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The Advantages of Twin Keels

There has been a growing interest in twin keel boats in North America. Although some design work has been done here on sail craft of this type, there are more numerous examples in Europe, particularly in Britain. When first developed, these boats had large keels to support them when sitting on the mud flats, causing them to be slow in light airs due to excessive wetted surface. Because of lack of moorage, twin keel boats were the answer to a need for a shallow draft craft which could sit high and dry in the Thames between tides. Yet these very same boats had to be perfectly at home sailing in the strong winds and rough waters of the North Sea and English Channel. They quickly acquired a reputation as good cruisers as their shallow draft and seaworthiness are features at the top of any cruising man's list. The few English-built twin keel boats that have found their way over to Canada and the U.S. have been a disappointment in our lighter wind conditions.

A word about the history of the design and development of bilge keelers. In the 1920s Lord Riverdale built the 25 foot Blue Bird, the first twin keel yacht. In the 1930s a larger Blue Bird of Thorne was started and measured 48 feet overall. Both these Blue Birds had twin rudders as well as twin keels and continue to sail today. Lord Riverdale had built and towed models in each case before building and sailing each yacht. His cruising experiences with these boats then brought to light new areas of development. Between 1930-1961 a series of twin keel yachts were built with success by various architects and clients based on Lord Riverdale's work. Yachts of this type became available in many countries including France, Australia, New Zealand, and South Africa. Surprisingly little work was being done in the U.S.

In 1962-63 a 54 foot motorsailer was tank tested in the U.S. with discouraging results. It was for an existing boat being adapted to twin keels. With modified keels at different angles, the design was re-tested and more satisfactory results emerged. Meanwhile, in 1961, Lord Riverdale had started work on a 50 foot design, which he felt should do most of it's cruising at less than 20 degrees of heel to be comfortable. He took his data to yacht designer Arthur Robb who promptly designed what has been termed "a high performance cruising machine" and "a flat out twin keel yacht". This second Blue Bird of Thorne was extensively tank tested and is the only published technical data available. As a result, many important features came to light showing that twin keelers, if properly designed, have a number of inherent good qualities that make them an attractive proposition to the cruising sailor.

The main advantages are as follows:

1. Higher sailing speeds than an ordinary cruising yacht of similar dimensions. Surprisingly, part of the reason for this is the relatively small wetted surface, which yields improved light air performance. Modern twin keels are of high aspect ratio and present less wetted area then a full keel or long fin keel while retaining the steady helm associated with full keels.

2. The twin keels become more effective with increased angle of heel, while a single keel becomes less effective. Because twin keels cant outward at the tip, the leeward keel becomes more vertical and deeper in the water as the boat heels. The windward keel is working more horizontally creating downward lift that increases righting moment giving more power to carry sail. Also with this cant outward from the vertical, leeway forces water up to the root of the fin as opposed to spilling over the tip in a single keel. Hydrodynamic tests have shown that decreasing end tip loss can double the effectiveness of a fin (the sole purpose of keel winglets).

3. The wave pattern reshapes to reduce the fore and aft crests. At hull speed a hollow forms amidship, but the bilge keels cause a wave to form in this hollow, canceling out the stern wave and giving a flatter wake. This increases the maximum speed of the hull, as much as 15 - 20%, in the same way that a bulbous bow or stern bustle works; by reducing wave making resistance at hull speed where it constitutes 85 - 90% of total resistance. To ensure the desired effect is at cruising speed the correct fore and aft placement of the keels and proper proportions must be checked by model testing. This placement is critical, as the model data shows. Too far forward or too far aft and the resistance will dramatically increase.

4. The deep plunging of an ordinary hull is avoided by the stabilizing action of the fins which are also very effective in dampening out rolling motions. The fins also provide a certain amount of lift to the stern at speed when the hull is upright. The effect of this lift is to flatten the trim angle, i.e. reducing squatting, which flattens out the wake and lowers the resistance.

5. Directional stability is markedly enhanced by the fins. This is demonstrated both by tank tests and full size yacht performance.

6. Speed and fuel consumption under power are better then usual. The prop can work in clear water without being shrouded by the keel and rudder. In the case of the motorsailer we were testing, 85 h.p. would produce 14 knots. Also the yacht can be controlled in reverse, which is seldom true of single keel yachts.

7. The rudder areas are smaller for the same reason as the keels. Each rudder is more effective as it works upright, deep in the water.

