship slide on an outrigger, which in turn slides from side to side. In a neutral position with the outrigger centered on the hull and the mast centered on the outrigger, the mast is vertical for best drive in light airs. As the wind increases, the outrigger is slid out to leeward and the heel of the mast slid to the lee end of the outrigger.

The mast is supported in the fore-and-aft plane by a strut braced to stand vertical in the fore-and-aft plane, and pivoted on a horizontal axis to allow the heel of the mast to run out to leeward. When it's all the way out, the heeling effect is practically nil — in theory.

This idea won't work without much more elaboration than is shown, if at all. The transverse movement of the heel of the mast would have to



have positive control with a "Line-driver" type of winch. The track and slides would have to be strong and very well made. The real problem is the instability of the mast in the neutral, centered position. As it comes up vertical in passing from one tack to the other, there's a dead-



center position in which the mast gets no support from the strut and could fall over either way, pivoting around its heel. It would fall flat on the deck and outrigger, breaking mast, strut, outrigger, or all three. Some kind of running shrouds could no doubt be devised to cope with this. Perhaps they could even be hooked up to some of the other moving parts to work automatically.

I'm making no assertion that the dead-center problem is the only one with this scheme. It's obviously flimsy and vulnerable at best. The cartoon is just an illustration of the kite principle that's at least superficially workable over a fair range of conditions.

RIG 98 Wing sail, semi-rigid

Sails of this type have been winners in the larger racing catamarans. A wild variety of them have been tried, some with elaborate slots and flaps to control the airflow, and designing them is a specialized business. They work best at high relative wind speeds: A Class-C catamaran with 300 square feet of sail routinely makes 20 knots close-hauled in a 20-knot wind. They never run before the wind. The old rule for that is that it pays to tack downwind whenever the wind speed is less than the maximum possible speed of the hull. Whatever the maximum driven speed of some of these machines might be, a wind of that speed would put up a sea few would want to race in.

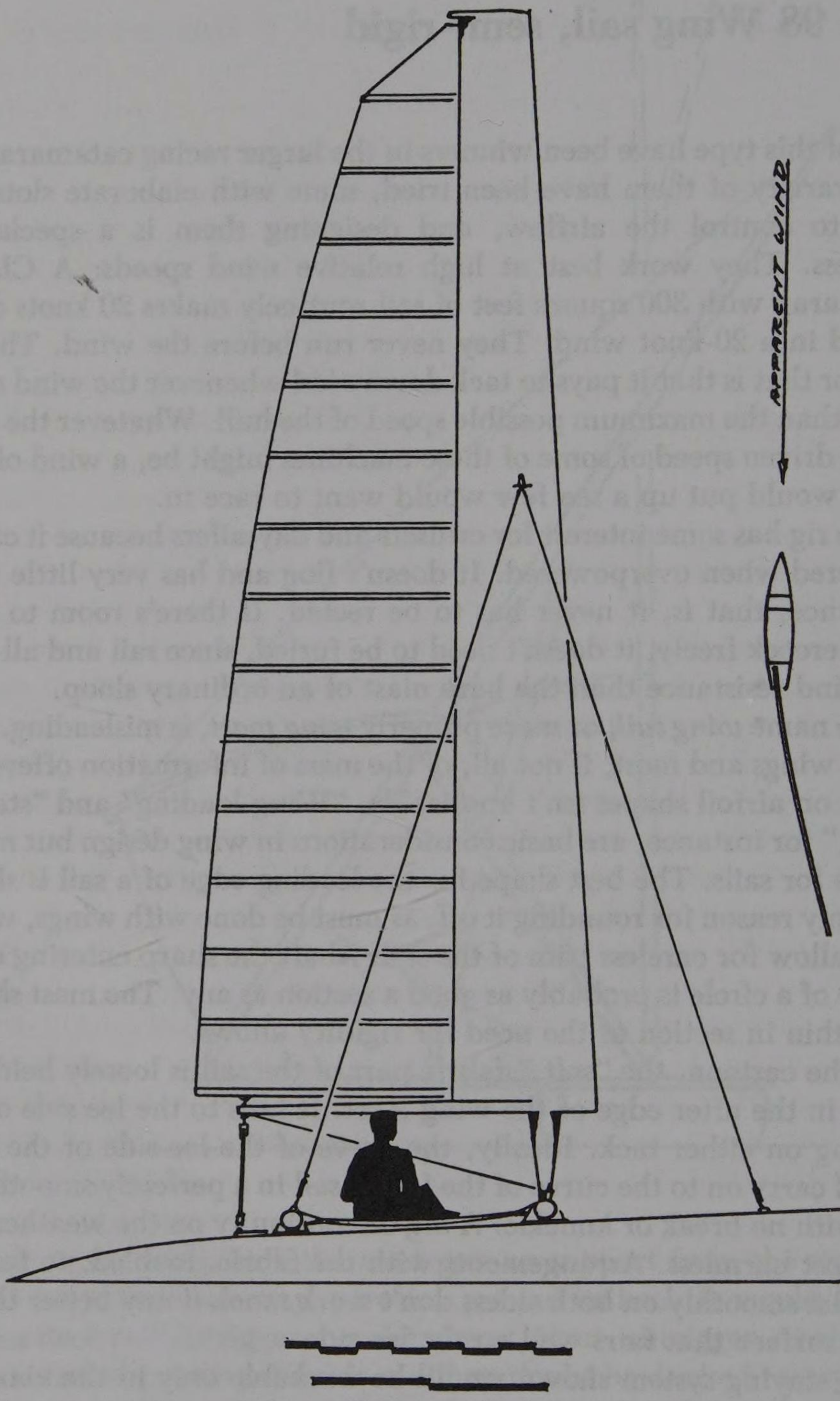
The rig has some interest for cruisers and daysailers because it can be feathered when overpowered. It doesn't flog and has very little wind resistance; that is, it never has to be reefed. If there's room to let it weathercock freely, it doesn't need to be furled, since sail and all have less wind resistance than the bare mast of an ordinary sloop.

The name *wing sail*, or more properly *wing mast*, is misleading. Sails aren't wings and most, if not all, of the mass of information offered by NASA on airfoil shapes isn't applicable. "Wing-loading" and "stalling speed," for instance, are basic considerations in wing design but meaningless for sails. The best shape for the leading edge of a sail is sharp. The only reason for rounding it off, as must be done with wings, would be to allow for careless trim of the sail. Abaft the sharp entering edge, an arc of a circle is probably as good a section as any. The mast should be as thin in section as the need for rigidity allows.

In the cartoon, the "soft," fabric part of the sail is loosely held in a recess in the after edge of the wing mast. It falls to the lee side of the opening on either tack. Ideally, the curve of the lee side of the mast should carry on to the curve of the fabric sail in a perfectly smooth surface with no break or knuckle. A big discontinuity on the weather side is almost harmless. Arrangements with the fabric doubled, to fair off the mast smoothly on both sides, don't work much if any better than a single surface that fairs well on the lee side.

The staying system shown would be workable only in the very fast types that are always close-hauled or nearly so, due to their speed pulling the apparent wind ahead of them. A cruiser or other modest performer would work best with an unstayed mast.

Apart from being outside the experience of most designers, so that most such rigs are far from optimum shape and proportions, the main objections to this rig are that it's extremely expensive to build and



maintain, and that it's either heavy or fragile. The inherent fragility is local. Such a rig can be built that is structurally sound without being heavy. That applies to either stayed or unstayed rigs. But it has to be

done by exploiting the bulk of the wing mast to build a bulky girder. The streamlined envelope allows this, but to make it light the mast has to have large areas of very thin, rigid walls, like an egg shell. Fliers are used to guarding such vulnerable surfaces, but sailors are apt to expect their gear to stand rougher treatment.

