Power to the People
An Onboard Energy Audit

by Nigel Calder

How much juice do you need? The prerequisite to designing an effective DC electrical system is to accurately gauge the demand for power on your boat.

Recently I came across the following remarks, written some 20 years ago by a very experienced world girdling sailor: "I have lost all patience with electricity. It requires far too much time to keep an extensive electrical system operating... The most miserable man in the world is the owner of an electrical miscarriage who can't get a drink, flush the head, raise the anchor, hoist the sails, or even see what he is doing, because his batteries are flat and he can't start his generator" (Bob Griffith, *Blue Water*, Norton, 1979).

How things have changed! When this was written most of the defining features of a modern boat's electrical system- deep-cycle batteries, high-output alternators, multi-step voltage regulators, systems monitors, Dc-to-AC inverters, nad so on- had been introduced to the market but were still going through their difficult teething stages. the result was many an "electrical miscarriage". These days the basic theory and components of a powerful and effective electrical system are pretty much unchanged, but the technology is greatly improved. This improved technology, coupled with the vast body of experience that has accumulated over the years, makes it possible to put together reliable, trouble-free systems that allow modern sailors to enjoy a previously undreamed of standard of living aboard their boats.

There are still plenty of electrical miscarriages on modern boats. In fact, amoung long-term cruisers especially, probably more frustration is caused by electrical problems (and more time and money is spent trying to resolve them) than by any other gear or equipment failures. But once it is set up correctly (there are often some initial problems), a modern electrical system can operate for years with minimal maintenance, delivering all the wonderful benefits of modern technology without the drawbacks.

A caveat

Before getting into the nitty-gritty of the systems, I need to point out that an awful lot of the systems on modern boats are not necessary for the effective functioning of the boat- they are there simply for the comfort and convenience of the crew and passengers. Here I will discuss a complex and demanding systems situation- a maxed out bluewater cruising boat of the kind that most long-term cruisers now hanker after. But it's important to bear in mind that less complex and expensive (and much lighter) systems will often be appropriate.

Remember, irrespective of how well they are installed, the more systems you have and the greater the complexity, the higher the cost and probability of failure and the greater the maintenance overhead, in terms of both time and money. There is, without question, a point of diminishing returns beyond which fancy systems are no longer worth having. Where this point is will differ for everyone. It is a function of your financial resources, technical skills, and core vision of sailing.

I urge you, therefore, to take a look at the systems on your wish list and categorize them according to those that are essential (navigation electronics, navigation lights, a basic complement of cabin lights), those that are highly desirable, and those that are simply luxuries. Think long and hard about doing without the luxuries and maybe some of those things that currently seem desirable. There is a good chance that what you gain in terms of sailing satisfaction will be much greater than the value what is sacrificed.

Once you've determined your priorities, the next step is to work out the details of how to meet them.

Energy Audit Form

Equipment	Amperage	Hours of use (in 24)	Total load (24 hours)
Refrigeration			
Lights			
Deck			
Cockpit			
Navigation			
Anchor			
Aft cabin			
Quarterberth			
Galley			
Nav Station			
Head			
Saloon			
Forecastle			
Guest Cabin			
Closets, etc.			
VHF			
SSB			
Autopilot			
Radar			
Fresh-water pump			
Bilgepump			
Gray-water pump			
Engine-room blower			
LPG solenoid			
Windlass			
Inverter load (calculated separately)			
Total amp-hours (in 24 hours)			

Acrobat PDF File Small (6.59 Kb) Acrobat file of the Energy Audit Form.

An energy audit

The heart of all systems on most modern sailboats is the DC electrical system. For numerous good reasons, it behooves you to keep it functioning properly. To do this, you absolutely must balance the energy demand on your boat against the available energy supply. This sounds easy, but getting the power equation right on a modern sailboat is one of the more difficult design issues, primarily because there is no single correct formula.

The starting point in figuring the power equation for any boat has to be an analysis of anticipated demand. This is done by listing all the energy-consuming equipment you would like to have on board (everything from cabin lights to a microwave, if it is to be run off of a DC-to-AC inverter), along with its operating voltage (generally 12 Volts DC or 110 vols AC), and its energy draw (expressed in terms of either amps or watts), together with an estimate of the hours of daily use for each device. Using these numbers and a bit of simple arithmetic, it is easy to calculate a boat's 24-hour energy demand and to express this value in terms of a unit known as amp-hours at 12 volts DC or 24 volts DC. (From now on, when I refer to amp-hours I assume a 12-volt DC system, since this is by far the most common system on American boats).

