



The Electric Wheel

by DAVID E. TETHER

The vessel is a 43-foot custom built cruising catamaran named *Sea Spirit*. It was built 5 years ago at Texas A&M University as a student project for Judge Frank Evans of Houston. *Sea Spirit* has beautiful lines and the interior layout is masterfully designed with ample space and functionality. The boat displaces 16,000 lbs, is 20 feet at the beam and is constructed of balsa core and epoxy. The propulsion system that was initially installed on the vessel was composed of two 25-horsepower gasoline outboard motors bolted to platforms that could be raised when not in use and lowered when necessary. These motors propelled *Sea Spirit* at approximately 5 1/2 knots in favorable sea conditions and, according to Frank Evans, were very cumbersome when docking or making tactical maneuvers in various other weather conditions. In heavy seas the motors actually came out of the water from time to time, causing cavitation of the propellers and loss of power. Additionally, because the motors and fuel tanks were located so far aft, *Sea Spirit* was heavy in the stern when under sail and never really made good speed as a result.

After hearing about the Electric Wheel, Frank theorized that going to a Diesel-Electric Hybrid would fix his ballasting problems, give him better fuel economy and, if the claims were correct, he would have better power and handling, too. A lot to ask for, but why not try. After much discussion and a trip to Benedict, Maryland to visit the Solomon Technologies facilities to see a Solomon electric motor in operation, Frank decided that this was a truly innovative technology that would cure the current deficiencies. Further, if the Solomon



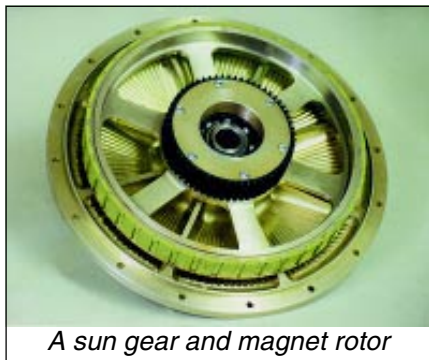
Technologies claims were correct about the regenerative feedback, it would be a self-sustaining boat. This is to say that the diesel generator would only have to be used occasionally to charge batteries when sailing conditions were not favorable and the addition of solar panels would minimize that need even more. Working with the builders Mr. Evans decided to put the battery packs forward of midships, to fix the balance problem. With some hesitation they also agreed with Dave Tether of Solomon Tech. to use 18" 14-pitch propellers. It seemed hard to believe that an electric motor could push a prop that size with authority, in a boat that heavy. The shaft holes were cut into the hulls and battery boxes built prior to the arrival of Dave Tether and his shipwright Hendrik Rasmussen.

The installation went as smoothly as any 'out of the water' boating experience could. The system was comprised of 12 Lifeline Absorbed Glassmat (AGM) Group 31 batteries in each hull, twin Solo 6 six-horsepower electric motors with chargers, twin 18" 14-pitch propellers and twin E-Meters from Cruising Equipment with prescalers which allow them to be used for the 144 VDC battery packs. The E-Meters function exactly as they would on a 12-volt system, giving total voltage, amp hour utilization, incrementing amp hours during charg-

ing and they also monitor the regenerative feedback collected by the Solomon motors and increment the amp hours accordingly. Frank could not have been more correct in his theories. *Sea Spirit* was now everything he had dreamed of.

Many people watched as *Sea Spirit* was lowered into the water and, having been in this situation before, I knew exactly what they were thinking... "this guy is nuts!" Keith Palmer, spiritual leader of the Texas A&M sailing program, who was there along with the builders and Frank's son Richard, who came to toss me overboard if it did not work. These Texans are a rough sort. Both motors were turned on and the waiting was over. Each motor was tested for operation at low power and then given full power. It almost tore the dock lines off the boat.





