REPOWERING: THE ELECTRIC OPTION • JAPANESE SAWS • SKIPJACK SURVIVORS

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Repowering VAGABOND

Powered by Elco

A hybrid motor for a century-old Consolidated launch

by David S. Gillespie, with Jon Hall

Installing an electric motor in an old boat didn't sound that hard. Take out the old engine, hook up an electric motor to the shaft, put in some batteries, and away we go. It turns out it's not that easy.

VAGABOND was a sad boat. In the middle of winter in upstate New York she looked forlorn, with windows missing, planking falling off, 2×4s valiantly trying to hold her in shape and failing. But she had three things going for her: (1) She had nice lines and a good history, (2) most of the original bits and pieces were reported to be in the owner's hands, and (3) she had a soon-to-be owner looking for a good project.

One of six 40′ launches built in 1909 by The Gas Engine & Power Co. and Chas. L. Seabury & Co., Consolidated (generally known by the shortened name "Consolidated"), VAGABOND was exhibited at the New York Boat Show in January 1910 where, to quote *The Rudder* magazine, she "attracted the crowd in droves." According to the previous owner, she was purchased by Atwater Kent and used at his home on Long Island until his death. Then she passed to his lawyer and then to the previous owner's family in the early 1950s. Apparently they intended to make her restoration a father-son project, but that idea lost steam and VAGABOND sat untouched until I bought her in 2005.

DAVID GILLESPIE

Top—VAGABOND, a 40′ launch built by Consolidated Shipbuilding in 1909, conducts sea trials near Jacksonville, Florida, after a restoration that included the installation of a state-of-the-art electric propulsion system. *Above*—This is how VAGABOND appeared when the author found her in upstate New York in the winter of 2005. A web of 2x4s held the superstructure together.

TOP: RICHARD FAULKNER

If brass-era cars were buggies with engines, then the boats of that time were sailing hulls with engines, sans mast and keel. This trait made VAGABOND a bit unstable, so at some time in her past a piece of railroad track was bolted to her keel, leaving me to wonder how she would fare in the water. An answer to that question would have to wait until most of the frames, about 50 percent of the planking, and an equal percentage of exterior brightwork were renewed. But that's another story.

DAVID GILLESPIE

VAGABOND's hull required replacement of most her frames and 50 percent of her planking—mostly in the after sections.

The Propulsion Dilemma

While working on the hull, I began to wrestle with the question of how to repower her. In 1909, the dawn of the motorboat era, people were extremely proud of their new engines and liked to put them where they could be seen and worked on. Thus, VAGABOND's engine had been placed in the aft cabin between the galley (to port) and the crew berth (to starboard). The space was further compromised by the ladder leading from the cockpit down into the galley and by the fact that the galley's locker doors had to open. The maximum width the motor could occupy was 24½″.

The original gas engine was a Speedway of about 30 hp, but this had been replaced in 1923 with a 40-hp Lathrop that weighed a stout 1,750 lbs—considerably heavier than the original, causing the boat to ride bow-high. Unfortunately, this engine was so badly deteriorated that a replacement was needed. The new one would have to meet the following criteria:

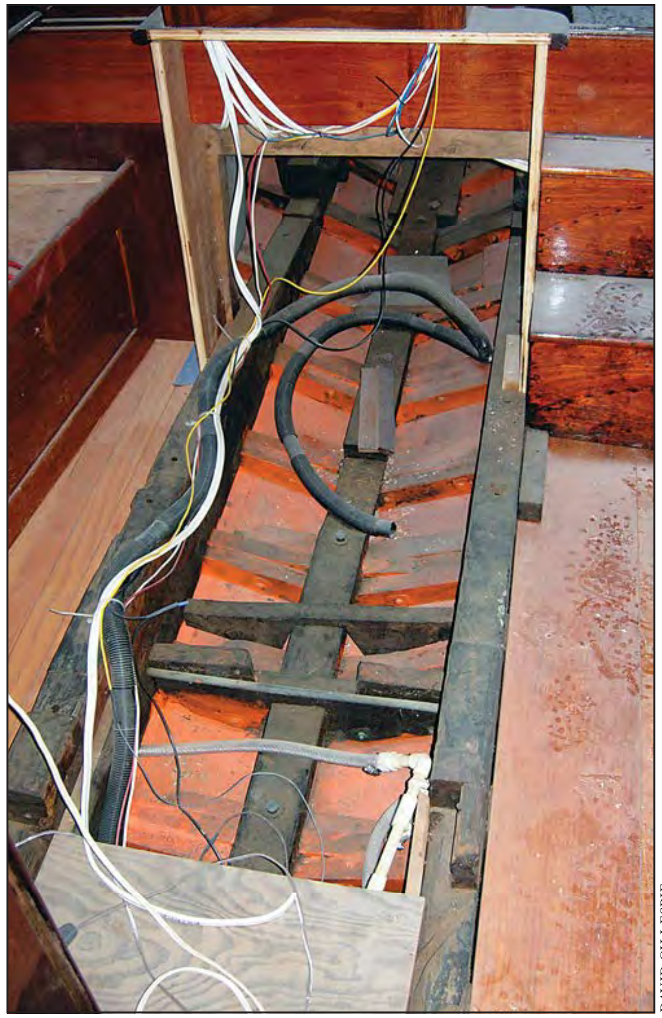
- It could be no more than 24″ wide to fit within the outer dimension of the old engine beds. The height was more flexible.
- It should develop at least 40 hp at 600 rpm in order to turn a fairly large propeller and give good maneuvering at low speeds.
- Room for fuel tanks was very limited, so the motor should be economical and allow at least 16 hours of cruising.
- It should be quiet, since it occupies space in the galley.
- It should push the boat at hull speed—8 knots—and cruise at 5 knots.