Amp-hour loads are calculated as follows:

- If the operating load of DC equipment is given in amps (for example, a bilgepump with a 5-amp draw), multiply the hours of daily use by the amperage (½ hour x 5 amps = 2.5 amp-hours).
- If the operating laod of DC equipment is given in watts, divide the wattage by the system voltage (12 volts or 24 volts) to get amps, and then continue as above.
- When evaluating AC equipment that will be run off a DC-to-AC inverter, take the power drain in watts of each appliance and divide this by 10 (for a 12-volt DC system) or 20 (for a 24-volt system) to establish the approximate load, in amps, on the DC system. Multipy this value by the hours of use to derive amp-hours.

If DC refrigeration is installed, I like to do a second energy audit based on the seven-day demand on the boat of it is left unattended with the fridge running (this, for example, allows for extensive forays ashore while a boat is left anchored out). The audit should assume a worst-case situation, which is to say a closed-up boat in the Mediterranean or tropics with cabin temperatures at 100°F or higher. The audit must include not only the requirements of the refrigeration unit, but also those of any other electrical loads that will come on in those seven days. These most likely will include an anchor light, a bilgepump, maybe a carbon-monoxide alarm, and perhaps the combined loads of various LED dispays scattered around the boat. (Note that the anchor-light load can be kept to a minimum by wiring the light through a photo-electric cell that automatically turns it off inthe daytime, or by using an LED cluster light.)

Keeping the load down

If the DC load comes to more than 200 amp-hours per day, as it commonly does these days on mid-size and larger cruising boats (particularly if air conditioning is wanted- this drives the load through the roof), you have a problem. Once the boat unplugs from shore and goes off the grid, there is no way its electrical system will function without an AC generator or excessive running of the main engine.

Before concluding that a generator is necessary, you should review your notions of what is essential, desirable, and luxurious to see id some lifestyle compromises might be made. Some questions to ask yourself include:

- Is air conditioning really necessary? In a hot climate, using an awning plus a well designed ventilation system is often an adequate substitute. If air conditioning is necessary, a generator is unavoidable, in which case it can be used to charge batteries and run DC equipment, greatly reducing the required hold-over capacity of the DC system.
- Can the refrigeration load br reduced? After air conditioning, refrigeration is

generally the highest energy consumer on a boat in warmer climates. Very often the ice-box is larger than it needs to be and is poorly constructed and insulated. By using some of the unnecessary volumne to add extra insulation, and by tightening up on the construction standards, the energy load can be cut by half. There is also a potential for dramatically reducing energy requirements, albeit at a high cost, by using some of the new high-tech vacuum based "super" insulations.

- Can the autopilot load be reduced? This is generally by far the largest energy consumer when making ocean passages. The load can be completely eliminated with a windvane and/or absorbed by the output from a towed water generator.
- Can the light load be reduced? Learning to turn off lights that are not in use and substituting flourescent lighting for incandescent lighting will often reduce the load by half.
- How about fan usage? Replacing higher-energy fans with low-energy units (such as those manufactured by Hella) can reduce this load by half.
- Do you really need an electric toilet? Or an electric shower pump?
- Do you really need to use a microwave other than that when energy is in plentiful supply (such as tied to a dock with shore power or when motorsailing)? If you can limit microwave use to fit available energy supplies, you will remove an enormous strain from the DC system.

With careful equipment selection and some minor lifestyle compromises, it is almost always possible to keep energy consumption on a cruising boat well below 200 amp-hours per day. Often, you can get it down to not much more than 100 amp-hours per day. This brings you within the practical realm of a DC-based electrical system that requires no supplementary AC generator and derives most of its necessary energy from routine boat operations, such as motoring in and out slips and anchorages, without additional engine running time devoted soley to recharging the batteries. This is, in many ways, the ideal for a cruising sailboat

Power to the People
Part 2: PUTTING IT IN THE BANK

by Nigel Calder

ONCE YOU KNOW HOW MUCH JUICE YOU NEED ON BOARD, YOU NEED TO FIND OUT WHERE TO STORE IT. Here are some tips on designing functional battery banks for your cruising boat.

