APLUXOR MARINE ELECTRICAL LIBRARY · PART III. ENERGY: HOW MUCH YOU HAVE AND WHERE IT COMES FROM

Chapter 9. Charging from the Engine and from Shore; Starting

Find out why the bank is not charging, and burn out neither the alternator nor the electronics

The engine's alternator and the charger on shore power put back what your boat uses, and for a few seconds the starter takes one of the largest currents on the boat. This chapter shows you what each charging source on your boat is allowed to charge and how it reaches your banks, how to find out why a bank does not charge, and what to do when the engine will not crank.

AFTER THIS CHAPTER YOU CAN

- say what your outboard's charging output is allowed to charge, and by which unit a house bank gets its share;
- find where your inboard's alternator lands and what its regulator reads, and tell what suits a house bank;
- set a charger for your battery's chemistry, and read what its "charge complete" light means;
- read your battery monitor while several sources charge one bank;
- follow the route when the engine does nothing, clicks or turns slowly, and keep an engine from starting while it cranks the way its manual shows;
- judge an automotive charger or a truck alternator against what a boat asks of it.

Read first: → 1.7, → 3.4, → 6.1, → 8.1, → 8.3

9.1 The outboard's charging output
9.2 The inboard alternator and external regulator
9.3 The shore charger as a DC device
9.4 Several sources at once
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9.1. The outboard's charging output

What does your outboard's charging output put into your batteries, which battery is it allowed to charge, and how does a house bank get its share? An outboard with a charging output carries its own alternator under its cover, and the current it makes reaches the start battery through the cables between the engine and that battery, or through the engine maker's isolator where one stands between them (→ 8.1). Everything else in this section follows from that path: the start battery is the battery the outboard charges, and any other bank gets its share through a unit between the two.

Not every outboard has a charging output. One maker installs the alternator of a family of small outboards only on one model of that family and offers it as an option on the others; another maker's electric-start conversion kit for one of its fuel-injected outboards has a voltage regulator/rectifier installed with it. Whether your engine MFR has a charging output, what it is rated at, and whether it came only with a model or a kit, its manual says. An outboard with none charges no battery: another source charges it — a charger (→ 9.3 · p. 17), solar panels or a wind generator (→ 10.1, → 10.5).

What it delivers

An outboard maker prints its charging output as one figure per engine, and that figure is not what reaches the bank at idle. One maker's manuals give the alternator output for the battery as 45.0 A for two of its models and 46.0 A for a third, without naming the engine speed (→ Table 9.1 · p. 3). A second maker rates its 150 hp engine's alternator at 60 A and its 75 to 115 hp engines' at 35 A, and on the 150 hp engine

raises the idle speed by itself to boost the alternator's output and recharge low batteries: at the ordinary idle speed that engine gives less.

What reaches your bank while the outboard runs is what the battery monitor shows at the helm: its current, at the speed you run, with the loads you have on (→ 7.5). A bank near full takes less than a low one (→ 9.4 · p. 24). MFR

Table 9.1. Two outboard makers: charging output and start battery MFR

Engine	Charging output, as printed	Start battery its manual asks for	Engine speed of the figure
Maker 1, two models (manual of 2004)	45.0 A, "alternator output for battery DC"	At least 711.0 A cold cranking amps (CCA) and 100.0 Ah at the 20-hour rate	Not given in its manual
Maker 1, one model (manual of 2006)	46.0 A, the same words	The same two minimums	Not given in its manual
Maker 2, 150 hp	60 A, on the maker's product page	1000 marine cranking amps (MCA), 800 CCA or 180 Ah, in its manual's specifications	Not given on the product page; the engine raises its own idle speed to recharge low batteries
Maker 2, 75 to 115 hp	35 A, on the same page	In each engine's own manual	Not given on the product page

Which battery it charges, and why that battery

One outboard maker's manual tells you not to use a battery that does not meet the specified capacity, and gives a minimum cold cranking current and a minimum capacity at the 20-hour rate for each engine; the battery its two manuals describe is a flooded lead-acid battery, whose electrolyte contains sulfuric acid and is topped up with distilled water. A second maker's manual lists a low electrolyte level among the causes of a battery that will not hold its charge. Your engine's manual gives its own figures, and your battery's label is read in the same ratings (→ 6.1). MFR