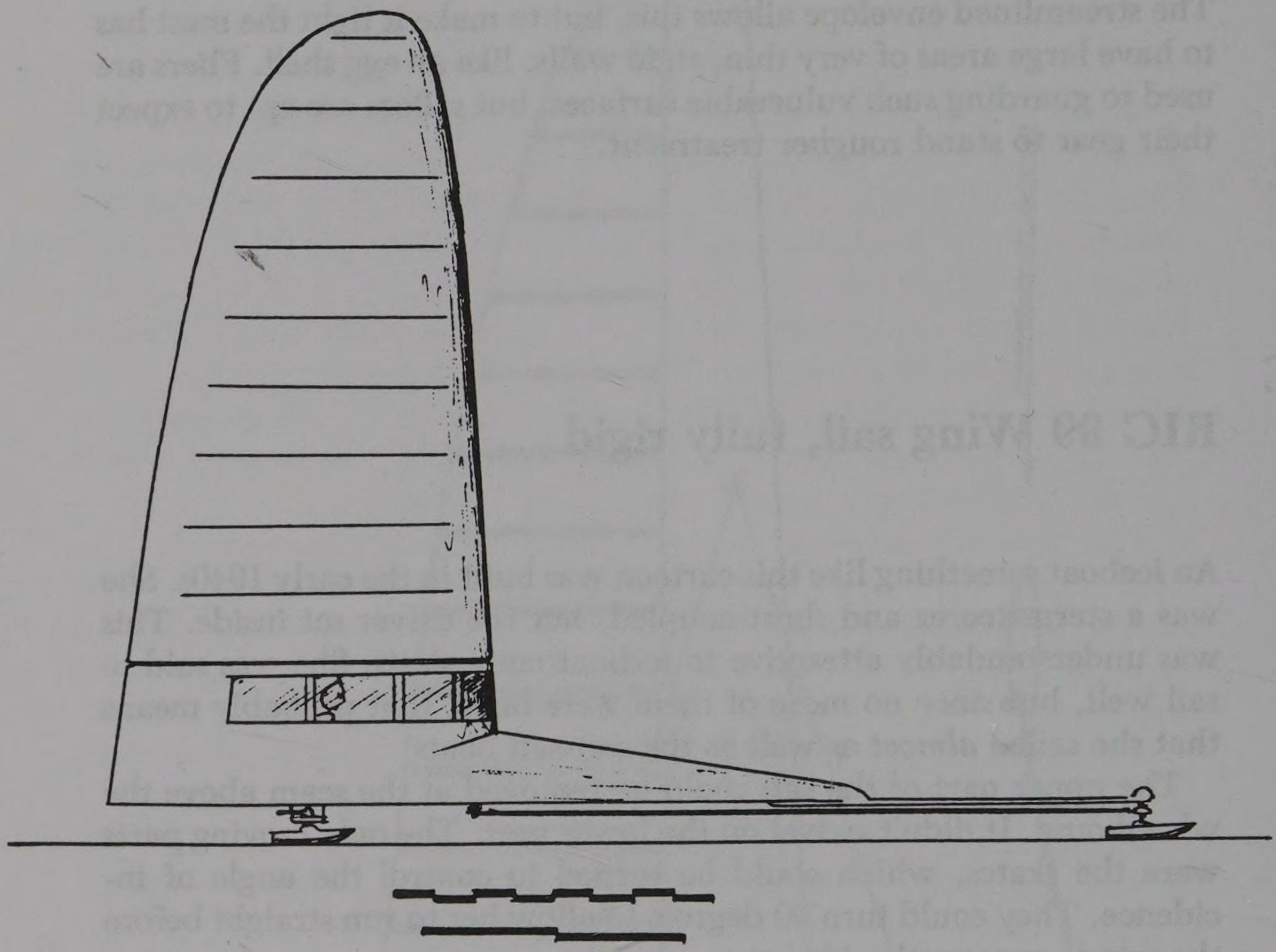
RIG 99 Wing sail, fully rigid

An iceboat something like this cartoon was built in the early 1940s. She was a stern-steerer and short-coupled, but the driver sat inside. This was understandably attractive to iceboat enthusiasts. She was said to sail well, but since no more of them were built, that probably means that she sailed *almost* as well as the soft-sail boats.

The upper part of the sail could be removed at the seam above the wheelhouse. It didn't swivel on the lower part. The only moving parts were the skates, which could be turned to control the angle of incidence. They could turn 90 degrees to allow her to run straight before the wind, apparently sideways.

A few small boats have been rigged with fully rigid sails of this type. They rotate on the hull, of course. The attraction is the same as that of the semi-rigid sail discussed in Rig 98 — they can be feathered in strong winds instead of furling or reefing them. They'll drive a boat, but not very powerfully as compared with a single-surface, curved-plate sail. To work on both tacks, the sectional shape has to be symmetrical, which means that the entering edge has to be rounded, like a wing. Such a shape has more drag and less drive than the curved plate.

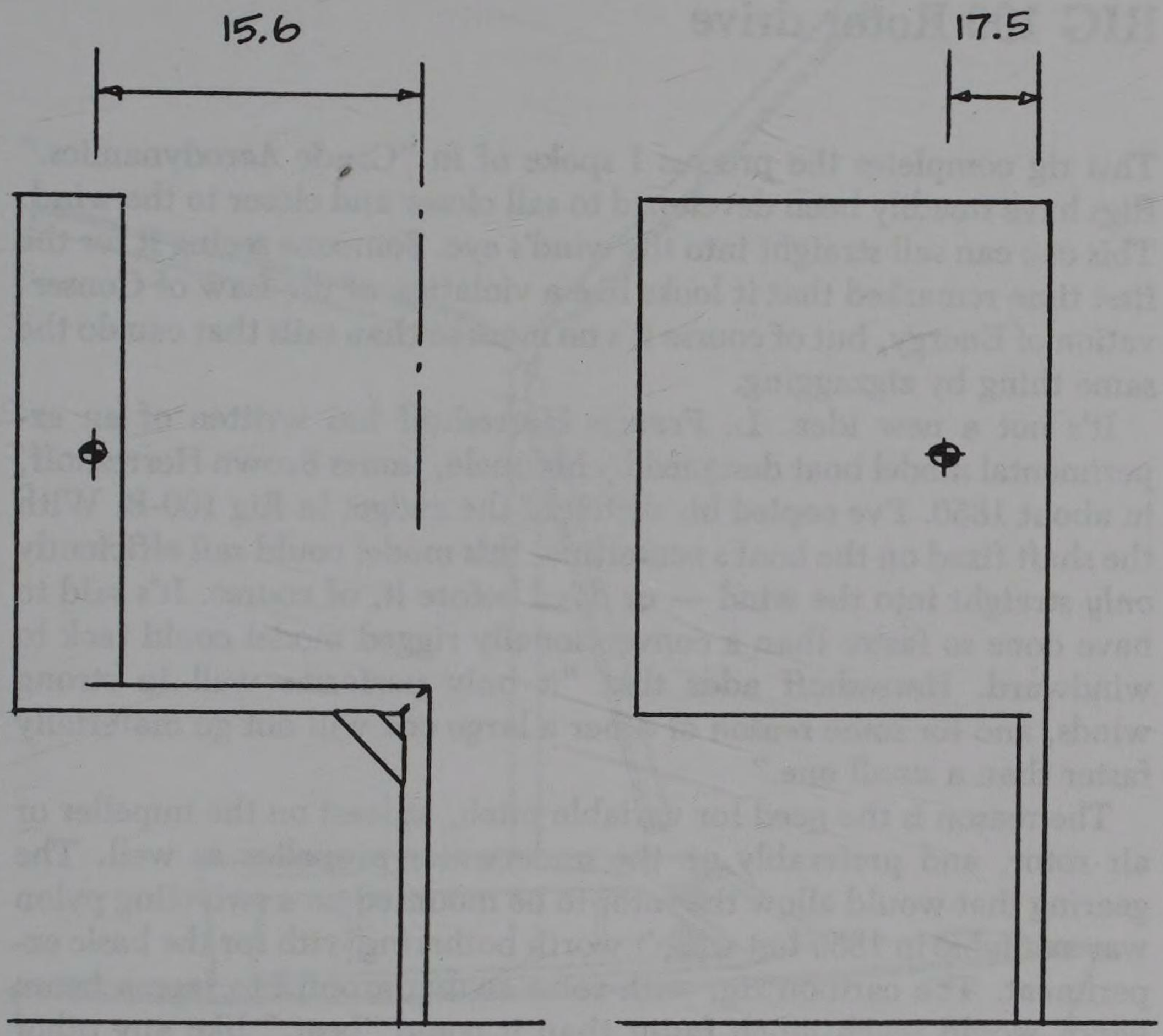
Such rigs tend to be built too small for the boats. The wings of aircraft are surprisingly small. A DC-9 airliner, for instance, which is a big machine about 120 feet long, has wings only about 40 feet long and 500 square feet in area. The apparently long, tern-like wings of sailplanes are, at the most extreme, only 35 feet long out from the "hull." A structure like this, which is big enough to drive even a small boat, is extremely expensive to build, is apt to be heavy compared with even a primitive soft-sail rig, and is hard to store and worrisome if it's left standing. It doesn't have much wind resistance when it's feathered,



but it's not always convenient to have it weathercocking — in a marina, for instance.

Some such rigs have been built with more or less flexibility in the trailing edge. These merge into the semi-rigid types like Rig 98. Others have hinged flaps on the trailing edge. So far they've shown promise only in the larger racing catamarans. In boats working with 40- and 50-knot apparent winds, such a sail can be trimmed flat without being blown aback as a soft sail is. Rigid sails are worth thinking about as storm sails and riding sails in cruisers for that reason.

They're often used as the vanes of self-steerers. This type of foil is like a wing, in that at moderate angles to the wind the pressure center is about a quarter of the chord from the leading edge. In a vane four feet wide, the center is a foot from the "luff." A narrow vane offset from its axis is much more powerfully self-centering than a broader one with luff on the axis, even if the trailing edges are the same distance from the



axis. The point is becoming somewhat moot as self-steerers controlled by the relative wind direction are replaced by steadily improving electronic steerers, solar powered and compass controlled.

(A rigid "sail" on a different principle was the Flettner rotor. This was simply a tall cylinder, like a silo, that rotated on a vertical axis. When the wind blew against the rotating cylinder, thrust was produced. The "rig" was invented as auxiliary boost for large motorships, but it was tried in a 22-square-meter racing boat in Sweden. The boat sailed, but very slowly. A motor running continuously is needed to spin the cylinder.

It's a crying shame that this device didn't come along at the time when steamers had to have tall stacks for their boiler uptakes . . . .)

