Yachting

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Photos by M. Rosenfeld

"Rainbow," the 1934 defender, was a small yacht, well under the limits of the class. Her headrig was typical of the period before the advent of the quadrilateral jib. At right, the 165-foot duralumin mast of "Ranger"

DESIGNING AN AMERICA'S CUP DEFENDER

By W. STARLING BURGESS

IN THE early eighties, the narrow, deep and heavily ballasted English cutter was in full flower. Fostered by a curious tonnage rule which made beam a heavy penalty, the English yachts of that period had developed into a uniform and distinctive type. "Planks on edge," we called them. Their stems were plumb with a deep forefoot; their keels swept aft to a raking stern post; and their sterns, ending in a narrow transom, were carried out with a long and graceful overhang. Despite their generous freeboard, they were wet and uncomfortable at sea. Their sharp bows, without any supporting shoulder of overhang, combined with low and heavy ballasting, caused them to pitch deeply and dive under, rather than ride the seas. Their long bowsprits, carried to one side of the stem head and arranged to reef inboard, were often buried in green water. However, so strongly were these vessels constructed that they had the reputation of being able to live through any stress of weather. That this reputation was no idle boast has been amply attested by many a long and perilous voyage carried out in their old age by survivors of that time.

In America, a totally opposite design was in vogue. With long reaches of protected water, with shallow harbors numerous and close together, with comparatively lighter weather, and few tidal currents to contend with, we had developed, to a high degree of individuality, the wide, shallow draft centerboarder with inside ballast. Like the English craft, our boats were plumb-stemmed; on the other hand, their sterns were short and chunky. Their freeboard was low and so shallow were their hulls that flush decks were impossible and ungainly cabin trunks were almost universal even in the largest yachts. The term "skimming dish" was used to describe them.

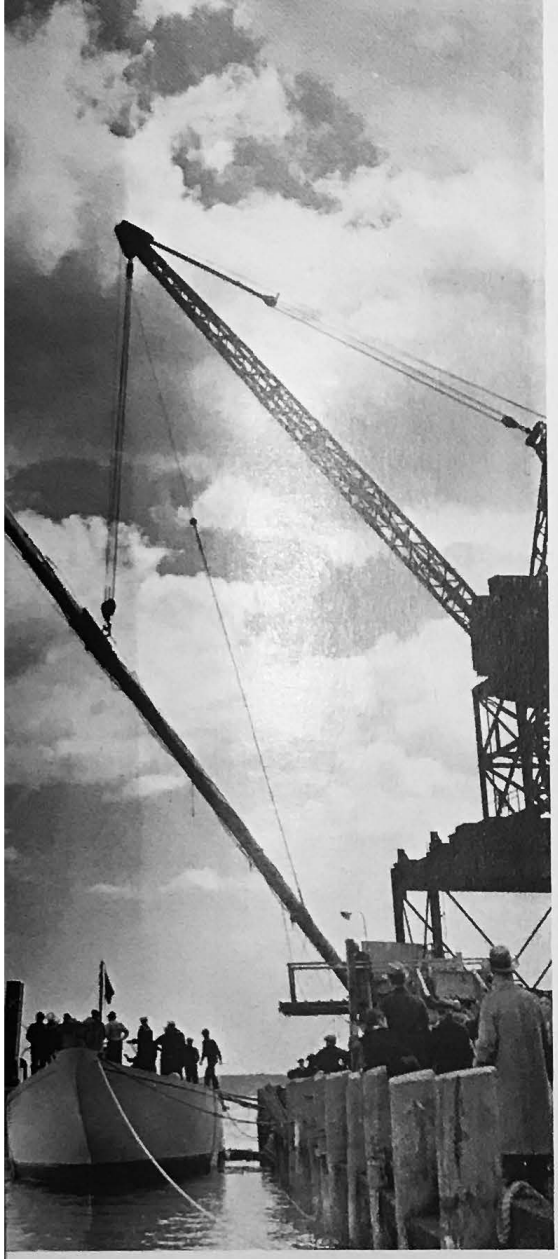
My father, Edward Burgess, having spent the summer of 1884 sailing in English waters, was thoroughly familiar with the characteristics, especially the greater seaworthiness, of the English cutters when, in the fall of that year, he was given the order to build the *Puritan* for a Boston syndicate as a candidate for the defense of the America's Cup.