The reason a charging output needs the battery its maker allows is the battery's job in the circuit. An alternator pushes its current into the battery, and the battery holds the voltage down. If the battery is taken away while that current flows — by a cable that comes loose, by a battery switch between them turned away from that battery, or by a lithium battery's own protection opening its circuit — nothing holds the voltage: it jumps, the load dump of → 1.7. One maker of alternators and regulators writes that running an alternator without a battery will damage the alternator and may damage any attached system; one outboard maker's manual writes, for the battery of one of its models, that the battery leads must not be disconnected from the battery while the engine is operating, because the electrical parts could be damaged. MFR

An outboard's charging system meets the same physics: a lead-acid start battery stays in the circuit whatever its charge, whereas a lithium battery carries a battery management system (BMS) that can take it out of the circuit (→ 11.4). A third outboard maker writes, in a numbered statement of its own, that its outboards' electrical systems were originally developed for lead-acid batteries, AGM and gel included, and allows a lithium-ion battery that meets the engine's amp-hour (Ah) and cold cranking amp (CCA) requirements, with a battery management system, a lithium-ion compatible charger that the battery's maker recommends or approves and whose charging output is within that maker's specified ranges, and the battery installed in a location that resists shock or vibration and operated within that maker's temperatures and limits. That is why the start battery is a lead-acid battery unless the engine's own manual or its maker's bulletin — a numbered statement like that one — allows a lithium one, on the conditions it gives. Your engine's manual or bulletin is the document that decides; a lithium bank and its charging are in → 11.3. MFR

One lithium battery maker reports that the second maker of → Table 9.1 · p. 3 approves lithium iron phosphate starting batteries that meet a list of that engine maker's requirements, for a list of its outboard models. VERIFY

Where a battery switch stands between the outboard and its start battery, turning that switch while the engine runs takes the battery

away from the charging output in the same way. When a battery switch is turned is set in → 1.7, and the outboard's case is in → 8.1.

An outboard's charging output charges the start battery its engine's manual or bulletin allows — a lead-acid battery unless that manual or bulletin allows a lithium one, on the conditions it gives — and charges a house bank only through a unit between them: the engine maker's own isolator or accessory charging lead, as its manual says; a charging relay (ACR); or a DC-DC charger. An inboard with an external regulator may charge the house bank directly (→ 9.2 · p. 8). PRACTICE

A house bank behind an outboard

A house bank gets its share of an outboard's output through one of three units, each with its own fuse at the battery on every lead it has there (→ Fig. 9.1 · p. 7): the engine maker's own isolator or accessory charging lead, which starts at the engine, or a charging relay or a DC-DC charger between the start battery and the house bank.

The first is the engine maker's own isolator or accessory charging lead. One outboard maker writes that many of its large outboards, 150 hp and up, have a separate battery isolator or charging leads specifically for charging house batteries, that the charging system charges the starting battery or batteries first to help keep the voltage up, and that once they are fully charged it switches the charge to the house batteries. MFR

On three older engines of the same maker, in two manuals, the lead is an optional part, a small red lead for accessory battery charging. Both manuals ask for a cable between the negative terminals of the starting battery and the accessory battery made from wire thicker than the starting battery cable, with the warning that smaller wire could lead to a fire; one sends you to the maker's dealer for the wiring of the accessory battery, the other for the wiring of a battery selector switch. A second outboard maker's service diagram of 1997 draws, for one of its four-cylinder engines, a battery isolator between the engine's output lead and both batteries, the start battery and an auxiliary battery. None of these documents names the type of battery the lead may charge.

Whether your engine has such a lead is in its manual, and so is who wires it; a lithium house bank is charged as → 11.3 says. MFR

The second is a charging relay (ACR), fused at each battery: it joins the two banks while it senses a charge and parts them when the voltage falls (→ 8.3). While it is closed, the start battery and the house bank are one battery for the outboard's output, and for every load on either bank. Whether a lithium house bank may be joined to a lead-acid start battery this way is in → 11.3.

The third is a DC-DC charger, fused at each battery: it takes power from the start battery and gives the house bank a charge controlled by its own settings, while its maker's run conditions are met (→ 8.3). One maker's onboard DC alternator charger for trolling-motor batteries gives each battery its own output, and its manual says each output bank is independent and isolated from one another. How a 24 V or 36 V trolling-motor bank ties to the rest of the boat is in → 6.4 and → 14.3. MFR

A battery switch at BOTH, ALL, 1+2 or COMBINE while the outboard runs charges both batteries as one, and leaves them joined when the engine stops: the trap of → 8.5, not a fourth unit. Which unit your boat has is read on its label and traced by eye (→ 8.3), and goes into field 9 of the Boat Passport; why a bank does not charge from the engine is found by the route of → 9.2 · p. 8.