In part 1, I explained how to perform an energy audit on a modern cruising boat. Such an audit typically defines a daily DC electrical demand of somewhere between 100 and 200 amp-hours. The starting point for figuring out how to meet this demand is the boat's batteries, because they are almost always the limiting factor in any onboard electrical system.

Batteries in “house” use on typically “cycled,” which is to say they are repeatedly discharged and recharged. Automotive-type batteries soon fail in this kind of service. A deep-cycle battery is needed to withstand the stresses involved.

There are numerous deep-cycle batteries on the market, including wet cells (the type that need topping up from time to time), gel-cells (sealed “no-maintenance” batteries), and AGM (absorbed glass mat) batteries (which have another type of sealed cell). The pros and cons of each type can be argued backwards and forwards. All work well so long as you buy quality (you pretty much get what you pay for), so long as different battery types are not mixed in use, and so long as the manufacture's recommended charging regimen is adhered to (which may require special voltage regulators).

Even with a quality deep-cycle battery, battery life will be significantly shortened if the battery is repeatedly discharged much below 50 percent of its total capacity. On the other hand, for reasons inherent to the internal chemistry of batteries, it takes longer time to charge a battery much above 75 to 80 percent of its capacity. As a result, except when it is plunged into shore power with a battery charger on, or during extended periods of motor-sailing, a cruising sailboat's house batteries are rarely fully charged.

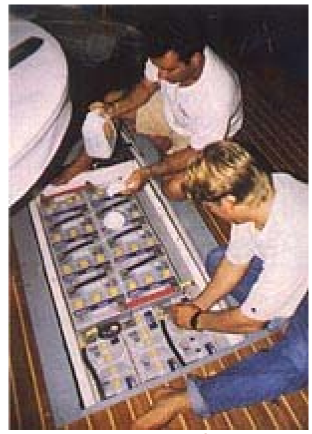
If a battery is discharged to 50 percent of capacity and then recharged to 75 or 80 percent, for practical purposes only 25 to 30 percent of capacity is usable on a daily basis. This leads to a rule of thumb that the batteries on a cruising boat should have a rated amp-hour capacity of four times the anticipated daily load as established in an energy audit. However, battery banks of this size are often not practical because of the space requirements and weight of the batteries. Realistically, banks with a capacity of as little as 2 1/2 times the daily load may be deemed acceptable, although there will be a significant loss of DC system performance and a reduction in battery lifespan as compared to larger banks.

So let's assume the energy audit predicts a daily load of 150 amp-hours. It is therefore best to have a battery bank of 4 x 150 = 600 amp-hours. However, the batteries will weigh somewhere on the order of 130 pounds and will occupy 16 gallons of space. It may be necessary to settle for a bank of as little as 2.5 x 150-375 amp-hours.

If at this point the size and weight of the required batteries are still unacceptable, you have to go back to square one and review what equipment on the boat is truly essential and what is merely desirable or luxurious (see “Energy Audit”). You need to cut more demand out of the system. If you try to fudge this, you will just create a long-term problem for yourself.

One Bank Or Two?

For many years conventional wisdom held that the best arrangement for house batteries on a boat is to have two separate banks and alternate between them daily. The two banks may be supplemented with a third dedicated engine-cranking battery, or the idle house bank may be held in reserve for engine cranking. This is how systems on many boats come from the builders. However, it is not the most efficient way to use batteries.



This installation of wet-cell batteries has separate cranking batteries side by side.

For a number of reasons, it makes more sense to combine all the house batteries into a single large bank. By the same token, it makes little sense to have a separate battery up forward for the windlass. The windlass should be powered from the house bank. (This may need to be qualified for DC bow-thrusters, some of which draw horrendous amounts of current and require huge cables if the batteries are not close by. Each situation should be considered on its merits.)

To be viable, however, a single house bank must be combined with a fairly bulletproof method of cranking the engine. Since you must assume that at some time the house bank will be discharged to a point at which it cannot crank the engine, there should also be a separate battery reserved solely for engine cranking that is kept in a state of full charge at all times.

This is achieved by wiring all house loads to the house bank and nothing but the starter motor to the cranking battery, so there is no chance of accidentally draining the cranking battery in house service. The cranking battery need be no larger than what is needed to crank the engine. An emergency parallel switch between the house bank and the cranking battery can be added just in case one is needed to back up the other, but this can also be accomplished by simply keeping a set of jumper cables on board.

Irrespective of how your batteries are currently wired, for optimum DC system performance you should consider going to a single house battery bank with an isolated cranking battery.