RIG 100 Rotor drive

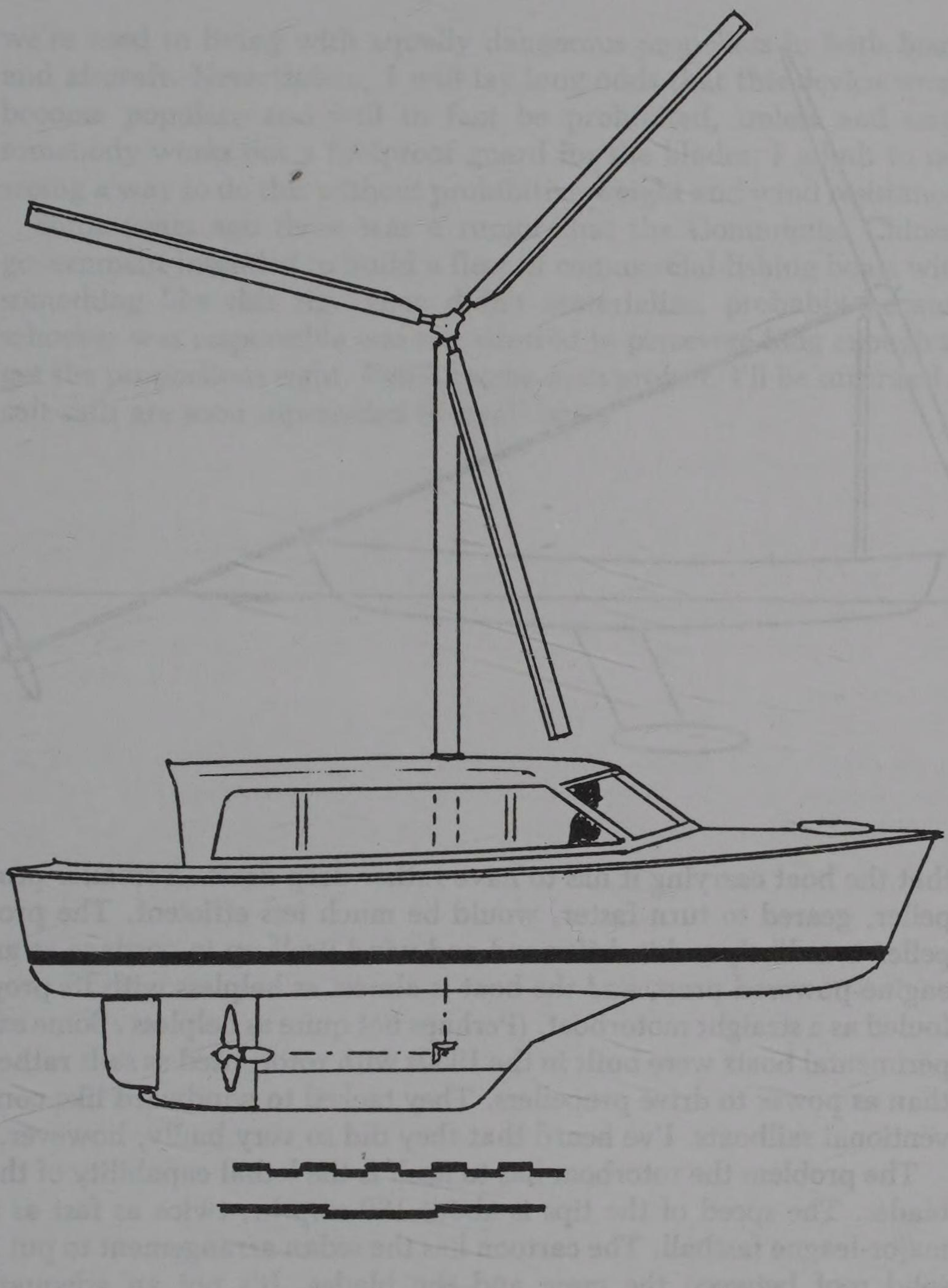
This rig completes the process I spoke of in "Crude Aerodynamics." Rigs have steadily been developed to sail closer and closer to the wind. This one can sail straight into the wind's eye. Someone seeing it for the first time remarked that it looks like a violation of the Law of Conservation of Energy, but of course it's no more so than sails that can do the same thing by zigzagging.

It's not a new idea. L. Francis Herreshoff has written of an experimental model boat designed by his uncle, James Brown Herreshoff, in about 1850. I've copied his sketch of the gadget in Rig 100-B. With the shaft fixed on the boat's centerline, this model could sail efficiently *only* straight into the wind — or dead before it, of course. It's said to have done so faster than a conventionally rigged model could tack to windward. Herreshoff adds that "it only performs well in strong winds, and for some reason or other a large one will not go materially faster than a small one."

The reason is the need for variable pitch, at least on the impeller or air rotor, and preferably on the underwater propeller as well. The gearing that would allow the rotor to be mounted on a swiveling pylon was available in 1850 but wasn't worth bothering with for the basic experiment. The cartoon rig, with rotor swung around to face a beam wind, would reach much faster than it could "beat," like any other sailboat.

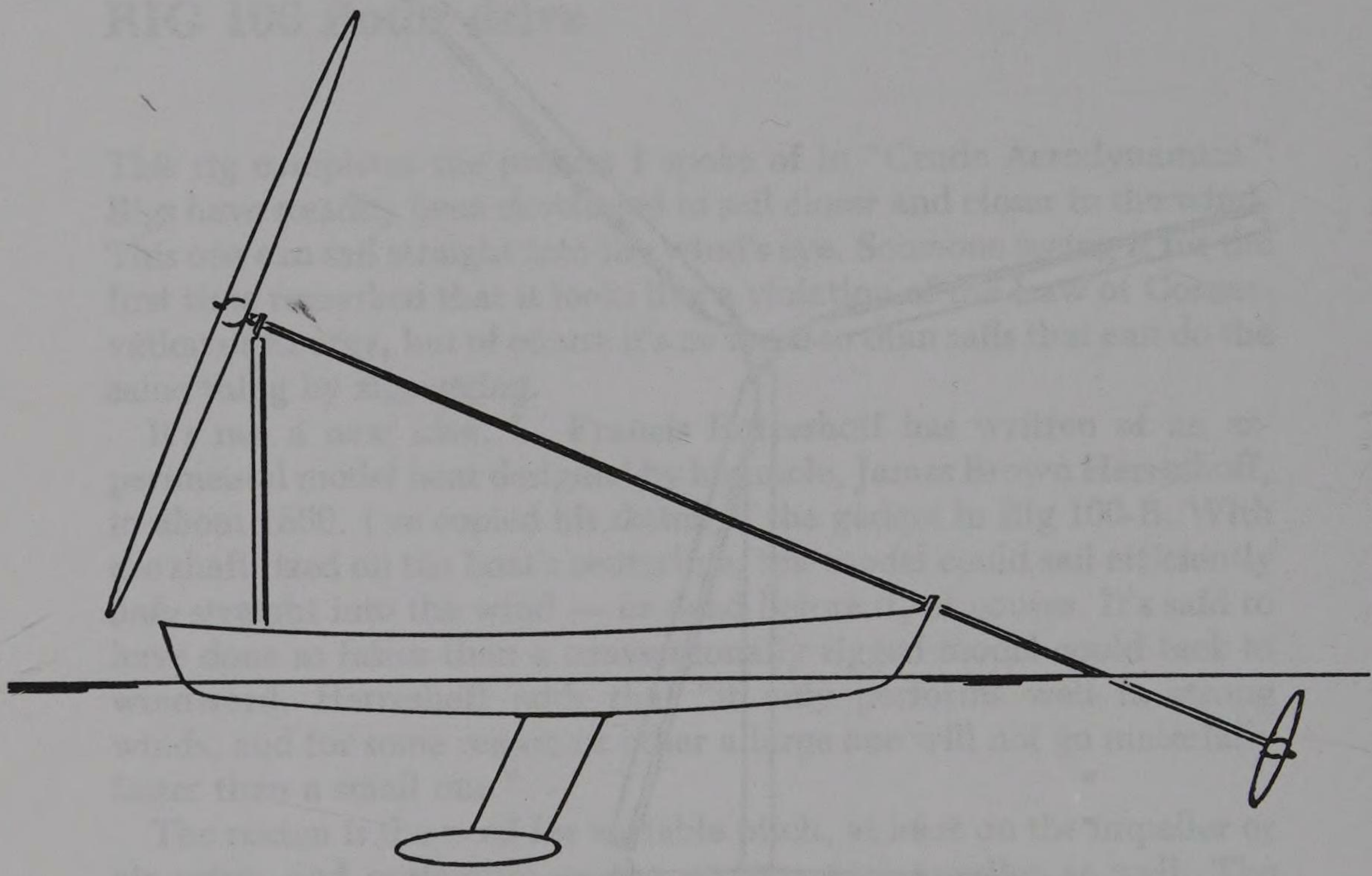
It's based on a boat built in New Zealand, which had a rotor 26 feet in diameter, turning 400 r.p.m. maximum, and driving a 36-inch-diameter-by-36-inch-pitch, three-bladed propeller through 2:1 reduction gears. The boat was said to be able to drive straight into the wind at four knots. That's 33 percent propeller slip and seems conservative. A lot of accumulated experience would be needed to find the best relative diameters of impeller and propeller, even if they both had variable pitch. The best chord and section for the rotor blades need specialist advice, presumably from somebody working with generating windmills. Very likely the blades shown here are too narrow.

The "sail area" of an impeller like this is supposed to be comparable to the area of its swept disk — in this case, 530 square feet. With the rotor blades feathered, the rig has very little windage compared with any conventional rig of the same power. I see no reason why it couldn't be built with all its components strong enough to be fit to weather a gale.



It promises fine handling. It's independent of the wind direction, can "reduce sail" with a few twists of a wrist, and if the underwater prop is reversible it can stop short and back up. It can be turned without headway, like a powerboat, using the propeller stream against the rudder.

There are some problems. The large underwater propeller means



that the boat carrying it has to have rather deep draft. A smaller propeller, geared to turn faster, would be much less efficient. The propeller is as likely to hit driftwood and wind itself up in cordage as an engine-powered prop, and the boat is almost as helpless with its prop fouled as a straight motorboat. (Perhaps not quite as helpless . Some experimental boats were built in the 1930s with rotors used as sails rather than as power to drive propellers. They tacked to windward like conventional sailboats. I've heard that they did so very badly, however.)

The problem the rotorboat has to itself is the lethal capability of the blades. The speed of the tips is about 180 m.p.h., twice as fast as a major-league fastball. The cartoon has the sedan arrangement to put a solid roof between the crew and the blades. It's not an adequate precaution. Sooner or later, a hand or a head will bounce once on the deck and roll overboard, leading to a lawsuit. The idea of a fleet of rotorboats crowding each other at a racing mark calls to mind the war chariots with spinning scythes on their axles.

Bringing up considerations of this kind is irritating to inventors. They naturally resent having a technical irrelevancy raised as an obstacle to a promising development. In this case they'll point out that

we're used to living with equally dangerous propellers in both boats and aircraft. Nevertheless, I will lay long odds that this device won't become popular, and will in fact be prohibited, unless and until somebody works out a foolproof guard for the blades. I admit to not seeing a way to do this without prohibitive weight and wind resistance.

Some years ago there was a rumor that the Communist Chinese government intended to build a fleet of commercial fishing boats with something like this rig. They didn't materialize, probably because whoever was responsible was not allowed to persevere long enough to get the proportions right. Failing some such project, I'll be surprised if soft sails are soon superseded in small boats.

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ADDENDUM RIGS 101-103

by

Susanne Altenburger
Full Partner in Phil Bolger & Friends Inc.
(August 1998)

Since the first 100 chapters in this book were written in the early 1980s there's been more time for thought. Over 200 boat designs have been finished in this office since then. Amongst those, a growing number of sailing craft have been drawn with various versions of what we've come to call the Chinese Gaff Rig. Reports on the performance and handling of the first 525 sq. ft. cat version of the new rig are encouraging indeed, confirming our reasoning as to the utility and economy of this geometry. So far sail-areas of new designs range from around 260 sq. ft. to around 1200 sq. ft. per sail on mono- and multihulls between 1.500lbs and 63.000lbs. In deviation from the previous shorter commentaries, these new geometries warrant a longer discussion.