The most obvious choices were gasoline or diesel. But most gasoline engines these days are V-8s, and therefore too wide. A four-cylinder in-line would have fit, but seemed too small to do the job. A marinized Mazda rotary was also considered but rejected because they are not fuel-efficient and would require too much tank capacity. Diesels were also considered but most were too large—and they are noisy.

HUCKINS YACHT

Before her systems were installed, VAGABOND was launched and floated to determine how the weight distribution of the new systems would affect her trim.

VAGABOND, because of her fine hull shape, had minimal space for machinery. The space is bordered fore and aft by the crew berth and the steps leading up to the cockpit, and measures only 25″ wide.



DAVID GILLESPIE

Several years ago Mystic Seaport successfully installed an Elco electric motor in one of their launches. Electric power seemed to have several advantages, such as small size, high initial torque, and no need for a large fuel tank. And so I resolved to repower with electric, and with that resolution came two more criteria to add to the list above:

- Running time should be 5–6 hours on electric alone.
- The cost should be competitive with a diesel repower.

And so began a long process of turning this option into reality.

Confusion Sets In

Initial inquiries revealed several companies offering electric motors for boats. They varied from 12 to 108 volts, DC and AC, from 5 to 20 kW (by their ratings), and had a variety of controllers and other ancillary devices including, in one case, 16 batteries and eight chargers. Clearly there was more to this than met the eye.

How big an electric motor did I need? This question received a wide variety of answers, all predicated with, "It depends...." The biggest factors influencing the decision are hull shape, propeller size, and displacement. A diesel engine's horsepower rating is usually calculated at its maximum torque, which develops at high rpm. An electric motor, on the other hand, develops full torque once it begins spinning. So, it's difficult to make a straight-line comparison between a diesel engine and an electric one: The two may be equivalent at 2,000 rpm, but they won't be equivalent at 600 rpm—which was my target engine speed based on the size and pitch of VAGABOND's propeller. Examining torque curves, I found that a 120-hp diesel engine would produce the appropriate torque for my boat at 600 rpm; a smaller diesel would produce too little torque at this speed and would bog down. I then set out to find the electric equivalent of this at 600 rpm, and determined that 20–30 kW (only about 40 hp using the standard conversion of 1.34 kW per horsepower) electric motor would be about right for VAGABOND's slippery, relatively light hull.

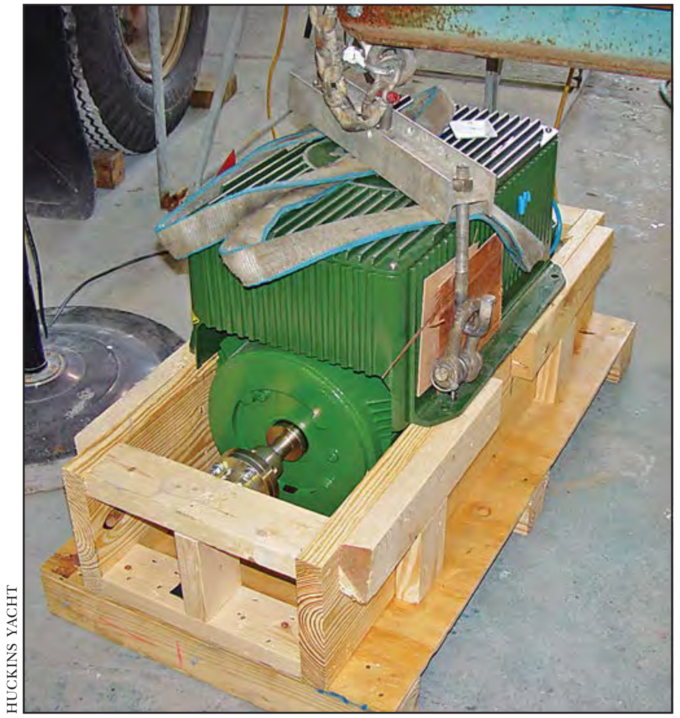
There were several vendors who had systems that might work. Most ranged between 5 and 15 kW, but it was difficult to know how this would translate into real running time on the boat.