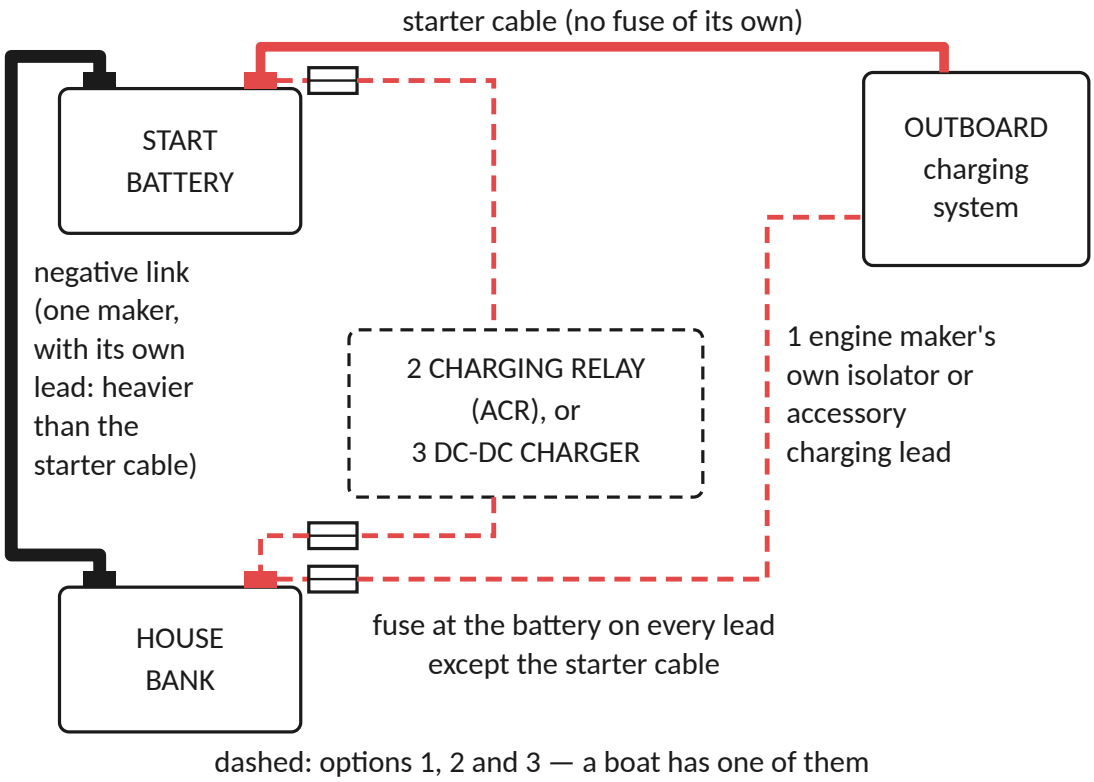


Fig. 9.1. An outboard, its start battery and a house bank, on one typical boat. The outboard's charging output reaches the start battery through the cables between them. The house bank gets its share through one of three units, drawn dashed: 1, the engine maker's own isolator or accessory charging lead; 2, a charging relay (ACR); 3, a DC-DC charger. Every lead from a battery has its own fuse at that battery, except the starter cable. One maker's diagram puts its isolator outside the engine, between the engine's output lead and both batteries; that variant is not drawn. Your boat can be wired differently.

WHY IT WORKS

Where an outboard's charging system has a voltage regulator — one maker lists a rectifier, an alternator and a voltage regulator among the charging parts of its engine — the regulator holds the voltage at its output to its setting, and the battery on the other end of the cable takes whatever current that voltage pushes into it. A start battery gives up only a little of its charge to a start, so it is back near full soon after the engine runs, and from then on it takes little. A house bank that the night's loads have discharged behaves differently: joined straight to the start battery, it would take most of the output for hours, the two would sag together under every load, and the next start would come from what the night left in both — the trap of a switch left at BOTH (→ 8.5). A unit between them changes that. One maker's own isolator charges the start battery first and only then the house batteries; a charging relay joins the banks only while it senses a charge; a DC-DC charger takes a controlled current from the start side and stops on its own conditions. Where the explanation stops working: a relay that stays closed with nothing charging joins the banks after the engine stops (→ 8.3); and an inboard whose external regulator reads the house bank charges that bank directly, which leaves the start battery to be charged through the unit between the banks instead (→ 9.2 · p. 8).