Problems with the 'One-Type-fits-All' State of the Art

As the previous 100 discussions have shown, history offers a broad variety of ways to make sailing craft perform. Dramatically different solutions can be found from culture to culture, or, at times, just fishing village to fishing village only a few miles apart. And the evolution of rigs has by no means come to a halt.

On the other hand, at least in pleasure craft, from liveaboards to racers, global reach of certain ideas has resulted in an embrace of rather a narrow range of alternatives in sailing rig geometries. Indeed, if seen in the context of the still growing body of available knowledge of opportunities to rig a boat, an *implausible* reduction of options is dominating thinking, production, and use of rigs on pleasure boats.

Almost exclusively pursued in a myriad of different detail solutions are variations of the three-sided high-aspect ratio sail/spar geometry. It is usually proposed under the premise that maximizing actual and presumed 'efficiencies'

per given squarefoot of sail is the primary variable in the quest for rig-performance on a given hull geometry. This book has already commented on a broad range of single and multi-sail examples of three-sided sails on single and multiple masts, touching on basic strengths and weaknesses of this dominant geometry.

Aerodynamic theories, wind-tunnel testing, and hands-on experimentation on an historically unprecedented world-wide scale have by now produced a broad agreement as to the apparent 'correctness' of that reasoning. Short of going taller yet and ignoring for the moment additional hardware and ropage for third and fourth sails per given mast, getting more sail-area per given mast/boom-length on a nominally tri-angular cloth geometry can only be achieved by dramatic roach increases high up, using various geometries in a high-tension cloth, batten, and spars arrangement.

The currently dominant geometry thus

- maximizes mast height,
- limits boom length,
- and often attempts to essentially 'square' the tall narrow sail,
- all of which is dependent for its aero-dynamic and mechanical integrity upon high-quality rigging hardware maintaining significant continuous and peak tension,
- supported by a hull-structure adequate to the task of maintaining these high stresses at particular locations to particular angles across the boat's life-time,
- and finally upon of course equally high-tensioned fore-sail(s) geometry to at all achieve adequate sail-area per given weight and drag.

With modern materials carefully assembled, this is one well-established way to pursue performance - assuming owners' willingness and wherewithal to accept significant up-front costs and short to mid-term maintenance to control at times surprisingly rapid 'aging'.

Consequently, the dominance of this approach has produced a high level of uniformity across the sail-boat spectrum - racers and cruisers very much alike. Many of the experts are by now proficient in essentially just this one kind of rig-geometry, aware of alternatives only as 'quaint' distractions, such as the few instances of 'character boat'-related 'old' rigs, deemed thoroughly irrelevant when it comes to performance on modern sailing craft. Actually even proponents of 'other' rigs are frequently not free from that complex.

Someone is always eager to write yet another tome on the subject of 'the proper rig', making the same points over and over again - with model-year upgrades for the next edition -, until the last self-proclaimed textbook on the matter has finally been purged of any serious discussion of alternatives, offer-

ing just distilled 'essence' in the form of just *one* small family of 'relevant' sail-geometry, carried by at best two or three 'stock' hull-shapes.

In the context of 'information-age' and growing personal freedom, it is remarkable indeed, how 'deviation' from what is unquestioningly embraced as de facto 'revealed truth' of modern rig design is by now a rather improbable intellectual occurrence. Emotionally it may perhaps be understandable as a quick fix to quench some thirst for 'certainty' - no doubt 'market research'-confirmed (!) - in a commercial environment where incessant model-cycle driven episodes of self-proclaimed rigor of rigors leaves ever less room for relevance.

But most sailors, whether they trust the experts' apparent canon or not, have to follow the dictate of this 'conventional' rig as a matter of sheer momentum in the market place. The broad sailing public has thus become conditioned to be at least wary of any viable alternatives. If questions ever emerge at all, users, prompted by their favorite expert, reflexively point to that geometry's widely published virtues, and shrug off its inherent and obvious problems as 'inevitable' and thus apparently 'acceptable' - if these inherent short-comings are noted at all by now. Indeed, while many are just plain unaware that the 'givens' of this rig are not 'normal', many otherwise well-endowed people block their impulse to critically assess *how much this type of rig actually imposes significant limits* on their options in choosing their boat, pursuing their cruising and racing, and trying to maintain and repair it.

On all sides, there is a strong element of convenience in maintaining well-trodden paths of understanding, designing, engineering, marketing, paying for, and finally living with this 'proper rig' - whether in each sailor's individual case it makes much sense or not. No doubt you could argue philosophy endlessly as to whether the 'market place' - boating and otherwise - will inevitably lead to the dramatic narrowing of widely-offered options under an explanation of 'efficiency', or whether the market-principle has never functioned freely in this case because it is manipulated by those, who in pursuit of the 'perfect racing/rating rules' have been responsible for hardware-intensive, utility-reducing, and therefore costly and thus inherently *inefficient* solutions to rigging a boat, not to mention a long and growing fleet of decidedly unwholesome examples as to how to bend and break that rule - usually obsolete before some write-off schedules have run their course.

Apart from the occasional editorial 'fig-leaf' exercise, referees are absent from this game, with the occasional 'quaint rigger column' of course subject to predictably strict limits as developed from 'demographic' surveys and advertisers' opinions. Beyond a few notable exceptions, how many boating journalists and magazines can actually afford to act as serious referees, soberly ques-

tioning some of the basics upon which their pay-checks depend. It seems to matter little how economically short-sighted that dictate may actually be for all involved in that industry; how many marinas can you build along a finite shoreline, to fill with lookalike craft suffering the same shortcomings, before saturation is reached. Along with once 'noted' builders of experience and economic relevance in their community, quite a few of well-known periodicals have gone under, some of them magazines coasting clearly 'readerless' solely on advertisers believing readership-research data, but some of them more 'real' periodicals with an actual following of eventually disappointed readers. Usually there are prompt replacements started up, eager to fill the sudden void often doing the same thing, 'only better', until 'merciless' competition has decimated the number of clones 'yet again'...

Much more defensible is *this* book's candid discussion of broad options, available ranges of opportunities, and the numerous promises of stimulating alternatives, which are plausibly more likely to suit the various conditions of the endless variety of sailing craft than the leaden 'one-type-fits-all'-approach. You would assume particularly cruising sailors would be more 'independent' in their thinking!?

Questioning the 'canon' is easy enough. Leaving aside as irrelevant the particular P.R. logic that produces decals-covered professional racers and their floating athletic devices, 'real-world' cruisers and weekend warriors could spend the winter-season looking at their boat-expense account and contrast that with their logbook entries in an assessment of last year's actual cost versus benefit equation. Soberly approached, without undue optimism or bending facts, the actual reality of the dictate should give pause.

> The philosophical problem is the underlying assumption, that ***'drive per given squarefoot of sail'*** is the overarching concern in the theoretical and practical assessment of possible sail geometries, particularly those of the main-stream application of cruising craft.

- First of all, aerodynamicists, among others, can still argue whether the current western triangular geometry is indeed 'the most efficient' of all known rigs, never mind the other already conceivable ones. Respective practical comparative tests, even the more serious and expensive ones, have frequently been riddled with obvious but unaccounted assumptions resulting in conclusions of remarkably limited value.
- Secondly, any philosophical claims to technical 'efficiency' can only collide head-on with the reality of inherently *arbitrarily defined* racing/rating

'rules'. The deep chasm between scientific procedure, and that of an assembly of parties interested professionally and financially in the next seasons of fun and games racing boats, is quite obvious. No matter how many learned theorists, savvy class/club-organizers, forward-looking corporate sponsors, and seasoned/leathered professional sailers sit on racing/rating-rule boards, the record of such assemblies of minds throughout this century has proven repeatedly that the combined wisdom does not/can not aspire to pursue 'efficiency' in any hard definition. What these collections of minds do accomplish is to direct the focus on certain design details that are perceived as promising *racing* performance/'fun', and are presumed to matter to the more main-stream boaters as well, usually helped by a heavy glossy dose of PR to 'make it matter'.

Therefore, a subjective rule, which, for instance, measures sail-area as a matter of rating boats, is inevitably going to cause concentration on maximizing performance per given sail-area. Whether this focus requires just plain extra cost, or actually has multiple obvious and less obvious impact throughout the whole design, is secondary, and essentially to be seen as part of doing 'racing' business.

On the one hand, efficiency as defined by 'power per given area of cloth' might constitute actual aerodynamic progress fostered by the rule's focus on area. But if the inherently arbitrary preoccupation with this single variable compromises the rest of the design, the definition of *technical efficiency* in respect to the whole boat is up in the air again, conceivably reduced overall.

- This points directly at the third problem in this matter. It is the challenge of soberly defining 'efficiency' beyond some arbitrary rule's narrow focus on a boat's single or three particular 'desirable' attributes. The *systemic whole* of a sailing craft depends for its conceptual and practical viability on a *coherent integration* of many different dimensions of concern.
  - Initial and continuing cost matters.
  - So does daily utility cruising, racing, or just 'bumming around' in the craft across a broad variety of off- and inshore waters, under multi- or single-crew circumstances, and preferably delivering performance throughout four seasons beyond the 'balmy belt', all in order to offer pleasure to the owner and crew, rather than another source of stress in their lives; if a pleasure boat does not 'please', it has little to excuse its existence.
  - Next, there is the vital technical issue of reliability away from the umbilical cord of tech-support.
  - Ergonomics is a major concern as risk of fatigue, injury, or hardware damage can have serious consequences.

- Structurally will the hull be able to handle the rig's strain mid- to long-term.

Such serious concerns go far beyond the narrow pre-occupation of 'efficiency per given sail area'. And yet, copying the 'findings' from the racing circuit in cruisers for instance, many boats' overall capabilities are subjected to degradation in a number of these important areas by attributes deemed related to and thus defensible by 'speed'.