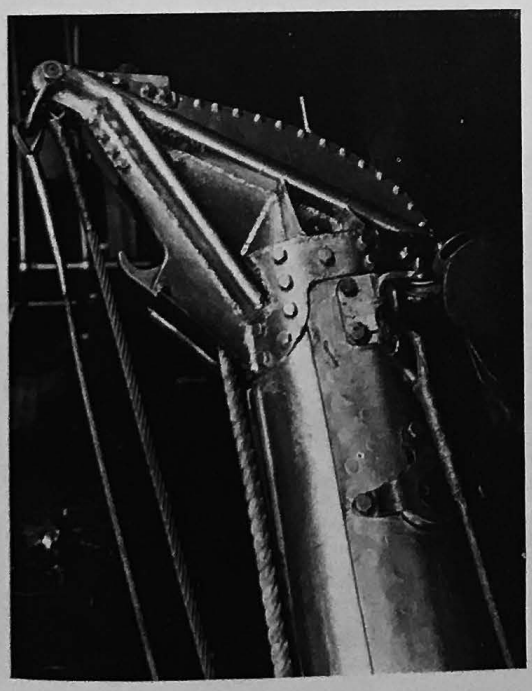
The *Puritan* was a fast, able, and thoroughly wholesome vessel of great beauty. She was a cross between the extremes of the American and English types; of deeper body than the American, of greater beam than the English. The outside lead keel was the major part of her ballast, but she retained the customary American centerboard.

She and her successor, the *Mayflower* of 1886, both of which were built at the Lawley yard in South Boston, and the *Volunteer* of 1887, built on the Delaware, both designed by my father, changed not only the whole trend of American yacht designing but that of the great American fishing fleet as well.

The work expected of the yacht designer of fifty years ago was very different from that of the present day. The model and the cabin arrangement, the sail plan and the superintendence of the construction were about all he was concerned with. Designing in those days was an intuitive art, not an intricate engineering problem.

Most yacht designers of his time, as did Nathanael Herreshoff who succeeded him, shaped a wooden model by hand, but my father (who was a superb draftsman) preferred the drawn line. The preparation of the board and paper was a serious affair, almost like a religious rite. Cotton cloth was stretched over the six-foot board and secured at the edges by innumerable tiny





"Enterprise," 1930 defender, carried the triple headrig in vogue. She was the smallest of the four built that year. Bottom, left, "Ranger's" masthead fitting, showing toggle for supporting head of sail

By the time "Ranger" was designed, more efficient headsails, of greater actual area, had come into general use

tacks. Meanwhile, my mother cooked the flour paste while the rough white paper was asoak in the bathtub. When mounted and dried on the cloth, the paper shrank to a drum-like tightness. Then, with many grades of sandpaper, a surface was attained quite as smooth and much sweeter to draw on than the glass and marble boards of today which are used for big ship work.

An important design was always begun on Sunday morning when my father had the whole uninterrupted day before him. It was always my privilege to spend Sundays with him at the office. We arrived at an early hour, my father, his draftsmen, Waterhouse and Arthur Binney, and myself. There being no steam heat week-ends, we were kept warm by an enormous pot-bellied iron stove which it was my duty to stoke.

Having drawn the sheer and deck plan, my father ran in approximate sections by eye, checked the stability with an Amsler integrator (of which he was very proud) and then began serious work by filling or cutting with great exactness to a predetermined displacement curve. Just how or from what he evolved this displacement curve, I have often wondered in vain. He set great store by it. When a section, diagonal, or buttock line finally satisfied him, he immediately inked it in with whatever color of ink (and there were bottles of many colors) came handiest. Neither draftsman was ever allowed to touch the lines until they were faired and ready to trace.

The construction was a matter of neither calculation nor invention; it was simply a duplication, with changes on a linear ratio, of what had gone before and proved sufficient. The sail plan was the conventional cutter rig; gaff-headed mainsail, club topsail, forestaysail, jib and jib topsail. Little or no change seems to have been made in the shape or proportionate area in going from an older to a newer vessel. All spars, of course, were solid. The masts were big sticks of Oregon pine in a single piece from heel to topmast band. Topmasts were housing. Details of iron work and fittings were stereotyped. Sheaves and bitts were usually of lignumvitae. I can remember how the bitts used to smoke with heat when the long main sheets were eased off "on the run." Except for the centerboard, there were no winches.

The size of spars was settled in a few words between designer and sparmaker. Rigging details were left entirely to the professional rigger. Those of the yacht differed but little from coaster and fisherman practice.

Puritan won two of the three trial races, defeating the new New York sloop *Priscilla* and the older yachts *Gracie* and *Bedouin*. On September 14th and 16th, she met and defeated the fine cutter *Genesta*, challenger for the America's Cup, owned by Sir Richard Sutton and designed by J. Beavor Webb.

Mayflower, built the following year, was much like *Puritan* save that her deadrise was higher and that the turn of her bilges was almost at the water line. She was defeated in the early trials by *Puritan* but in the end was selected to meet *Galatea*, whom she easily defeated. I can remember *Galatea's* arrival at Marblehead after a prolonged ocean passage. Her sailors were a picturesque lot, with loose red caps and brass earrings like ancient pirates. *Galatea*, owned by Lieut. Henn and like *Genesta* designed by J. Beavor Webb, was not as fast as her predecessor.