Charging outputs by model and engine speed, which models carry their maker's own charging lead, and the lithium start batteries engine makers approve are the subject of → module "Engines".

9.2. The inboard alternator and external regulator

What does your inboard's alternator need to charge a house bank well, where does its output go, and what does its regulator read? An alternator makes current only while the engine turns it, and its regulator decides how much: it reads a voltage, and it turns up or down the current in the alternator's field — the winding whose magnetism makes its output, fed through the alternator's field terminal — to hold that voltage at its setting. Where the regulator reads, what it is set to, and where the output lands decide how full each bank gets.

A regulator built in, or an external regulator

An alternator's regulator is either built into it or mounted apart from it as an external regulator. A built-in regulator works at the setting its maker gave it, and one maker of heavy-duty alternators gives some of its models a second wire that reads the actual voltage at the battery, which it calls remote sense. An external regulator is set for the MFR battery it charges — by a program its maker offers for each battery type — and reads the voltage through a sense lead of its own. Two things depend on which you have. A field disconnect on a battery switch works only with an external regulator (→ 8.1). And behind a diode isolator, a regulator that reads the voltage on the alternator's side of the isolator holds that side at its setting, so each bank gets that voltage less the diodes' drop: the house bank that never gets full of → 8.3.

What a given alternator delivers depends on its own speed and temperature: one alternator maker's table for its 165 A alternator gives, hot at 194 °F and with its test voltage set at 13.5 V, 153 A at 6,000 alternator rpm and 59 A at 1,500, and the alternator's speed is the engine's speed times the ratio of their pulleys (→ 7.5). MFR

What suits a house bank

An external regulator suits a house bank when three things are right: it reads the voltage of the battery it charges, it is set to that battery maker's charge numbers, and it knows how warm the battery is. One regulator maker's manual shows what each of these takes.

Its sense lead runs through its own 1 A fuse, which that maker's harness kit carries in the center of a pigtail, with a ring terminal at one end, whose length its manual does not give. That fuse belongs at the start of the lead, within the distance → 4.2 gives from where the lead takes its power: measure where yours sits. That maker names three places that work best in most instances: the positive output of the alternator, the common side of a battery switch, or the positive post of the battery being charged. Its power wire, in most applications, runs from the alternator's positive output post, through a 10 A fuse that the maker asks for to protect the regulator. With a diode isolator, both the power

wire and the sense lead go to the battery side of the isolator, the sense lead at the larger of the battery banks, the place that maker prefers.

MFR

A regulator that reads on the battery side of a diode isolator raises the alternator's voltage until that battery reads the setting, which makes up for the diodes' drop. The isolator maker of → 8.3 offers a second way, a compensation diode that raises the alternator's output slightly. Either way the bank the regulator reads is the one held at the setting.

The same regulator reads two temperature sensors where they are installed: one on the alternator, to limit the alternator's output when it runs too hot; one on the battery, to adjust the charging voltage to the battery's temperature and to discontinue charging when the battery runs too hot. Its manual puts the battery sensor's lug on the battery negative post closest to the center of the bank, and warns that a sensor connected with reversed polarity gives invalid readings and can damage the alternator, the regulator or the batteries. A lug on a battery post is work at a battery terminal (→ 1.8).

MFR

Its default settings differ by battery type, each a voltage for a stage of its charging profile — bulk, absorption and float, in that order. That maker's regulator holds each stage's voltage for a set time, and the float voltage, which keeps a full battery full, is the lowest. For example, bulk is 14.1 V for gel batteries and 14.6 V for deep-cycle flooded batteries, and these are one regulator's defaults, not your battery's numbers: your battery maker's charge settings decide, and they go into field 12 of the Boat Passport (→ 6.1).

MFR

For a lithium house bank, the same maker writes that its lithium profile is not a replacement for a BMS, that the regulator cannot prevent charging at low temperatures, and that the alternator must not be able to exceed the battery's maximum continuous charge current. A lithium bank on an alternator is in → 11.3.