8. Both keels and rudders can be asymmetrical (more curve on one side than the other) like a wing, and tailored to work on their one specific tack. This again makes them more efficient allowing smaller appendages. Generally it is felt that both the rudders and keels can be made 25-30% smaller because of the greater efficiency.

9. Windward ability equal to that of an ordinary yacht is achieved on a fixed draft approximately comparable to that of a centerboarder without the problems associated with lifting foils. Windward

performance in rough water is superior because of the roll and pitch dampening abilities of the keels.

10. Stability is equal to that of an ordinary yacht without recourse to extreme beam. Righting moment and range of stability are at least equal to those of a well designed centerboard yacht of relatively deep fixed draft, because ballast can be placed in each fin the ballast is as low as any keel-centerboarder.

11. The general advantages of twin keels include the ability to take groundings in a level position. This allows the bottom to be cleaned and painted (although the shorter and shorter keels are making this more precarious), without the cost and nuisance of a haul out, as well as being easily shipped without a cradle. When sailing in shallow water, if one should touch bottom, the boat rights and clears itself. This is possible because twin keels draw more water when heeled than upright, unlike single keel boats which when righted dig themselves in deeper.

Preliminary model tests carried out by Bray Yacht Design and Research at the Ocean Engineering Center of B.C. Research have shown that all the above stated advantages are very real, and that by using current state of the art design practices, twin keel yachts can produce very high performance boats. In England many production single keel yachts have had twin keel versions added to the production line up which have performed better then their single keel counterparts. In racing circles, no one has ever argued with the superiority of bilge boards (essentially lifting bilge keels). Scows dating back to the beginning of this century have used bilge boards exclusively. In 1974 yacht designer Bruce King did a series of bilge board one tonners of which Terrorist was notable. She was so superior that the I.O.R. immediately outlawed bilge boards. In sailing his bilge boarders Mr. King says there was not a significant difference in performance between one or both boards down. In a cruising yacht the simplicity and lack of interior clutter certainly makes up for any performance difference between lifting and fixed keels.

Indications are, from all work that has been done, that twin keels will perform as well or better in a shallow draft then a centerboarder, and definitely better then a single keeler. The key is in the understanding of the complex hydrodynamics involving the interplay of keels with the hull. Only in the last 20 years have yacht designers began to explore the effects of pressure patterns on hulls. The relationship of keel volume to hull volume to produce constructive wave interference at the required speed and the correct toe in angle of the keels to align them with streamline flow have more to do with the success or failure of twin keels then anything else.

We tested a model of a 37'-9" motorsailer, first with a deep fin keel (6'-4") and then with shallow draft twin keels (3'-9"). The vessel was to have a top speed under power of 14 knots. The difference in speed between the single and twin keel version varied from 3/4 of a knot at 6 knots and 14 knots to 1/4 of a knot at 10 knots for the same power applied. Still we felt we could do better. After re-reading the previous test results and information on other twin keelers we decided to place the keels 2'-5" farther forward. This was as much for convenience as anything else as the forward keel bolts now became the aft ones, a new set drilled forward, and the now useless after most ones plugged. With all our hopes raised we again ran the tests only to find that the resistance had increased from 2% more at 6 knots to 93% more at 14 knots, for this twin keel placement over the previous twin keel position. It was at this point that our project ended unfortunately as we certainly felt that we could have done better. None the less it indicates that proper twin keels are not as slow as generally considered. Also when you consider all the other advantages that twin keels offer to the cruiser, it is quite an overall gain.

The cost difference in a single or twin keel is negligible and can be compared to buying a boat with a skeg rudder or a spade rudder. Fiberglass boats require no special molds especially is a separate keel mold is used. Twin keels do not present a structural problem in any material and have been built in fiberglass, wood, steel, aluminium, and concrete.

It is for these reasons that I believe that properly designed twin keel boats are faster and much better cruising boats then single keel boats. The time has come to consider the performance aspects of all cruising boats rather than the "traditional for tradition's sake" approach without thought to the purpose, which is out and out cruising.