In '87 came the *Volunteer*, the last of my father's Cup defenders and the last of the line which might be called racing and cruising vessels in contradistinction to the out and out "racing machines" which have defended the Cup ever since.

In the *Volunteer*, my father departed from the plumb stem and drew a clipper bow of moderate overhang, his object being the increase of deck room and the decrease of length of bowsprit rather than taking advantage of the water line length rule. The *Thistle*, challenger of that year, was owned by a Scotch syndicate, and designed by the famous Scotch designer, George L. Watson. She, too, had a clipper bow and much greater beam than the two previous English challengers. She was a ship of rare beauty and excellence of design. Looking at her model now, one wonders why she lost.

Not long after *Volunteer's* victory, Nathanael Greene Herreshoff, of Bristol, who had been devoting his genius for many years to the design of hulls and machinery of high

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WHERE THE BATTLE WILL BE FOUGHT

Top. Aerial view of Newport Harbor, looking out to sea. The Narragansett shore and Point Judith are seen at upper right. The white line in the upper center of the picture is Block Island.

Left. Point Judith from the air. In westerly winds the course will take the Cup yachts close to this point.

Photos by Avery Lord

And there is ground for their belief in the fact that *Rainbow* was selected after she had defeated *Yankee* in an abruptly concluded series of trial races by a margin of one second. But in defense of the New York Yacht Club's choice it may well be said that *Rainbow* was more generously financed than *Yankee* and was on the upgrade while *Yankee's* form was either stationary or retrograde.

Anyway, *Rainbow* met *Endeavour* off Newport and with devastating dispatch lost the first two heats. For the first time in the long history of the Cup, the challenger was definitely a better boat than the defender. In the third heat *Endeavour*, handled either carelessly or locklessly, threw away a commanding lead by walking into a soft spot which *Rainbow* sailed around, and *Rainbow* won. The fourth heat was the occasion for the first protest in nearly forty years of racing, and, *Rainbow*, finishing first, *Endeavour's* protest was disallowed because her owner had not complied with a racing rule and flown his protest flag "promptly."

It was said at the time that this resort to technicalities saved the match — that either Vanderbilt, who raced *Rainbow*, or Sopwith would have withdrawn if the protest had been decided on its merits. Be that as it may, animosities were aroused by the display of red burgee and the challenger was unable to get the best out of his boat in the two remaining races. *Rainbow* won them both, and the fifteenth match ended as the first match began — in a welter of accusations and denials.

This year the same challenger and defender race again, each in a newer and better boat. The conditions for racing are more fair to the challenger than they have ever been. The boats themselves are capable, as large yachts were in the *America's* day, of a race across the Atlantic — although their rigs are too lofty and precarious for such a dangerous undertaking. Despite the acrimony of 1934, the contest starts in an atmosphere of mutual good will. It is the hope of all observers that it will be concluded without rancor and with the sportsmanship of both contracting parties unimpugned

Designing an America's Cup Defender

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speed steam-driven craft, reëntered the sailing yacht field and, when the next challenge came from England, his *Vigilant* was selected to defend the Cup in 1893. From then on until 1920, his boats were the defenders. They were *Defender*, *Columbia*, *Reliance* and *Resolute*, and each one was selected after a series of trial races.

In the summer of '29, came to me the fruition of an ambition nearly fifty years old. The New York Yacht Club flag officer's syndicate ordered me to prepare the design of a Cup defender to meet Sir Thomas Lipton's last challenge with *Shamrock V*. Harold S. Vanderbilt had been selected to sail the new yacht and it was between Vanderbilt and myself that her proportions, rig and characteristics were decided.

For the first time, challenger and defender were to meet on equal terms. That is, both were to be built in accordance with Lloyd's scantling rules, at the top of Class J and to sail without time allowance.

No longer would the challenger, necessarily strong enough to cross the Atlantic on her own bottom, have to meet a vessel of lighter scantlings sufficient merely to sail off the coast in summer weather. The yachts were to be designed under our Universal Rule. Many years of building under this rule had proved that it never paid to make bow and stern full enough to incur a "quarter-beam length" penalty nor to take a penalty for less than rule displacement. Without these penalties, sail area becomes a function of water line length, slowly diminishing as length is increased. Water line length, however, is limited to 108 per cent of the yacht's rating measurement plus the constant five. The largest sloop-rigged vessel that can be built in Class J has a water line length of 87.08 feet with a displacement not less than 164.3 long tons. An 80-foot water line vessel of this class has a minimum displacement of 128.3 tons, which is but 78 per cent of that of the yacht built to the limit.