The Optimum Charging Circuit

IBy far the best arrangement for charging a house bank and an isolated cranking battery, particularly if there is a large DC demand, is to leave the existing alternator and voltage regulator wired to the engine-cranking battery and wire a second high-output alternator, controlled by a multi-step regulator, to the house bank. This way both banks can be charged independently, with the voltage-regulation parameter on each alternator set to provide the most efficient charging regimen for their respective batteries. In practice, the regulator for existing alternator will probably not be adjustable, but should in ant case provide a regimen suitable for cranking battery. The multi-step regulator, meanwhile, can be programmed to achieve the maximum state-of-charge and life expectancy for the house batteries. If either the alternator or the voltage regulator fails, the emergency battery-paralleling switch, or jumper cables, can be used to charge both battery banks from the remaining alternator.

With the kind of dual-alternator system just described, there is no need to play with the battery switches except in the case of fire, to isolate a failed battery bank, or to shut down circuits when leaving the boat for long periods of time. You turn on the house and cranking switches when you board the boat and leave them alone until the boat is laid up. Hence there is little room for confusion or operator error.

However, if the house battery bank switch is turned off when the engine is running, the high-output alternator may be damaged. To ensure this does not happen, the installation should automatically shut down the alternator whenever the battery switch is turned off. This requires a special (but readily available) battery switch incorporating something known as an alternator field disconnect, through which the alternator's “field” circuit must be wired (any competent marine electrician can do this).

Single – Alternator Installations

The more typical installation, where two or more battery banks must be charged from a single alternator, requires that the banks be paralleled while charging, so that both are charged, but then isolated when the engine is shut down, so the cranking battery is not discharged in house service. Two methods have traditionally been used to accomplish these objectives. First, a manual switch can be used to parallel the batteries when the engine is running and to isolate the cranking battery when the engine is not running. Alternatively, battery-isolation diodes can be used to provide the same service automatically. Neither option is ideal. Any kind of a switching arrangement is subject to operator error, resulting in one or the other battery bank not being charged (a common event) or both being discharged (also common). Also, the act of switching from one bank to another can sometimes result in alternator damage.

Battery-isolation diodes are subjects in themselves. Their principal advantage is that they parallel batteries for charging and isolate them in service without any user interaction. As such, they are idiot-proof. The major stumbling block is that isolation diodes create a voltage drop in the charging circuit that frequently plays havoc with voltage-regulation circuits, resulting in perennially undercharged batteries that die prematurely. Historically, battery-isolation diodes, which are installed to guarantee proper charging of more than one battery bank, have in fact been major cause of premature battery death.

A much better device for charging more than one battery bank at a time is a voltage-sensitive heavy-duty relay or solenoid that is wired between the banks. This is commonly known as a battery combiner, a name originally coined by West Marine for their device, but which is now more-or-less generic. Any time the combiner senses voltage rising on any battery bank (caused by a charging device coming on line), it parallels the batteries. If the voltage falls (the charger device goes off line), the parallel circuit is broken. With a combiner, the alternator should be wired to the house batteries, since these will need the most charging. This keeps the current flowing through the paralleling circuit to a minimum.

If you currently have more than one battery bank that needs to be charged from a single alternator (or any other charging device), the best approach is to replace any switches or isolation diodes in the charging circuit with an appropriately rated battery combiner. Its amp rating should be at least as great as the maximum output from most powerful charging device on board, which is generally the alternator. A simple on/off battery-isolation switch should also be provided for each battery bank.

This suggested battery configuration is not only the most efficient way to meet DC system demands, it is also the simplest. Further, it guarantees an ability to crank the engine at any time. The big challenge lies in finding enough charging capability to keep the house batteries topped up. I'll look at this in part 3.

Power to the People
Part 3: Supply-Side Economics

by Nigel Calder

SYSTEMS Charging devices and voltage regulators are key elements in the care and feeding of healthy onboard electrical systems.

The typical cruising sailboat is chronically short of battery-charging capability. This is because the primary means of recharging batteries when away from a shore-power connection is the boat's engine-driven alternator. And, of course, the point of having a sailboat in the first place is to run the engine as little as possible.

Unfortunately, with the increasingly heavy DC loads on most boats these days, there is no getting away from some engine-running time. In order to minimize it, a key design objective for a sailboat's DC system should always be to recharge house batteries as fast as practicable.