Which 'efficiency' is then on the table? There are the very obvious and serious issues related to matching rig to hull-shape, matching rig to the projected use, and matching rig even to particular waters - the remarkable idea notwithstanding of a well-established cruising club years ago protesting the construction of bridges across 'favorite' cruising waters as too low at 'merely' 60+ feet.

In this environment of arbitrary narrow rules compromising the 'overall efficiency' of a large percentage of cruisers as well, could deeply entrenched representatives of 'the canon' conceivably ever issue a plausible list of 'desirable characteristics' and not immediately be mired in the morass of decades of racing-oriented assumptions, particularly those they have not questioned in years and are now taking as 'given'/laws of nature - such as, for instance, the continuing primacy of 'power per given sail-area'?!

What currently passes for 'conventional knowledge' - frequently even hinted as being a 'scientific rigor' - may be fine for intellectual coasting on the wave of the tried and (presumably) true. And it offers decided advantages for all levels of purveyors of 'proven' racing-derived ideas and hardware, when offered to the cruising public at serious mark-up 'per given hour of sailing'. Not surprisingly then - 'rigor' always attracts with the good feelings it bestows for little effort - the professional, industrial, marketing, and personal intellectual momentum is too strong to see even 'up-and-coming' people willing to question it seriously - they are supposed to be carefully raised and prodded to eventually join the 'trenches'.

It would take limiting one's monetary expectations, a thicker than average skin resisting professional pressures towards conformity from the 'as yet unrepentant' fellow brethren - "be professional!". And it would require opening the mind and jealously keeping it that way to pursue different opportunities. But most importantly, as a matter of actually doing the work, it would take practice, persistent experimentation in the face of opposition and risk of 'egg-on-your-face' ridicule, and more practice yet, to develop at least a minimal level of dexterity from which to push the envelope increasingly vigorously; doing one 'different' design every once in a while in an attempt at catharsis won't cut

it, as many embarrassingly 'underdone' examples demonstrate periodically.

Getting to that point of independence is rather a tall order indeed - even without the sniping from the self-proclaimed 'main-stream'. But it does happen perhaps just enough to at least offer a refreshing counter-point to the at times frenetic spectacle of - 'thank Ford' - developing the latest twists on the well-entrenched concepts to keep them 'relevant to the market' one more cycle, with gloss, patents, 'babes' and all.

Looking at the issue from a position of such independence, it could readily be argued, that rather than internalizing as 'given' the continuing upward-trend of 'acceptable' stresses on rig, hull, crew, and budget per mile sailed, an actual reduction in mechanical, financial, and physical exertions would be a sign of 'advanced' thinking, engineering, and use indeed.

Furthermore it should be argued that 'real world' concerns of extended living with the rig must drive the discussion of 'advancing the state of the art':

- Whether racing across the local bay for a day or circumnavigating, *keeping the number of sails low* necessary to keep the boat moving would be an advance, favoring alertness of the crew as a serious performance-enhancing factor over the fatigue and on-deck hazards generated by the effort of constantly setting and dropping foresails and more sails in response to varying wind- and sea-conditions.
- Whether racing for an afternoon or cruising offshore, reducing excessive-mast-length related top-hamper and aero-dynamic drag - under full sail or reefed - should yield advantages in terms of speed, stability, and safety.
- Whether for trailer sailing or full-time blue-water cruising, concepts such as 'On-Deck Masthead Work' have immediate hands-on safety-enhancing, cost-reducing, independence-supporting meaning.
- Whether you can afford every gold-plated fitting in that glossy catalogue or have to scrounge for cast-off bits and pieces of hardware, *keeping the over all number of vital rigging parts low* inherently enhances reliability on your afternoon-sail or off-shore-safety in a gale.
- And it would be a serious advance if the rig's overall risk from high-tension geometries and chafe were designed out of the boat before any parts are bought at all.
- If whatever parts remain were largely of the simple and almost universally available type readily identifiable far from reams of specialized hardware catalogues at 'tech-support', there may really be a contribution to useful progress in the area of sailing rigs.

The 'canon' is indeed just a small piece of the spectrum, and its de facto dictate disproportional to those virtues it does possess. Other options clearly exist

for more affordable, more utilitarian arrangements of cloth and hardware, a good comforting distance 'back from the ragged edge' of the ascetic, freeze-dried rush, consisting of speed at any expense and the flavor of performance-enhancing 'nutritional supplements' to keep the body alive in the wake of the boat.

There is the whole underdeveloped option of four-and five+-sided single-sail geometries with which actual and presumed '*inefficiencies* per given area' could be accounted for by plain *more sail-area in a more compact silhouette*. This in turn means that 'maniacally' oversparring is a ready option using the Chinese Gaff Rig - with less hardware, cost, stresses ....

> ***Drive per given mast-height,*** might be a more plausible yardstick for particularly a *cruising* sailing rig, with ***drive per invested Dollar*** an immediate second concern in an overall view of the matter.

Compared to conventional high-tension three-cornered sail-geometries, a four+-sided sail promises

- more sail-area,
- to stand longer,
- lower,
- for probably more drive,
- on lower mast-height,
- of significantly less heel from the windage and weight incurred by the typically inefficient upper 20+%
- of triangular sails and the mast (s) and rigging they need to stand.

Finally, in an age, when production boats call 1/8" stainless steel brackets at the foot of the cabintop- stepped mast 'tabernacles', one further significant advantage is likely to be missed. Assuming a hull-structure with a full-fledged tabernacle supporting a pivot pin through the mast a good distance up from the mast's foot, a major advantage is

- any shorter mast's greater mechanical probability to be tabernacled for mast-lowering within minutes with just on-board means, or even just minor muscle-power by an individual, if the mast is fully counterweighted. Readily lowering the mast may well save the boat in an exposed anchorage during a blow when others' lofty rigs cause them to drag their moorings, not to mention the obvious advantages of being able to perform 'on-deck-masthead work', or just 'shoot' bridges for explorations upstream.

A four+-sided sail may indeed make up for presumed relative aerodynamic

inefficiencies with plain *more cloth working*. Further serious development of four+-sided rig geometries could promise performance *beyond* that of the dictate of the however shaped high-tension/high-cost triangle.

Bolger's Chinese Gaff Rig

This book has already discussed a range of Gaff rigs and Chinese Lug rigs. In western working sail traditions, the four-sided Gaff sail found wide-spread use as one way to use shorter masts and still get significant sail-area of reasonable aero-dynamics and handling characteristics, manageable by small crew with very limited mechanical support. The far-eastern working sail experience offers the broad varieties of the Chinese Lug (Junk Rig) configuration, in which similar limits such as tree/mast-height, cost of materials suitable for sail-making, and available man-/mechanical power, produced geometries of great docility and utility. It is characterized by the division of each sail into well-controlled panels by full-length battens of which each is usually sheeted or at least connected to a sheet by spans. The Gaff Rig's aerodynamics are better, while the Junk Rig shines with unrivaled redundancy, stress control, and superior reefing system readily controllable by just about every hand aboard.

We have drawn and seen built numerous boats with both rigs in a range of variations, just about matching the respective chapters in book. The largest Gaff Rig was drawn to do duty aboard a 126'x16'x3'6"steel leeboard oceanographic research vessel and offers 1217 sq. ft. area out of a total area of 3518 sq. ft. to allow quiet movement for certain scientific operations when the diesel won't do; while afloat and running under power that project is still under assembly. The largest Junk Rig we've drawn amounts to a little over 1000 sq. ft. on a single mast (plus a 250 sq. ft. mizzen for convenience) stepped aboard a cold-molded 50'x13'x2'9" centerboard Cat Yawl and has been sailed for many years by a middle-aged couple in Florida. We've thus investigated the subject matter from both ends and feel comfortable continuing the trains of thought involved in deciding on rigging opportunities.

Combining the best attributes of both, while attempting to avoid their drawbacks in one new sail, seems worthwhile pursuing. As Phil ruminated already in 1983/84 in this book on p. 53 under RIG 18 Chinese Lug: "It's possible that a gaff sail with two halyards could be used with the Chinese battens and sheeting system and keep most of the functional advantages of both." What we've since come to call the 'Chinese Gaff Rig' combines the eastern full-length

sheeting- and reefing-friendly battens, with the western attributes such as a boom and gaff behind and the luff *on* the mast, in order, so the basic reasoning, to get enhanced ergonomic utility, lower mechanical stresses, and thus lower cost, along with better aerodynamic shape to sail faster and more close-winded.

Adopting the battens of the eastern Junk Rig to the western Gaff's geometry eliminates one of the eastern rig's major problems inherent in its geometry. Typically, relatively stiff battens are necessary in the Junk Rig to allow them to extend well past *one* side of the mast to achieve the characteristic silhouette. If these battens are as stiff as they need to be to spread the cloth in the usual geometry, they inherently produce a fairly flat sail shape, asymmetric to boot, depending upon which tack the mast-to-sail relationship favors. If these battens are too flexible, the wind-filled cloth's compression forces, in conjunction with the impact of the unavoidable mast-to-sail asymmetry, are bound to produce an unfavorable S-shaped sail foil. Amongst western proponents of the Junk Rig, discussions to find solutions to this inherent nagging problem extend by now across decades, and range from experiments with mechanically articulated battens to some recent efforts towards steady reduction in the sail-area ahead of the mast...

Rather than waiting further for the outcome of those experiments, we take the obvious next step, and go straight to the so-called 'Chinese Gaff 'geometry. We integrate low-tech mechanical components, in a lower-stress arrangement of familiar spar and cloth geometries, all of which should not only be cheaper to own, but put much less structural stress on the boat, and allow reliable sail-area variations from initial raising to ghosting under 130% main with minimal crew, and limited hardware assist.

The Chinese Gaff Rig employs stock unmodified round industrial pipe as the mast material, with boom, battens, and the gaff all riding *on* the mast with simple bolt-on leather-cushioned jaws and stock parrels, in its principle familiar from the western Gaff Rig. This produces a number of favorable results right off the bat:

- With all the sail-area behind the mast, the eastern rig's structural and aero dynamic asymmetry is avoided.
- Without the mast interfering every second tack, the battens can now be shaped individually to the relative stiffness/flexibility necessary to achieve a shape aerodynamically more suitable for drive and pointing ability than that possible with the Junk Rig. No doubt, as is the case with choices of cloth weight, the degree of relative stiffness/ flexibility is bound to be a

matter of compromise across the range of wind force expected under sail. But, as the option of varying cloth weight from sail-panel to sail-panel allows matching the heaviest material to the conditions when sailing with the last reef in, experience with each particular sail-shape and hull-shape combination will invite respective 'tuning' efforts to optimize hardware and performance.