MFR

What does not suit a house bank is the reverse of these three: a regulator that reads somewhere the house bank's voltage does not reach, a setting made for another battery type, and no way of knowing the battery's temperature. A house bank behind a diode isolator,

charged by a regulator that reads the alternator's side, has the first of them.

Where the output lands

Where your alternator's output lands — at the starter, on the engine terminal of the battery switch, at the start battery or at the house battery — is found by following its heavy output wire by eye, by the procedure "What each battery switch connects", whose Fig. 8.3 draws all four (→ 8.1). No landing is the rule, and field 8 of the Boat Passport records yours. The landing decides three things here. Which bank the alternator charges directly: the battery it lands at, or, where it lands at the starter or on the battery switch, the bank the switch connects. Which bank gets its charge through the unit between the banks (→ 8.3). And where an external regulator's sense lead has to read: at the bank you want held at the setting. When any battery switch is turned, whatever the landing, is set in → 1.7.

On a boat with two engines, one sterndrive maker's manual writes that isolators can be used to charge an auxiliary battery used for powering accessories, that they "should not be used to charge the battery of another engine in the boat unless the type of isolator is specifically designed for this purpose", and that boats with multi-engine EFI power packages require each engine to be connected to its own battery. MFR

The output conductor runs without a fuse only under conditions. The 2003 edition of ABYC E-11 exempts the conductor from a self-limiting alternator with an integral regulator, where that conductor is connected to a source of power other than the battery, stays within a length limit and is in a sheath or enclosure along its whole length (→ 4.2). An output landed at a battery terminal is connected to the battery, and an alternator run by an external regulator has no integral regulator: neither is under that exemption, and → Fig. 9.2 · p. 12 draws the output with its fuse at the battery. A positive with no fuse where it needs one is the unprotected positive of → 4.2. ABYC