There is a limit to how fast a battery can be recharged without suffering damage. Different types of batteries have different limits. Even when heavily discharged, wet -cell deep-cycle batteries cannot be charged at a rate that is much above 25 percent of their amp-hour capacity. Gel-cells and AGMs, on the other hand, will take up to 33 and 40 percent of their rated capacity, respectively. Irrespective of a charging device's output capability, as batteries approach full charge these maximum charge rates steadily taper down.

Thus, with a 600-amp-hour battery bank, for example, there is little benefit in having an alternator output higher than 150 amps for wet-cells (25 percent of battery capacity), 200 amps for gel-cells (33 percent), or 240 amps for AGMs (40 percent). In practice, 150-amp and 200-amp alternator's are widely available, but 240 amps is pushing the envelope.

Sizing the Alternator

Alternators are typically rated "cold," but as soon as they warm up, which they do the minute they start producing power, and especially in hot engine rooms, the higher temperature reduces their output, sometimes by as much as 25 percent. Some alternators have a second "hot" rating, perhaps at 122°F: or even at 200°F. Such ratings will be more representative of real-life output than cold ratings.

Manufacturers will demonstrate that alternator output is a function of rotation speed and ambient temperature. Some alternators reach full rated output at much lower speeds than others. The sooner an alternator reaches full output the better, as this maximizes its effectiveness when an engine is idled solely to charge batteries. Maximum capacity is not always the determining factor. Balmar, for example, has a 160-amp alternator that has a higher output than its 200-amp alternator until engine speeds become quite high. In many cruising situations, the 160-amp alternator is not only cheaper, but is also a better performer.

In an ideal cruising-boat installation a second high-output alternator will supplement the engine's existing alternator. Most t times the second alternator can be mounted opposite the first, but if this is not possible because of space or other constraints, it can be mounted “backward” on a bracket on the front of the engine (if this is done, make sure the alternator has a bi-directional fan or it will burn up).

A high output alternator can add a significant load to an engine (up to 7 horse-power per 100 amps of output) so any mounting bracket will have to be solidly constructed. An additional pulley wheel will be needed on the end of the engine's crankshaft to drive the second alternator, and only high-quality drive belts will withstand the load.

To increase charging capability in a single alternator installation, the existing alternator will likely need to be replaced with an appropriately sized high-output alternator wired to the house bank. A battery combiner wired between the house bank and the cranking battery will keep the latter charged without compromising its isolation.

The bottom line is: To minimize charging times a boat needs an alternator with a hot-rated output, in amps, at typical charging rpm, that is at least 25 percent (preferably 33 percent) of the amp-hour rating of all the batteries it is charging. Absent this, it will be extremely difficult to keep the batteries charged when cruising.

Voltage Regulation

A properly sized alternate is only one piece of the charging puzzle. Just as important is the voltage-regulation program. No matter what the alternator's capabilities, unless regulated to optimum effect its potential will be largely wasted.

The standard voltage regulators inside alternators that came with most engines are optimized for charging engine-cranking batteries. They are very poorly set up for charging batteries that are regularly cycled in house applications. When used on house batteries they prolong charging times by a substantial factor at the same time contributing to premature battery death.

In an ideal two-alternator installation, the alternator that came with the engine will be internally regulated, with a voltage regulation program adequate for taking care of the engine-cranking battery. It can be left alone. The high-output alternator, mean while, should be externally regulated by a multi-step regulator. These can be fined tuned to match their charging characteristics to the type of battery being charged.

In a single-alternator installation, where the original engine mounted alternator has been removed, the high-output alternator that replaces it should likewise be controlled by a multi-step regulator, with the charging regimen fine-tuned to suit the house batteries.

A multi-step voltage regulator will do more to improve the health of the DC system on a typical cruising boat than any device on the market. Very often, the improved charging regimen will significantly extend the life of the batteries, such that the regulator may be one of the few things on a boat that can almost be said to have paid for itself. Of all the equipment available to contemporary cruising sailors, this is one of the most important.

When using a high-output alternator and a multi-step voltage regulator, there is at times only a thin line between force-feeding batteries and damaging them. In order to walk this line and manage the DC system to best advantage, precise monitoring and control of the system is needed. This is accomplished in the fine-tuning of the regulator. Although not strictly necessary, it helps to have an accurate systems-monitoring device on board. These are best bought as part of an integrated package from the voltage-regulator manufacturer.