False Starts

With the reconstruction of the hull and interior about half completed, I settled on one vendor so that the rest of the reconstruction could be planned with some certainty. This vendor could supply two 15-kW pods mounted at the stern of the boat. The reasoning was that they would use less space since the motors were actually inside the pods and outside the boat while at the same time giving the advantage of a twin-screw configuration. It would also free up space for the necessary batteries. Moreover, as advertised, the pods appeared to be something I could install myself. Unfortunately, as the time came close to commit to this path, the manufacturer disappeared, leaving a trail of unhappy customers.

I was lucky not to be one of those customers. It reminded me that I needed to add to my list of requirements a vendor with a stable track record. But the original questions remained: How big a motor was needed? What kind of voltage—AC or DC? What kind of batteries? What kind of charging system? There was clearly much more to putting together a working system than just selecting an electric motor. Having found no clear option myself, I decided to seek help from Cindy Purcell at Huckins Yachts. She introduced me to Jon Hall, Huckins's longtime lead designer. Huckins, it turns out, had been looking into electric power for some time, and Jon was already aware of some of the problems I'd encountered. But he's an engineer, so was not as easily confused as I was.

The challenges that had to be overcome included balance and trim, battery size and placement, and charging.



HUCKINS YACHT

The new Elco motor arrived in a neat package and fit nicely into its allotted space.

Both Jon and I realized that the balance and trim of the boat would be changed no matter what we did. We needed to minimize those changes as much as possible. VAGABOND is a 40′ boat, but space for machinery is at a premium. The forward cabin soles are only about 6″ to 8″ above the keel. There's only a small triangular void under the settees and berths. Just aft of the engine the hull converges gracefully upward to form a pretty fantail that was beautiful but not terribly buoyant. For balance, two tanks—one for fuel and one for water—were placed vertically in the forepeak in a space usually reserved for the anchor rode. Even so, based on a 1940s photograph, the boat rode bow-high.

In reviewing the options, Jon quickly agreed that diesel would not work because of its noise and size. A diesel with an electric drive coupled to it was then considered since it was smaller and could be tucked away more easily. The batteries could be distributed around the boat for an acceptable balance. However, a sufficiently powerful electric unit that met my goal of a 5-hour cruise on batteries alone wasn't yet available.

There did not seem to be a single, plug-and-play system that would accomplish our goals.

Arriving at a Solution

In the course of his research, Jon had rediscovered Elco, one of the oldest names in yacht building. They still build electric launches and have continued to advance marine electric propulsion since their founding. Jon contacted Peter Houghton and soon began conversing with their engineer, Joe Fleming. Suddenly the way forward became clear. We would select the motor and then build everything else around it to complete a reliable and user-friendly system.

Several years ago when I first contacted them, Elco's largest motor was 10 kW. Now the company produces a range of power units. Based on their recommendation, we chose the EP-7000, which is rated at 35 kW (equivalent to a 70-hp diesel according to Elco) and runs on direct current (DC).

The Generator—Although I toyed with the notion of installing only the motor and batteries, the thought of being left without power was unsettling. So, I decided to install a generator. It seemed sensible, costwise, to go with an AC generator, as these are generally less expensive than DC. A 6-kW Kohler unit, which spins at 1,800 rpm, seemed the best choice. It was the largest unit that would fit in the available space. We elected to use a standard 110-volt system providing 25 amps of charging to the batteries, which is sufficient to run the boat at a reduced speed when the batteries are discharged, and provides power to all the other 110 circuits on the boat.

HUCKINS YACHT

With the propulsion motor in place, there was still space to fit the generator on the old engine beds.