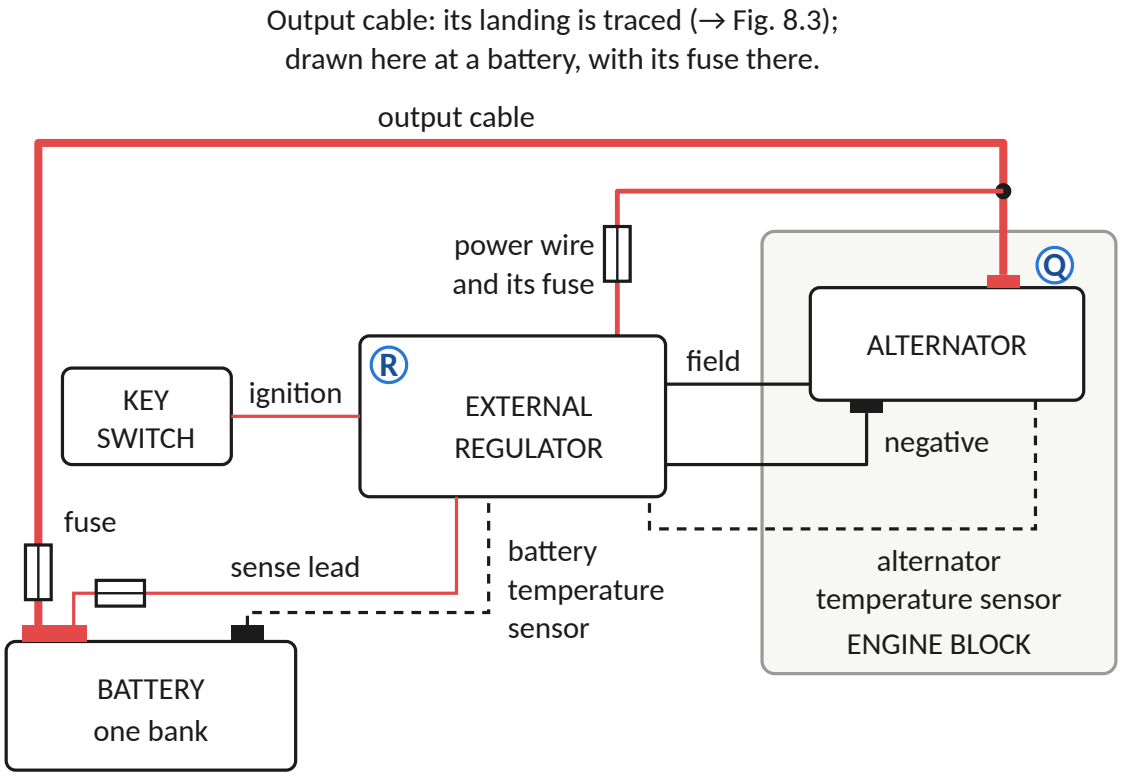


Fig. 9.2. An inboard alternator with an external regulator, on one typical boat. Q is the alternator's output post, R the regulator's terminals. The output cable lands where your tracing finds it (→ Fig. 8.3); drawn here at a battery, it has its fuse there. The regulator's power wire, its sense lead and the output cable each have their own fuse; the regulator reads the battery through its sense lead, and the two temperature sensors where they are installed. Its power wire leaves the output cable just above the alternator's output post and its negative goes to the alternator's negative terminal, as its maker writes for most installations; the sense lead's fuse is drawn at the start of the lead, at the battery (→ 4.2).

What you read, and what is a pro's

Three kinds of reading tell you whether the engine charges, and none of them needs a hand near a turning belt. With the engine running: the bank's voltage and current on the battery monitor or voltmeter at the helm, or, with no instrument there, the voltage at the battery's terminals where that battery is outside the space with the turning belts. With the engine stopped and the key OFF: the belt, the output wire and the fuse on it, by eye. With the key at ON and the engine stopped, on an external regulator: whether its power, sense and ignition terminals have the battery's voltage, and its field terminal a voltage too — the pattern

of one regulator maker's own test, whose manual says that if voltage is not present on the power wire, the ignition wire and the sense wire, the regulator will not work. That maker also names an oil-pressure switch as one way of feeding the ignition wire, and its test skips this reading on such a system: there the ignition and field terminals read nothing with the engine stopped, and that is normal. MFR

An alternator's output, a regulator's voltage or an isolator's drop read with the engine running, beside a turning belt, is a pro's reading (→ 3.4, → 8.3). The route below takes you as far as the readings that are yours, and gives the pro what you found.

Route: the bank does not charge from the engine

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → its wiring, where the output lands (field 8) and the unit between the banks (field 9): step 1
- after charging → whether the charger or the solar panels had already filled the bank, which then takes little from the engine (→ 9.4 · p. 24): step 2
- after rain or washing the boat → the belt, the output wire and its fuse, by eye: step 4
- after the boat sat unused → the bank's own condition (→ 6.6), then step 1
- after switching sources (shore power, generator, inverter) → which source was charging the bank: step 2
- nothing you noticed → step 1

ROUTE: THE BANK DOES NOT CHARGE FROM THE ENGINE — POINTS Q AND R ON → FIG. 9.2 · P. 12



1. Read fields 4, 8 and 9 of the Boat Passport: where the alternator's output lands — on an outboard, which battery the engine's positive cable reaches — and which unit charges the

second bank.

You will see: The bank that does not charge is the one the output reaches — the battery it lands at, the bank the battery switch connects where it lands at the starter or on the switch, an outboard's start battery: step 2. The output lands at a diode isolator with both banks behind it: step 2, for the alternator first. It is the second bank, charged through a charging relay, a DC-DC charger or an outboard maker's own lead: the route "The second bank does not charge" (→ 8.3). No unit between the banks — none in field 9 and none seen, only a battery switch: that bank charges from this engine only while a switch position joins the banks, the trap of → 8.5, and a unit between them is a pro's to install — what to order is in What to tell the pro (→ 9.7 · p. 41). An outboard whose manual shows no charging output, or names one only with a kit your engine does not have: it charges no battery — another source charges it: a charger (→ 9.3 · p. 17), solar panels or a wind generator (→ 10.1, → 10.5). A landing you do not know: step 5 of the procedure "What each battery switch connects" (→ 8.1) first; still not seen, step 2 with the bank your monitor shows, and a "?" in field 15.

2 Switch the charger off at its own switch — a charger with none: its breaker on the AC panel OFF, from the front of the panel, or the test made where the boat has no shore power and no generator running, at anchor or under way — cover the solar panels or switch their controller's own switch OFF, and stop a wind generator as its manual says, so that the engine is the only source. Run the engine — at a fast idle in neutral, as its manual allows, at the dock or at anchor, or under way; on a trailer, only with cooling water supplied as its manual says. The bank then takes a charge from the engine alone. Read the bank's voltage and current on the battery monitor or voltmeter at the helm.