Vanderbilt and I first made a study of average wind velocities as reported by the Government Weather Bureau at Block Island over a twenty-year period for the summer season. This study led us to believe than an 80-foot boat, carrying 7580 square feet of sail, was as large a boat as it would pay to build. It must be remembered that we were designing for a triple headsail rig and that such effective sails as the present four-sided "Greta" jibs and parachute spinnakers were unknown in such sizes as would be required; so to 80 feet we designed *Enterprise*. She was the smallest of the four American boats built for the 1930 Cup series. In the many races of that summer, the speeds of the American yachts were definitely proved to be in the exact reverse order of their length and weight, the shortest and lightest being the fastest, and the largest and heaviest

the slowest. *Enterprise's* hull was of a fair and normal model, freakish in no way. On her rig, however, we stretched ourselves. There were no limitations on weight and size of mast other than length. Therefore, I asked my brother, Charles P. Burgess, a naval engineer who had had great experience in light aluminum structures, to design the lightest possible aluminum alloy mast. It was a 24-sided spar of two skins without interior framework of any kind except at the deck and the points of rigging attachment. As our nearest rival, Clinton Crane, said of it, it was a marvel and it was also a marvel that we succeeded in keeping it in the boat. It had the delicacy of a fly rod and its staying had to be adjusted with every change of headsail or main sheet tension.

As the season progressed and our nearest rival, the *Weetamoe*, pressed us harder and harder, Vanderbilt's indomitable will to win pushed me to many inventions. The most outstanding was the "Park Avenue" boom with a four-foot-wide top surface on which were mounted cross tracks allowing the sail to slide to leeward in whatever curve we chose; then came spreaders of extraordinary lightness; and a battery of winches and gadgets, both above and below decks, which caused our boat to be nicknamed the "mechanical ship." *Shamrock V*, although of excellent design, was so poorly rigged that we beat her with great ease.

When it came to designing *Rainbow*, in '34, to meet *Endeavour I*, Vanderbilt and I found ourselves up against two radical changes in rule. First, the boats had to have cabin accommodations with no gear except the headstay below decks; and, second, the mast could not be below a minimum weight, center of gravity, or width of cross section. Feeling that *Enterprise* was about the right size for the conditions under which she was built, we figured that but two feet increased length in the new boat would be enough to take care of the added weight of cabin and heavier mast. In the trial races, *Rainbow* met a rebuilt and much faster *Yankee*. For the first part of the season, the *Yankee* had the better of us and it was not until we had ballasted *Rainbow* down to the limit of her flotation marks that she really began to go. She was selected, but the margin over *Yankee* was a narrow one. So, during the season, we learned that our boat was too small. The double head rig, as compared with the triple head rig of *Enterprise*, allowed much larger sails to be hung on the same framework of spars. *Rainbow* lacked the power and size to carry these sails to the best advantage. Then, too, Clinton Crane, in *Weetamoe*, had proved the vast possibilities of enormous parachute spinnakers which also called for a larger boat.

The final victory of *Rainbow* over *Endeavour I* was due to Vanderbilt's consummate strategy and helmsmanship, his power of organization, and, above all, his never lagging attention to detail.

Vanderbilt ordered the design of *Ranger* from Sparkman & Stephens and myself last fall. *Endeavour II* was already built, to the 87-foot upper limit of the class, and had made a creditable showing against *Endeavour I*. Olin Stephens and I found at our disposal the new towing tank of the Stevens Institute of Technology in which Professor Kenneth S. M. Davidson had worked out a most extraordinarily ingenious method of testing sailing models in which the useful driving force of the wind, its heeling force, and its component of leeway were closely resolved by the mechanical resistance of springs and balance weights. For testing a model's ability to go to windward, we were enabled to plot speed made good to windward directly against wind speed.

Nicholson had given me the lines of *Endeavour I* so our first step was to try out, as measuring sticks for the new model, the models of *Endeavour I*, *Rainbow* and *Weetamoe*. We were encouraged to find that the models of these three boats gave results strictly in accordance with the observed performance of the full-sized vessels.

Vanderbilt, Stephens, and myself were fully agreed that we must go to the 87-foot hull. Four parent models were constructed and departures in the shape of overhangs, position of the rudder post, and so forth, were tested in most of the parent forms. The model selected for *Ranger* was so unusual that I do not think any one of us would have dared to pick her had we not had the tank results and Kenneth Davidson's analysis to back her. However, not only did the dial readings indicate her as the best of the lot but her photographs showed a wave formation much smoother than that of the others.

Aeroplane design, the development of high tensile strength, corrosion resisting aluminum alloys, and the progress of metallurgy in general, have had a profound effect on the spar and rigging design of the modern America's Cup defender.

Ranger has not only an aluminum alloy mast but a main boom and two spinnaker booms of aluminum as well. So resistant are the new aluminum alloys to corrosion that *Ranger's* mast is left bare of paint or protective covering of any nature. With steel, this would be quite impossible.