- And there is no 'western' sail-track and matching expensive and less reliable 'batten-cars' of various complexities, since they inevitably induce undesirable asymmetries at the sail's leading edge any distance off center-line - surprising under the presumed primacy of 'efficiency per squarefoot of sail'. Avoiding this arbitrary degradation right from the start, this allows an identical aerodynamic relationship between sail and mast, *irrespective* of particular location along the 180° arc of horizontal sail travel. Thus the most advantageous distance between mast-diameter and the leading edge of the sail can be found within the context of the 'jaws structural requirements.

On the boat, the Chinese Gaff can thus be set up like 'stout-pole' catboats without any supports for the mast above its footing. Or it can feature the usual shrouds parallel to the mast - but obviously no spreaders below the gaff-jaws - with running backstays offering a good part of mast-support if jib-sag matters as in the sloop geometry for instance. The other part of that strain is transmitted aft, when part of the press of the sail on the gaff, battens, and boom is taken by the sheets and their spans and thus the sheet-staff aft. Unlike the traditional cat-rig, the Chinese Gaff cat can always offer some support for the mast via the sheets when reaching and running.

These sheets are vital in the control of the 'sag' of the boom, battens, and gaff, to produce the most favorable sail-plane shape per given course. As illustrated with the three silhouettes below, we have so far used geometries with three sheets in conjunction with respective spans. The use and effect of these sheet geometries improves on that of the Junk Rig, already considered of greater ergonomical and mechanical advantage than the current western triangular 'canon':

- The *main (boom) sheet* is the convenient one for *close-quarter quick maneuvering* in lighter airs when concern for best sail-shape control is secondary.
- The *middle sheet* and the *gaff sheet* begin to matter in stronger airs, longer tacks, for greater efficiency.

- In conjunction with battens of varying stiffness, *one-by-one* these three sheets are adjusted to produce the most desirable shape.
- Since their pull is quite a bit aft rather than just down, there is less angular strain down on them and thus less mechanical advantage necessary to handle them with for instance just one rope clutch per sheet, with the option/necessity on large sail-plans of routing the sheets one at a time to an optional small winch. As the wind-load on the cloth increases, subsequent reefs produce more favorable angles yet, with the option of using for instance parrels and hauls with which sheet-blocks' elevations can be varied from the helm for even better sheet-stress and sail shape management under such harsher conditions.
- When a sagging peak would typically produce a traditional gaff-sail's 'twist'-which in turn reduces much of its efficiency as the breeze pipes up - the Chinese Gaff 's overall sheet geometry, under reefed or full sail, allows little opportunity for the gaff falling to leeward beyond a limited angle right off centerline. And the gaff-sheet can be stopped to prevent the gaff from ever falling forward of the mast.

The typical Chinese Gaff sail's shape should thus be fully controllable to any angle between boom and gaff you might prefer in a given situation. And running-off before the wind should allow full control of the sail without the risk of rhythmic rolling, while maintaining the option of pulling in or shaking out reefs under these conditions. Each reef has a leech and luff downhaul of each panel's batten onto the boom to prevent it from rising or going adrift in a knockdown as gravity alone may suffice or it may not; color code them. And to reduce the risk of frequently dragging the boom in steep seas, very long booms can be cocked up via topping lifts to the level of the first batten, tightening up that particular reef line, and adjusting the lazyjacks. Experience with the 525 sq. ft. Cat-rigged prototype of the Chinese Gaff sail proved the ability to vary the sail-area both while running downwind or beating to windward usually without altering the course.

One other major benefit of this geometry is the suddenly obvious opportunity to dramatically oversize the sail area per given mast height - without further rigging than the extra cloth, some line, and probably an additional batten. With the predictable docility of ready sail-area alteration drawn from the Chinese Gaff's eastern roots, the sail can be well oversized as one continuous expanse of well-shaped cloth - as a matter of course and without penalty:

- The untapered pole-mast does not need to be taller.
- But to add to the area, the gaff can be longer due to the control offered by

the middle and the gaff-sheet, than commonly deemed acceptable per given mast height in traditional gaff-rigging doctrine.

- To maximize the area further, the gaff elevation on the mast, along with its peak halyard angle to the mast head, can be much more extreme than normally considered structurally defensible, because it *only has to stand in light airs!*

With the first reef in, all the angles and forces are conservative again, at moment's notice.

Thus, rather than requiring an additional 'light air sail' the (main) sail can be cut beyond 130% oversize, for instance,

- likely producing more clean 'drive' as seamless part of the well-controlled rig-arrangement,
- on all points of sail,
- without having to explicitly adjust it after each course-correction, rather than hanging a third or fourth sail somewhere with its typically limited control and/or drive across a range of courses.

The Chinese Gaff would normally be sailed with the first reef left in, only to shake it out, at moment's notice, should airs get too light for adequate progress.

The conventional triangular canon on the other hand,

- would either dictate a taller mast yet - beyond a certain point not really possible with a straight face - ,
- or it would 'of course' require the budget, the boat, and the crew to be saddled with additional spars, third (fourth) sails, new lengths and leads of ropage, and all the other associated hardware and on-deck/mast clutter; good on a racer full of strapping crew, but less plausible in more typical sailing realities.

Once bought and integrated into the deck- and mast-structure, with bits and pieces taking up scarce hull-volume in numerous bags and racks, they have to be carefully set up and taken down again each time the wind strength varies across the day's itinerary, on a tilted heaving deck, rain, shine, darkness, or winter chills. There are plenty of cruisers in the market which despite already 'maxxed-out' high-quality towers of 'radio-masts' with intricate systems of spreaders, shrouds, and back-stay cranes, will still need to be equipped with all the additional hardware just mentioned, run by a crew of preferably above-average fitness and alertness, as some of these devices can become a handful should it suddenly freshen up too much; 'all hands on deck' may then require more than the available crew.

In fact, it could be argued, that the mechanically sound opportunity for a small crew of average build to habitually 'overspar' the Chinese Gaff geometry is perhaps the most impressive demonstration of its inherent merits. It offers all important virtually-instant on-demand variable geometry when it counts, without pricey and/or clunky additional layers of hardware, and stresses on boat and crew. Looking through this book again, how many rigs are there, that do combine this geometry's list of positive attributes for cruising and probably racing alike?! And the development of the rig is just in its early stages...

To be sure, the Chinese Gaff's benefits come at the cost of requiring the so-called sheet-staff aft, and quite a bit of additional ropage over at the helm to keep control of the shape:

- The sheet staff is usually a stock pipe, which adds some weight and some windage, plus the top extension in the form of for instance an 8' folding plastic antenna to keep the gaff-sheet from catching behind the sheet-staff.
- But being of limited diameter and aerodynamically and weight-wise rather low down, its overall negative impact should be significantly less than the conventionally much taller single mast, commonly accepted as geometrically and aerodynamically *necessary* to set a triangular sail of identical area.
- Dealing with three sheets rather than one may initially seem a challenge. And with the main furled, good old-fashioned belaying-pins or a battery of designated baskets are necessary to keep the helm area from becoming a snake-pit. On the other hand, underway, where snags and multiple demand at once are the major concern, adjusting three lower-tension sheets one-by-one seems no more a physical and intellectual imposition on the crew than that routinely expected in the normal procedures of sailing a conventional triangular main-sail/overlapping jib combination of equal sail area; indeed just putting over the rudder for the tack is usually all that is required of the single Chinese Gaff sail to result in the once perfectly adjusted sail area to draw just as well on the new tack.

Since the Chinese Gaff Rig is essentially just a combination of the best attributes of both older eastern and western geometries, we don't expect, and have not yet noticed on the prototype, any 'new' phenomena that might put this concept at risk; neither have clients examining closely their (as yet) 'paper version'. After all, both traditions are well-understood and continue to be in use.

No doubt quite a few followers of each western and eastern tradition will plead to leave 'their rig' alone, as they already are 'under siege' by the 'colossus of

the triangular truth'. Apart from just the really hard-core backwards-oriented traditionalists amongst them, those interested in further development of these older rigs may not welcome the distraction the Chinese Gaff Rig constitutes. On the other hand, unless there is something seriously wrong with the Chinese Gaff proposal, their well-meant efforts could focus on developing the future of this young descendant of both traditions, enhancing what is good about their 'old' rigs, while leaving their seemingly intractable problems behind.