You will see: The voltage rises above where it stood before the start, toward the charge voltage the battery's maker gives (→ 6.1), and the monitor shows a charge going in: the engine charges, and the bank's condition (→ 6.6), the time the engine runs (→ 7.5) and the sources together (→ 9.4 · p. 24) come next; at an outboard's ordinary idle the charge is small (→ 9.1 · p. 2); behind a diode isolator, a second bank that still does not charge: the route "The second bank does not charge" (→ 8.3). The voltage stays where it was, or falls as the loads run: step 4. The voltage climbs above the highest charge voltage the battery's maker gives: a regulator program set for another battery type, the regulator raising the voltage for a cold battery by its sensor, a failed regulator — or a gauge that reads high. Where the regulator shows its program and its sensor's

temperature, compare them with the battery maker's numbers in field 12; a program for another battery type that the regulator's manual lets you change is set as that manual says. Where the bank's battery is outside the space with the turning belts, a reading at its terminals, taken as step 3 says, tells the gauge from the bank. Anything else, or a cause you cannot tell: step 6, and until a pro has read it, run the engine only as far as you need it. On a lithium bank, a charge above its maker's limit can make its BMS disconnect the bank — the load dump of → 9.1 · p. 2 — and the bilge pump, the high-water alarm and the CO alarm on that bank lose their power with it: stop the engine, or turn the regulator off by its own control where its manual gives one, as soon as the boat can do without the engine. No instrument at the helm: step 3.

3 With no instrument at the helm, read the bank's voltage at its battery terminals with the engine running, where that battery is outside the space with the turning belts — on an outboard boat, a battery outside the engine's cover — the meter set as the entry of the METER LEADS sign says.

You will see: What the reading means: as in step 2; a reading here below the gauge's points to the gauge. The battery in the space with the turning belts: step 6.

4 Stop the engine and turn the key to OFF. Look, by eye, at the alternator's belt where the engine's manual shows one, its heavy output wire and the fuse on that wire where there is one, and the battery's terminals; on an outboard, under its cover, taken off as its manual shows.

You will see: A belt missing, broken or loose on its pulleys: one outboard maker has a worn belt replaced by its dealer — the engine's manual says who replaces yours, or a pro. No alternator belt on an engine whose manual shows none: not a fault — the other checks of this step; a timing belt is not the alternator's, and the manual shows which belt is which. An output wire landed at a battery terminal with no fuse there: an unprotected positive — it is written on the first line of the Boat Passport, and what it may carry until a pro protects it is in → 4.2, under its sign. An output wire landed at the starter or on the battery switch with no fuse on it: a "?" beside the landing in field 8 — whether it meets the conditions under which 4.2 lets it run without one is for a pro to say (What to tell the pro, → 9.7 · p. 41). A fuse on the output wire whose element is broken — one outboard maker lists an open circuit in the alternator output wire's fused link among the causes of a battery that will not hold its charge: the route "A branch breaker trips or a fuse blows" (→ 4.8). A loose or corroded lug on a

battery terminal: the planned job on a battery (→ 6.5), or a pro where that procedure says so. Nothing seen: on an external regulator, step 5; on any other engine, step 6.

5. On an external regulator, with the engine stopped, turn the key to ON and read the regulator's own lights or display, as its manual says. Where its manual gives a test with the key at ON and the engine stopped, read its power, sense, ignition and field terminals at point R against the negative, as that test says, the meter set as the entry of the METER LEADS sign says.

   You will see: Power, sense and ignition at the battery's voltage, and a voltage on the field terminal within the range of that test: the regulator is doing its part — step 6. Power or sense missing: the fuse on that wire, by eye — one maker puts a 10 A fuse on the power wire and a 1 A fuse on the sense lead; a blown one: the route "A branch breaker trips or a fuse blows" (→ 4.8). No voltage on the ignition terminal, or none on the field terminal: step 6, with the readings as you took them — on a regulator whose ignition wire is fed through an oil-pressure switch, both read nothing with the engine stopped, and that maker's test skips this reading there. A regulator whose manual gives no such test: step 6.

6. Take what you saw to a pro: the readings of steps 2 and 3, what step 4 found, and the regulator's readings of step 5. Ask for the charging circuit's drop at full charging current, the alternator's output and the regulator's voltage with the engine running, and an isolator's drop where the boat has one (What to tell the pro, → 9.7 · p. 41).