The Batteries—The choice of batteries was a crucial one, owing to the limited space. As a yacht designer, Jon is always concerned with safety at sea. While lithium-ion batteries may have merit and are used in many hybrid automobiles today, they are also complicated and prone to sudden failure, as we saw recently in the Boeing 787 Dreamliner. They do not like voltage spikes, sudden changes in current draw, or lightning. (Huckins's service department has repaired scores of lightning-struck yachts over the years, and it's not a comforting thought to be dead in the water during a storm.) Finally, while they would save valuable space, lithium-ion battery packs are still prohibitively expensive.

The choice at the other end of the spectrum was 6-volt golf cart batteries. Although they were the cheapest alternative, these batteries would have taken way too much space. Instead, we decided to stick with tried-and-true marine batteries. We settled on absorbed-glass-mat (AGM) Odyssey batteries, which have the electrolyte contained in a fiberglass mat. They have given good operating life in Huckins's experience.

With the major elements of the system—motor, generator, batteries—identified, a series of issues had to be overcome to make this a cohesive, user-friendly system.

The Elco motor, as manufactured, is rated for 108 volts DC and would require nine 12-volt batteries in series to produce an acceptable voltage. It became glaringly apparent that there was not enough space to install nine batteries in a practical bank allowing for minimal wiring. Mind you, 4/0 cable does not bend easily. Now what? Elco and Joe Fleming came to the rescue.

Following several speed/performance studies that took into account how easily these old yachts slipped along, Joe could predict the rate of discharge for a given cruising speed and calculate the hours available to operate without the generator. It appeared we could enjoy a good 5-hour cruise on the usually calm St. John's River in 5-knot silence. But this was based on a 108-volt system with nine batteries, and space was so tight that there was room for only about five or six of the larger D-size batteries. A further problem with the 108-volt system was that we could find no off-the-shelf 108-volt charger that had a satisfactory DC output. All the major players said they could custom-produce one. But as any boat owner knows, custom orders are very expensive.

Right—The entire machinery package is hidden under the galley counter space. *Below*—The motor and batteries took up almost all of the space under the sole. The absorbed glass mat (AGM) batteries could be located on their sides, which proved to be the only way to fit them all.

DAVID GILLESPIE (BOTH)

HUCKINS YACHT (THIS PAGE)

Top left—A charger from the Elcon company was custom-built to handle all eight of VAGABOND's batteries. It is attached to the cockpit coaming, and when the boat is in commission is concealed by the helm seat (bottom left). *Above*—The Elco package comes with a programmable electronic instrument panel showing rpm, amps being used, and battery charge remaining—much like a fuel gauge.

Stepping up to solve the problem, Joe and Peter concluded that they could adjust the motor to a 96-volt supply, enabling eight instead of nine batteries. Jon concluded that we had room for them provided we used ones that could be installed on their sides in a neat rack around the motor. These requirements led us to the Odyssey PC1800 battery—a 214 amp-hour model that can be drawn down without damage as long as it's recharged immediately. The batteries would total 1,100 lbs which, taken together with the motor and genset, brought our weight up to 1,800 lbs for the package. This was just a bit more than the original engine, but was located a few inches farther aft. Voilà! One major hurdle was overcome, but we still needed to charge those batteries.

Charging—Now all we needed to conquer was the charger problem. Most off-the-shelf chargers can handle only four batteries at most. But Jon discovered Elcon (elconchargers.com), a company that would customize one of their units to charge all eight batteries and fit nicely under a pilot seat on the starboard side of the cockpit. Joe stepped up and worked with Elcon's owner to build a 96-volt charger programmed to optimally charge the batteries from either the genset or shore power. The resulting unit produces 25 amps at 110 volts; if I ever desire more "get-home" power, it can be converted to 220 volts, which will deliver 45 amps.

Although it is possible to set the system up so that the generator comes on automatically when the batteries need charging, I elected to keep the system simple. When the digital monitor shows the batteries beginning to run down, I'll turn the generator on manually.

Sea Trials

As VAGABOND was slowly lowered into the slip below the Travelift, we all watched to see if the balance or trim would change, and were relieved when the straps released their lifeline hold and VAGABOND was on her own, floating exactly where her newly painted boot top wanted her to be.

At the dock we tested the genset by simply letting the motor run in place to create energy-use data. Remember, the battery bank is the fuel tank, and we needed to know where the full, half-full, and empty marks were before striking off on a cruise.

We chose a pleasant afternoon without too much breeze or current for the sea trials. The results were exciting. The 18×10 wheel pushed VAGABOND effortlessly—and we soon discovered that an electric motor is far different from a piston engine. While Elco states that the motor's 35-kW rating is about the equivalent of a 70-hp diesel, it actually has the torque of a 70-hp diesel at 1 rpm, and pushes the boat to her cruising speed very quickly. Because it has maximum torque at the lowest speed, the electric motor can turn a larger prop—one that would bog down a gasoline engine. And you don't have to wait for the motor to spin up rpm's to get that power. Since there is no gearbox, changing motor rotation from clockwise to counterclockwise can make docking tricky at first because gentle maneuvers require a very light touch on the throttle; response is instant, and there is no sound by which to judge how fast the propeller is turning.