A sun gear and magnet rotor

Frank then took the helm and backed *Sea Spirit* out of the travel lift slip. A grin came across his face as he noticed the raw power and precise control. We had a 20-minute motor out of the channel in Galveston to get to Galveston Bay. We went against the tide and into a 15-knot head wind, exceeding the 5 1/2-knot limitation that existed with the fossil fuel motors. Frank's grin widened. We left the dock with the battery pack charged to 152 volts and we were drawing approximately 20 amps which was not full power, but it was enough to exceed any previous speeds. Rounding the channel buoy Keith Palmer took charge of setting sail, and in 15 knots of wind they immediately noticed that the balance problem was cured and *Sea Spirit* was sailing faster than she ever had. More importantly, both Solo 6 electric motors had gone into regenerative feedback because of the flow of the water pushing the props and the amp hours/voltage were starting to increment. Switching to amps on the E-Meter showed that each motor was generating about 5 to 7 amps or 760 to 1,064 watts (5 amps X 150 V = 760 watts). The batteries began to charge and after about 50 minutes of sailing we had regenerated all of the power that was used to motor out of the channel. The crew was delighted.

It was at this point that we tested the system for max amperage and displayed the raw power that these motors are capable of, by putting the motors in full reverse. This also gives a good indication of the propeller efficiency. The propellers immediately went to full reverse and with a loud gurgling noise began to stop the boat. Within approximately 3 boat lengths the knotmeter went to zero, with full sail UP in 16 knots of wind. Try that with your diesel! After this test was complete, Keith Palmer suggested we put up the spinnaker and test full hull speed to see what kind of regeneration we could get in that configuration with 16 knots of wind. We jumped the spinnaker and immediately the boat speed and regeneration picked up. At this point each E-Meter was alternating between 8 and 10 amps or 1,240 to 1,550 watts (8 amps X 155V [increased voltage due

to increased battery charge] = 1,240 watts). At this stage we were putting the energy into the system 1/2 as fast as we had taken it out motoring... however, we had already replaced the energy we used, so we were now collecting additional energy which would be used to motor into Houston to dock the boat.

When we were sure that there was more than enough energy to motor in and dock the boat, we tried 'regenerative motor sailing' a new phrase that only Solomon Technologies and its customers know about. This mode is accomplished by setting the control to motor during lighter air or up the back side of a wave and then immediately the system goes into regeneration when a puff of wind blows stronger or the boat is sliding down the front side of the wave. When the control is set right, the energy collected during regeneration is stored in the battery pack momentarily and consumed to motor up waves or during lighter air. Because we did not have the heavy seas in Galveston Bay, we could only regenerate during the puffs and motor lightly in the steady air. We increased overall boat speed by 1 1/2 knots and never depleted our previously stored charge by even 1 watt. We adjusted the motor to expend 7 amps of current and when a puff came the motors regenerated 8 to 10 amps.

As we approached the Houston channel we had recharged the battery pack to 160 volts, so with the testosterone flowing (an experience that sailors usually only have in bad weather), we decided to motorsail and race every other boat into the channel. This is often done by our customers, just because they can with no noise, smoke or smell... and no one else knows you have your motor on! As we approached the dock, in a very narrow channel, the anticipation grew because a 43-foot catamaran is no free lunch when it comes to docking. I was told by Judson, the builder, that the previously installed

outboard motors had not performed well for Mr. Evans and had caused much grief in the past. With a light tide flowing, Mr. Evans was able to turn *Sea Spirit* around in its own footprint and crab it gently over to the dock. Shouts of joy immediately rang out from all on board. This was the best docking experience that *Sea Spirit* had ever had, and the motors had more than enough power to manhandle the props with precision control. When the dock lines were all secure we turned to the E-Meters and noticed that we had more energy in the battery pack than we had started with when we left Galveston. Frank, Keith and Judson were totally amazed and started shouting 'perpetual motion.' I calmly told them not to ever say those words again - just tell everyone you talk to that it does everything Solomon Technologies told you it would. And, after all, its not really perpetual motion, it is just taking better advantage of the power in the wind and water that is already there.

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