Critical Point A passion for boats

Lots of people enjoy messing about in boats, but retired mathematician Frank Sinden’s interest goes much deeper – he dreams up sailboats with innovative new designs, as Robert P Crease explains.

One day this summer, Frank Sinden plans to put a strange-looking, home-built vessel on a trailer, drive it with his daughter and son-in-law to northern New Jersey, and launch it in a lake. The last time the inventor, puzzle designer and retired mathematician launched a craft of his own design, the sail flew off and the boat had to be ignominiously towed to shore. Such failures don’t bother Sinden much though; they just give him new ideas.

Sinden, 80, loves boats. Now living in Princeton after a career at Bell Labs, he is not the kind of nautical expert who is funded by corporations to use supercomputers to seek tiny improvements in expensive yachts. He is an old-fashioned boat-lover, who builds sailboats of his own designs from scratch.

Sinden grew up outside Chicago. In 1928 his father and some other sailing enthusiasts bought plots of land at a new development on a lake in northern Illinois. After the 1929 stock-market crash, his father couldn’t make the payments – but no-one else could either, so the bank let him keep the land, and the sailing continued during the Depression. “I loved it,” Sinden recalls. “But how sailboats worked was mysterious to me.”

Pushing the boundaries

In 1950, thanks to a talent for mathematics and German, Sinden went to study at the Eidgenössische Technische Hochschule (ETH) in Zurich, Switzerland. There he learned about sailboats from a course on aerodynamics in which he studied the mathematical theories of the pioneering German physicist Ludwig Prandtl.

Prandtl was the first to describe wingtip vortices mathematically. These are the swirling air cones that form at the ends of wings; their slight updrafts are why geese and fighter planes fly in “V” formations. Prandtl also defined the thin, fluid “boundary” layer that lies right next to a surface. The boundary layer is key to the behaviour of wings and sails, and explains why a sailboat’s jib – the small sail ahead of the mast – makes the mainsail work better. The jib delays the stall by helping to keep the boundary layer pasted to the lee (downwind) side of the mainsail, thereby allowing the boat to sail more into the wind.

Sinden moved to Bell Labs in 1956, getting a job as an applied mathematician. In his spare time he designed puzzles and games; two, Booby Trap and Avalanche, were turned into hits by Parker Brothers. But he could not keep his mind off sailboats.

New manoeuvres

Sinden decided that conventional sailboats were not manoeuvrable enough. He therefore took an aluminium canoe, installed a seat running down its length, attached a rigid frame called an “outrigger” on the lee side, designed and sewed the sails, and gave the boat a steering wheel. The boat was rather like the multihulled vessels known as proas that are common in the South Pacific: it could be moved by turning it so that the wind is at 90° to the hull, feathering the sail and pulling it in the other direction. This made it easier to change the boat’s direction, turning its tacking path into a series of cusps rather than a sine wave. Sinden’s daughter Amy liked to lie on the seat and steer with her toes.

Sinden filled notebooks with sketches of sailboats and calculations about boats; he even built and sometimes patented models. One of his strangest efforts was inspired by a guest speaker at Bell Labs in 1986 who mentioned a land vehicle, equipped only with wheels connected to a big propeller, said to be able to go faster than the wind in tests in the California desert. Jaws dropped. “Outrunning the wind?” Sinden recalls. “Sounded like perpetual motion.”

Through a series of back-of-the-envelope calculations, Sinden found that a wind-driven vehicle can theoretically extract energy from the relative motion of air and ground even when moving as fast as or faster than the wind. To do this, the vehicle transfers relative momentum from one medium (air or ground) to the other, just as an engine transfers heat between hot and cold reservoirs. He also found that, in principle, it was possible for a vehicle without an engine to sail directly into the wind.

When his calculations failed to impress the sailors among his colleagues, Sinden built a test model consisting of a propeller mounted on a 25 cm long arm that swung around a pivot at the hub of a gramophone turntable linked via gears to a wheel riding around the turntable’s rim (see image). The turntable revolved clockwise, simulating a counter-clockwise breeze striking the propeller.

At less than wind speed, the test vehicle moves clockwise like the turntable but slower. It stops – at rest relative to the turntable – when moving at wind speed, then starts going counter-clockwise when moving faster than the wind. To an observer riding on the turntable, the test vehicle replays (circularly) the California test vehicle. By slightly modifying the model – replacing the propeller with a hand-carved windmill – it illustrates how to sail directly into the wind.

Sinden is still proud of the counterintuitive model and is delighted to show it off.

The critical point

Last year, Sinden tried out a new boat design that used windsurfing sails, but he found that putting them up and taking them down in the wind was perilous. Also, in the excitement of sailing his creation, he forgot to install a nut, which led to one sail taking flight.

This year Sinden’s boat is about the length of a canoe, and has more conventional roll-up sails. Novel features include easy steering and a large, circular seat on which three or four people can sociably face each other. As in the past, he will not be too bothered if it fails to work exactly as hoped, if it gives him new ideas. For he is interested in exploring not merely the possibilities of any particular sailboat that he has built but the possibilities of sailboats themselves. Sinden, that is, loves boats the way only a scientist can: by experimenting with them, which is the only way to discover and explore their mysteries.

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