At 400 rpm she ran about 2.5 knots; at 600 rpm we moved along a little over 4, and at 1,000 rpm it was a hair-blowing 6.5 knots. At 1,500 rpm we approached VAGABOND's 7.5-knot hull speed. Any faster and the bow tries to rise while the stern settles, causing concern. The motor's top continuous rpm is 2,000, but you can give it a short boost to 2,500 in an emergency. On a boat of this size and hull shape the 35-kW motor develops more power than could actually be used.

Conclusion

Although we've had only a few hours' experience with this power plant, I can report that so far the system is working well and meeting expectations. Here are a few observations:

At 600 rpm, VAGABOND will go all day at 4.5 knots on batteries alone. This matched the running speed of the Lathrop engine and, because of the electric motor's having more torque, allows us to use a larger and more efficient propeller. If we decide to run our 6-kW generator, the boat can go almost indefinitely at this speed.

The same 6-kW, 110-volt AC generator also powers the rest of the boat, including chargers for the 12-volt house systems. Because it is so small, it uses very little fuel—only 0.3 gallons per hour—and a 12-gallon fuel tank suffices. Having a single, eight-battery charger also saved space.


HUCKINS YACHT

The restored VAGABOND sits ready for the water in a shed at Huckins Yacht Corp. in Jacksonville.

Under electric power the boat is eerily silent with only a slight hum detectable after the motor reaches 500 rpm and a slight swish of water once the boat is underway. This can be a little disconcerting, as most of us are used to judging boat speed by listening to the engine rpms.

At 600 rpm, with the boat moving at about 4.4 knots, we consume 21 amps. In 3 hours the batteries had lost only 2 percent of their charge, and the display indicated another 3½ hours left, although this may be a bit optimistic (AGM batteries tend to go along normally for a long time, but when they start to lose charge it is quite a rapid decline). Start the generator, and she will keep on at this speed until you run out of diesel. With the 12-gallon tank, that would come in about 48 hours with a 20 percent fuel reserve. Want to go faster? She will easily achieve hull speed, but this will use up the batteries in 3 hours, and the generator can't keep up; it will provide power for 600 rpm but not for 1,500.

If you need to run at 7½ knots, the trick would be to use the generator an hour on and an hour off for any trips that are expected to last more than 5 hours. But keep in mind that this is a pleasure boat meant for a quiet day on the river, not for running up and down the coast. Speed is not the objective, though you can run at hull speed for long enough to get back to port in a storm.

We looked for a company with a track record of success and were lucky to find one that would help us engineer a system made up of disparate elements from different manufacturers. Without Elco's flexibility in adapting their motor to our needs, the project could not have worked. They have been around for long enough that we have confidence that when help is required in a few months or years, they will still be around.

Weight distribution can be an issue. The newly launched VAGABOND settled to the same trim she had had with her gasoline engine in the 1940s. She had ridden bow-high with that old engine—so much so that it was impossible to see over the bow. Filling the two 40-gallon water tanks amidships helped a bit, but the solution required the addition of 250 lbs of lead ballast to the chain locker along with 125′ of chain for another 50–60 lbs. This brought her very long bow down to allow a view of the water ahead.

A system like this is really not for amateur installation. Matching the components, doing the wiring, and calibrating the motor and components all require a great deal of expertise and a highly qualified electrical engineer. Our installation was completed quickly thanks to the team at Huckins, but also thanks to the willingness of Elco's staff to work with us.

The costs of the system were not significantly more than a diesel engine and genset, along with the accompanying tanks, filters, and so on. Our batteries were a significant expense, but that is offset by the cost of fuel over the 10-year life of the battery bank. It is as if you bought diesel fuel futures.

Huckins CEO Cindy Purcell takes VAGABOND for her initial sea trials.

The project has been a great success from the owner's point of view. VAGABOND is over 100 years old but now goes silently through the water. She will follow a course for almost an hour without my touching the wheel, and she has minimal roll and pitch. I hope I can do as well when I'm that age.

David Gillespie last wrote for WoodenBoat *in 2003, when he detailed the lessons of his restoration of the 38′ Jakobson & Peterson motoryacht CYGNUS II. He also wrote a history of the Dawn Boat Company for WB No. 151.*