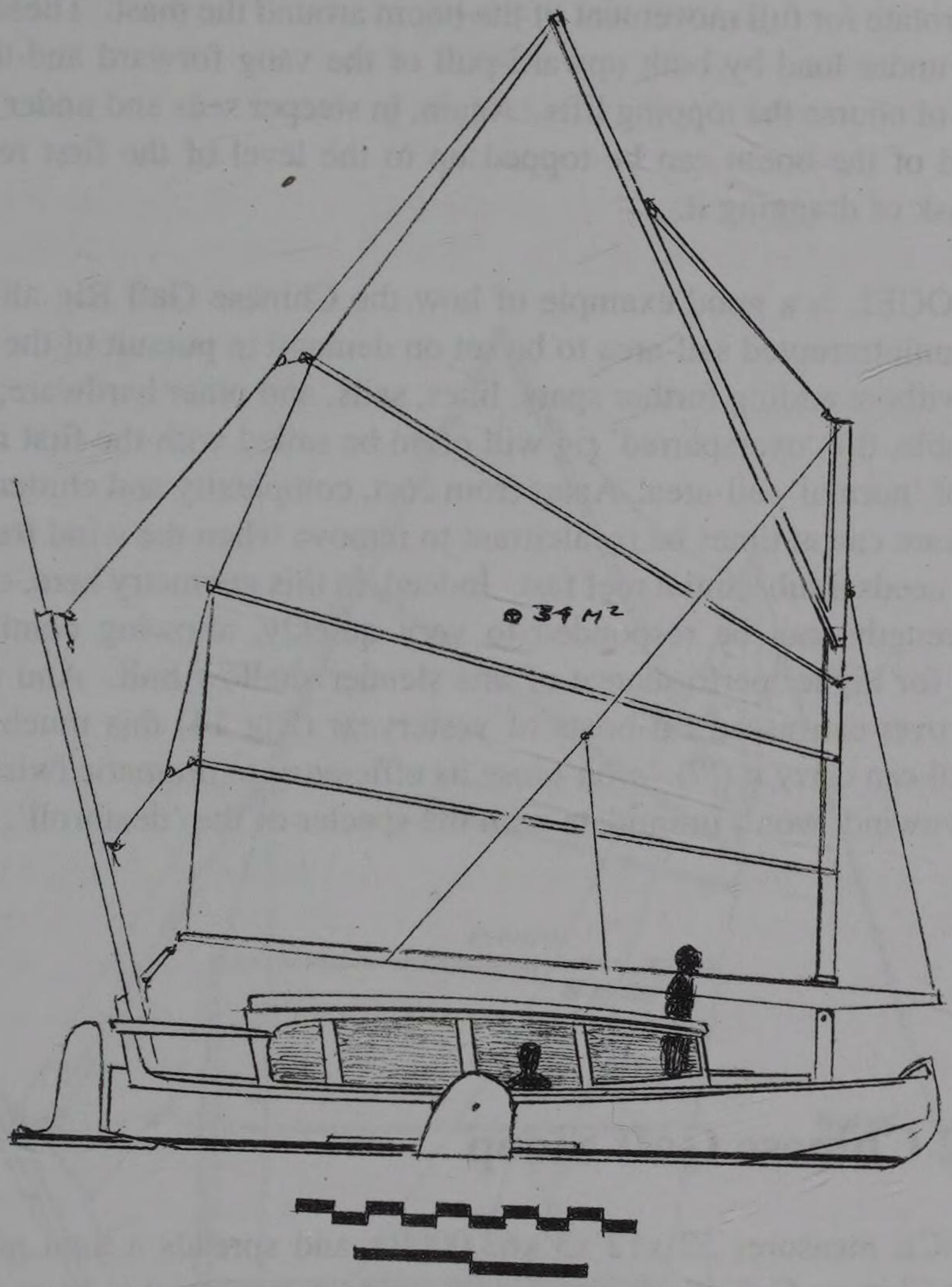
Here are three representative examples from our growing body of sailing craft drawn with versions of the Chinese Gaff Rig.

RIG 101 The Chinese Gaff Cat

23'x6'x10" WANDERVOGEL's mission as a sub-1500lbs trailerable water-ballasted cruiser, launchable by one, should not be burdened by the problems of conventional rig complexities of the typical fare on boats of her length. Rather it needs to accommodate the 'real world' requirement of single-handed mast-raising by elbow-grease or small tackle without counterweighing under her weight-restrictions, and thus a fully tabernacled pipe-mast. This in turn means a shorter mast overall, to allow trailering without man-handling the mast - and its attached boom, gaff, battens and sail (!) - out of its tabernacle-position. The overall mast-length is just within the boat's overall trailer-length. With the mast designed for honest folding and trailering, a large well-controllable sail-area within these given dimensions promises both performance and safety.

On WANDERVOGEL we chose a simple single unshrouded gaff-cat configuration of the Chinese Gaff which allows significant sail-area per given stock 20' aluminum-pipe mast-length without having to resort to a second (and third) sail to accumulate the generous area of 34 m^2 available on her. Between a single set of sheets, halyards, reef-lines, and a single uninterrupted expanse of well-shaped cloth, this rig combines the virtues of relative hardware simplicity with the opportunity of 'oversparred' performance in a single sail.

As in any Chinese Gaff Rig application, her sheeting arrangements are supposed to produce superb sail-shape control for performance and maximizing the ease and safety of reefing the rig. In this particular design, hoisting, sheet-



ing, and reefing of the sail is controlled from *within* the wheelhouse, with rope-clutches, and cleats immediately at hand overhead of the helm. With her outboard on centerline, the slight asymmetry of the sheet-staff location is a minor issue of adjustment from tack to tack in this 'sporting' light cruiser, not inherent in the sail-plan's general geometry.

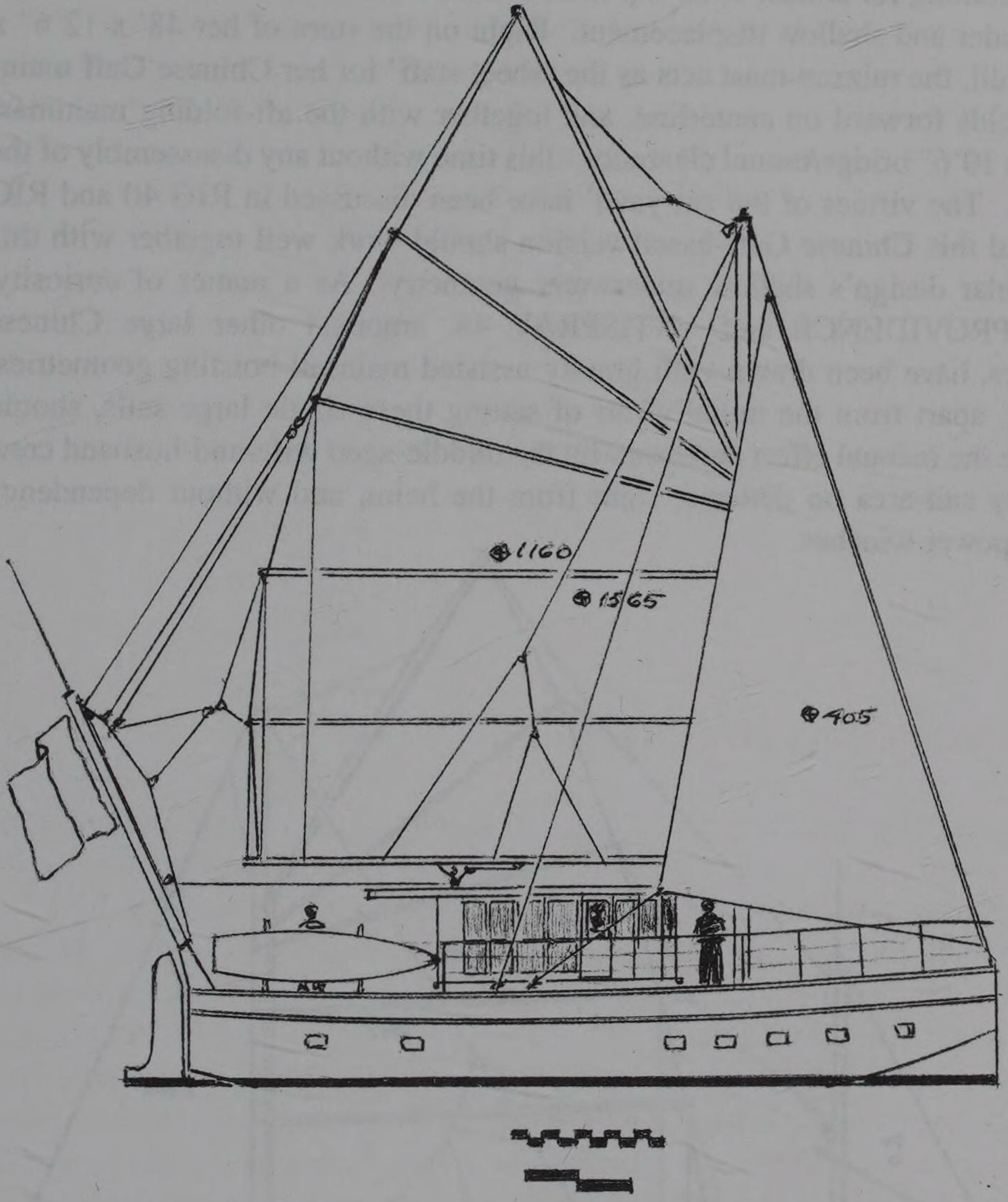
WANDERVOGEL's relatively slender boom is defensible in light of the limited strain exerted on it by just the lower sail-panel in the context of the batten- and thus sail-shape control by the middle-sheet and the gaff-sheet. The boom's unusual vang accepts a relatively close proximity of boom to cabin roof, without interfering with any foresail in this cat-rig configuration. Its fulcrum is the laminated ring fixed on the mast over a foot above the tabernacle pin, against which industrial hard-rubber casters on stainless brackets, integrated into the

boom-jaws, rotate for full movement of the boom around the mast. These casters are kept under load by both upward-pull of the vang forward and the set sail aft, plus of course the topping lifts. Again, in steeper seas and under much heel, the end of the boom can be topped up to the level of the first reef to reduce the risk of dragging it.

WANDERVOGEL is a good example of how the Chinese Gaff Rig allows a single large uninterrupted sail-area to be set on demand in pursuit of the lightest zephyr, without adding further spars, lines, sails, and other hardware; since readily reefable, the 'oversparred' rig will often be sailed with the first reef in as a matter of 'normal' sail-area. Apart from cost, complexity and clutter, such added hardware can at times be recalcitrant to remove when the wind freshens and that sail needs a substantial reef fast. Indeed, in this geometry here, changing wind-strengths can be responded to very quickly, allowing continuous adjustments for higher performance of this slender shallow hull. And unlike those scary over-canvassed cat-boats of yesteryear (Rig 14) this much sail - when the hull can carry it (!?) - won't lose its efficiency to dramatic twist, and, running downwind, won't intimidate with the specter of the 'deathroll'.