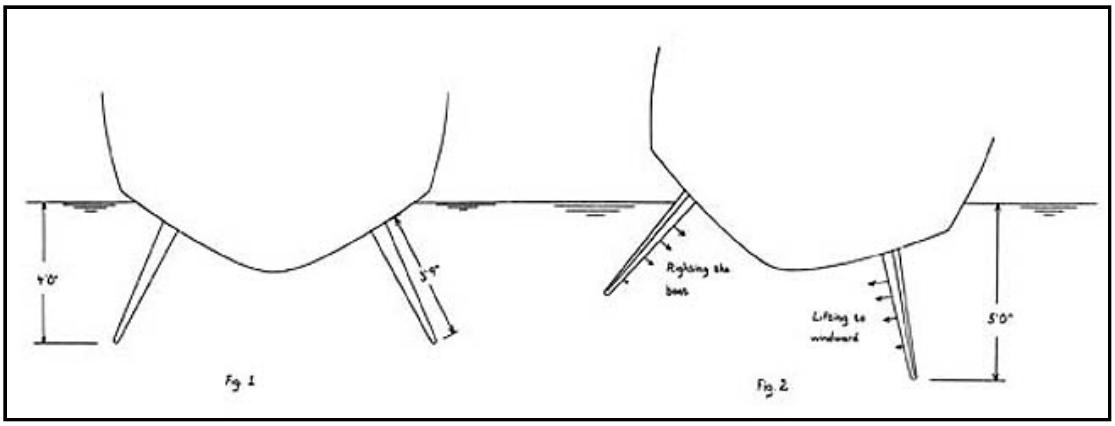

Fig. 1 Keel depth vs. overall draft. This bilge keeler has a 3'9" fin on a 4'-0" draft. A single keel would require a 5'-9" draft to place the same keel on the centerline.

Fig. 2 When heeled, bilge keels draw more water. At 15 degrees heel this boat draws 5'-0" but when upright it only draws 4'-0". Also the lifting action of the asymmetrical keels can be seen. The vertical one is reducing leeway and the more horizontal one is helping to right the boat.

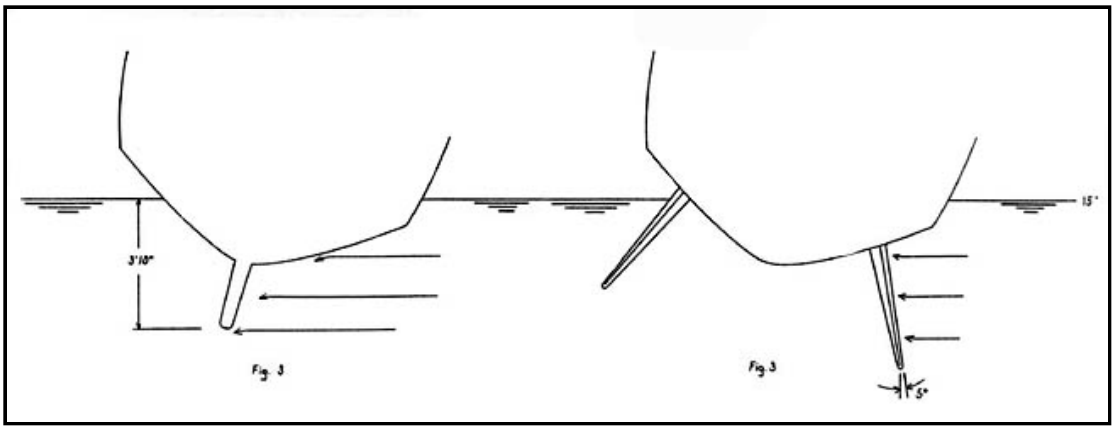

Fig. 3 The effect of leeway on a twin keel and a single keel boat. On the twin keeler whose fin is still canted 5 degrees outboard of vertical, water is sliding at a sideways angle (leeway) being forced up to the root decreasing end tip loss. Also the full vertical area is being used to the best advantage in deep water. In the single keeler the effective area is lessened because of the angle of heel.

Speed	Resistance			Heave		Trim Deg.		
knots	sgl.	twin A	twin B	sgl.	twin A	sgl.	twin A	twin B
6	1.01	1.40	1.45	.16	.18	.06	.06	.03
8	2.39	2.87	3.23	.35	.19	.44	.63	-.38
10	4.29	4.49	5.71	.45	.20	2.78	1.94	.52
12	5.95	6.35	7.46	--	.20	4.30	3.86	1.79
14	7.05	7.95	8.67	.13	.17	4.26	4.87	2.32

Power predictions calculate 85 h.p. to reach the maximum design speed of 14 knots with a powering efficiency of 50%.

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