Supplementary Sources of Power

Solar Panels and Wind Generators can minimize engine-run time

No matter how powerful and well regulated an alternator is, battery chemistry is such that it is just about impossible to replace the daily drain on house batteries in less than an hour to an hour-and-a-half of engine-running time. Normally, this is more than the engine is used for propulsive purposes, which means it may get used solely for battery charging when at anchor. This should be avoided both to reduce wear on the engine and to preserve the tranquility of the cruising environment.

Engine-running time solely for charging can be significantly reduced, and sometimes eliminated altogether, through the judicious use of solar panels and/or a wind generator. The choice of which to use is somewhat dependent on the chosen cruising grounds. In areas with light wind a wind generator will be a poor investment, whereas a couple of 75-watt solar panels may crank out as much as 50 amp-hours a day if the sun is shining brightly. In areas with steady winds (such as the Caribbean), solar panels may do as well as elsewhere, even a little better, but will still be eclipsed by far in terms of output by a good-size wind generator. (Note that the single most important factor in determining wind-generator output is blade diameter.)

Solar Panels and Wind Generators Can Minimize Engine Running Time

On many cruising boats a minimum amount of engine-running time, supplemented by alternative energy sources, is enough to sustain the DC system for extended periods. But with this sort of regimen the batteries will almost certainly never be fully recharged. They are, in effect, cycled daily from around 80 percent of full charge down to maybe 50 percent of charge, and back again to 80. This creates the risk of long-term battery damage through a process known as sulfation.

To prevent sulfation, batteries need to be brought to a state of full charge every once in a while, either by running the engine for up to seven hours (hopefully when motor sailing, so that the engine need not be run solely for battery charging for such a long period), or else by plugging 1 battery charger into shore power when it is available.

Defining the Limits

These, then, are the basic building blocks of a successful DC system on a modern cruising boat with a high electrical load. If properly sized and put together, it really is possible to enjoy, with a minimum of maintenance and inconvenience, many of the comforts that we have come to take for granted. Still, there are very real limits to how far this process can be taken.

Assuming a single-engine boat, it is rarely practical to install more than two alternators. High-output alternators up to 200-amps output (hot rated) are available at an "affordable" price, but above this they get extremely expensive. Multi-step regulators are also widely available to control alternator out put up to 200 amps; above this, the alternators field current demand (the energy needed to kick the alternator into life) maybe more that the regulator can tolerate. A 200-amp alternator is ideally sized for charging a 600to 800-amp hour battery bank. This supports a load of up to 200 amp hours a day, so long as adequate time is set aside for recharging. This pretty much defines the practical limits of current technology.

The figuration outlined—a battery bank of up to 800 amp hours capacity fed by a 200 amp alternator with an appropriate multi-step regulator---was pretty well established by the early 1980s and has remained the realistic limit ever since. What has changed is the ability of battery and component manufacturers and installers to bring the pieces together into reliable, trouble-free, user-friendly systems. Combined with the tendency of boat owners to fit all the latest gadgets, this has led to –more—powerful DC systems becoming the norm.

Our Pacific SeaCraft 40 is a good example of the state of the art and cruising-boat DC systems. We replaced the standard 60-amp alternator that came with our Yanmar diesel with an 80-amp alternator. This charges our 100-amp-hour cranking battery, for which it is grossly oversized (its surplus capacity serves as a backup to the main alternator). We have a second 200-amp alternator (Balmar) mounted on a custom bracket fastened to the front of the engine. This charges a 675- amp- hour house battery bank (AGMs). The 80- amp alternator is internally regulated. The 200-amp alternator is controlled by a multi-step regulator linked to a sophisticated DC systems monitor (Heart Interface Link 2000R).

This core system is supplemented by a wind generator (Air Marine) and a couple of solar panels (Siemens). We have all the energy we need to run the boat, including a fridge and freezer, lights and so on, an electric windlass, and a 2500-watt DC-to AC inverter that powers a microwave and, on occasion, the AC water heater (this is a huge DC draw-130 amps-so we run it off the DC system only when we have plenty of energy). We enjoy a wonderful lifestyle when cruising, far more comfortable than in the old days, but in the final analysis if it all fails we can still sail the boat and do fine without it.

Systems expert Nigel Calder is the author of the popular Boatowners Mechanical and Electrical Manual. *His latest book,* Calder's Cruising Handbook, *was published in May by International Marine.*
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