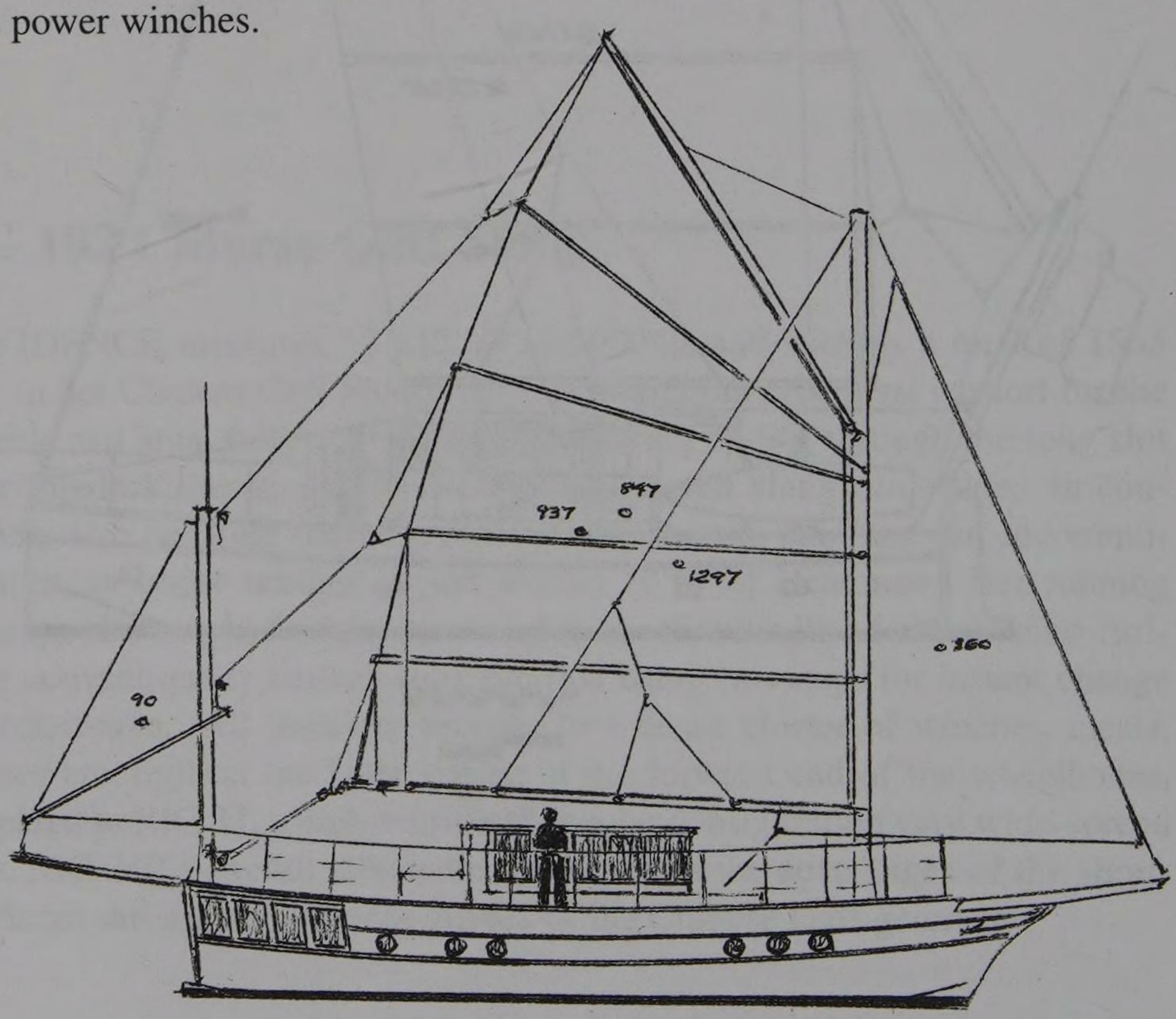
RIG 102 Chinese Gaff Sloop

PROVIDENCE measures 52'x12'x3'x63.000lbs and spreads a total of 1565 sq. ft. in her Chinese Gaff Sloop rig. Her aluminum pipe mast is short for the available sail area, fully counterweighted, swinging 90° through the long slot in her foredeck; her sheetstaff folds easily as well along centerline. In conjunction with her light partially-folding wheelhouse, she thus can accommodate running under bridges at just around 10'6" of clearance. Her running backstays allow tight forestay tension for an effective jib of either roller-furling or conventionally hanked configuration using two stays for instant change of foresail-area. All lines are brought to a dense cluster of winches, cleats, clutches etc, right at the helm station at the forward end of the wheelhouse. Compared to RIG 37, a high-tension triangular configuration very wide-spread today, RIG 102's overall silhouette really shows the advantages of the short-mast/large sail-area/lower-drag virtues of the Chinese Gaff geometry.


1160
1565
405

RIG 103 Chinese Gaff Cat-Yawl

ANTISPRAY 48 offers another variant this time with the optional reaching jib/spinnaker of 360 sq. ft., the mizzen of 90 sq. ft. and the main of 847 sq. ft. combining for almost 1300 sq. ft. of available sail-area to move her 20 tons of slender and shallow displacement. Right on the stern of her 48' x 12'6" x 2'4" hull, the mizzen mast acts as the 'sheet staff' for her Chinese Gaff main-sail, folds forward on centerline, and together with the aft-folding mainmast allows 10'6" bridge/tunnel clearance - this time without any disassembly of the house. The virtues of the cat-yawl have been discussed in RIG 40 and RIG 43, and this Chinese Gaff-based version should work well together with this particular design's shallow underwater geometry. As a matter of curiosity, both PROVIDENCE and ANTISPRAY 48, amongst other large Chinese Gaffers, have been drawn with gravity assisted mainsail hoisting geometries, which, apart from the initial effort of setting these single large sails, should reduce the manual effort necessary by the middle-aged wife-and-husband crew to vary sail-area on demand, right from the helm, and without dependency upon power winches.

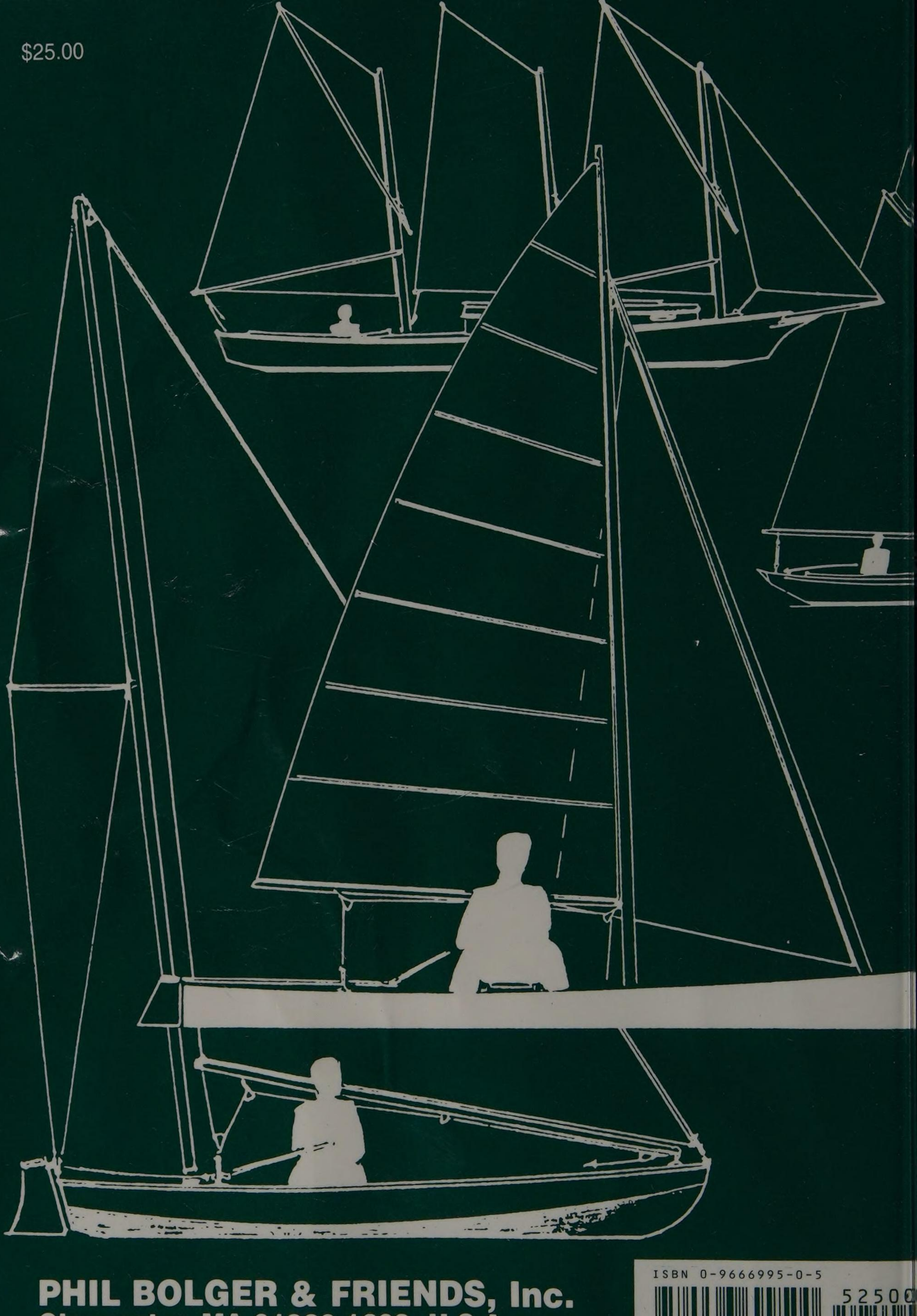


Phil Bolger has by now drawn over 650 boat-designs, sail and power, and has written 6 books on his designs. In this popular reference text, first published in 1984, he approaches the subject of rigs for sailing craft with his usual candor. An addendum by his partner Susanne Altenburger offers recent thoughts by both.

He gives you 103 of his own drawings. Tied for longest name are "shoulder-o'-mutton mainsail with full-batten standing lug mizzen," "jibheaded with balanced-club jib and full-batten standing lug mizzen," and "gunter mainsail with jibheaded full-batten mizzen and jib set flying." Under the heading Different Approaches, you'll find "kite sail," "wing sail, semi-rigid," "wing sail, fully rigid," the "rotor drive" and his new development the "Chinese Gaff." Undoubtedly, there's something here for everyone!

Never before has so much information about small boat rigs been gathered between two covers. If you want to add a rig to your rowing or sailing craft, If you'd like to change your present rig, or if you just enjoy experimenting with several ways of rigging your boat, you'll welcome this new book from Phil Bolger.

$25.00



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