   You will see: Until the pro has found it, the bank is charged by what still reaches it — the charger on shore power, the solar panels — and how long it lasts on its own charge is worked out by → 7.4. A start battery the engine does not charge: if it becomes too low for the next start, that start is by → 8.5.

PUT THE BOAT BACK IN SERVICE

- The key at OFF, where step 5 turned it to ON; an outboard's cover back on, as its manual shows.
- The charger or its breaker on the AC panel, the solar panels or their controller's switch, and a wind generator you stopped, back as you found them.

- A cooling-water supply removed as the engine's manual shows; if you ran the bilge blower before the engine ran, its switch back where you found it.
- A lithium bank its BMS disconnected: reconnected as its maker's manual says (→ 11.4) — steps that take cables off the battery are work at a battery terminal (→ 1.8); the entries of the BILGE PUMP and CARBON MONOXIDE signs say what to check then.
- The meter's dial at OFF.

Programming a regulator by brand, its belt and current limits, and alternator upgrades are the subject of → module "Engines".

9.3. The shore charger as a DC device

What does your shore charger do on the DC side, what is it set for, and how does it reach your banks? A charger takes AC from shore power and gives each bank it serves a direct current by a charging profile — the steps of voltage and current it follows from a low battery to a full one, made for one battery chemistry. Its AC side belongs to the shore power chapters (→ 17.2, → 17.3). This section is about its label, its settings, its outputs and how they reach the batteries.

The label: what it takes

The input on the charger's label says which shore power it takes: one maker builds some of its marine chargers for 120 V AC plus or minus 10 % and others for a range from 100 to 240 V AC. The shore power of this book is 120 V, or 120/240 V, at 60 Hz; a pedestal that gives another voltage or frequency is → 2.5. The maker and the model on that label go into field 12 of the Boat Passport, because every question about the charger's settings and outputs is answered in that model's manual. MFR

The profile: set for the battery's chemistry

A charger charges a battery fully, without overcharging it, only on a profile made for that battery's chemistry; the setting is the charger's,

and the numbers behind it are the battery maker's (→ 6.1). Chargers differ in what they offer (→ Table 9.2 · p. 19). One marine charger offers flooded, AGM, high-performance AGM and LiFePO4 — the last for approved lithium batteries only — comes set for standard flooded batteries, warns against overcharging a battery by selecting the wrong battery type, and is not for gel batteries at all, nor for 4D or 8D large capacity batteries; another charger of the same maker offers flooded, sealed, AGM, gel, LiFePO4 and a custom setting; a second maker's charger with three outputs allows only one battery type for the whole system. MFR

A charger that offers no setting for your battery's type is not that battery's charger: one battery maker of both types requires a voltage-limited charger for its gel and AGM batteries (→ 6.1), and the first charger above writes that gel batteries require a completely different charge profile that must be selected. A charger with one setting for all its outputs charges every bank on it by that setting, so banks of two chemistries need a charger whose manual lets each output be set apart, or a charger for each. MFR

Which setting your charger is on, and how it is changed — a switch, a menu, its maker's app, or, on the first charger above, a selection made in its analyze mode — its manual says; the route at the end of this section compares the setting with your battery and changes it (step 6). The setting goes into field 12 of the Boat Passport.

A charger's "charge complete" light shows its own decision: it has ended its profile. Whether your charger may then stay plugged in is in its manual — whether it ends its profile in a float or maintenance stage, and what it says about leaving it on — read against your battery maker's charge numbers (→ 6.1). One maker's charger lights its green LED "when the batteries are fully charged", asks you to always leave that charger plugged in to reduce sulfate build-up inside the battery, and in storage runs a recondition cycle for 3 hours once a month. MFR Whether the bank is full depends on the profile being the right one for the battery and on where the charger reads the voltage; a battery monitor that sets itself to full during the charge (→ 7.6), or the battery's resting voltage after its maker's rest (→ 3.5), shows it (→ 7.3).

An equalizing charge is given only as the battery's maker says, by its method, with a charger that can give it (→ 6.6); whether yours can is in its manual, where the mode carries that name.

Battery makers raise the charge voltage when the battery is cold and lower it when it is warm, each by its own coefficient (→ 6.2). Two makers' marine chargers read the battery's temperature through a sensor that comes with them: with it connected, one writes, the charger adjusts its charge to the battery's temperature; the other adjusts its charge voltage by it, and does not charge when the battery's temperature is above or below a set value. Where such a sensor is fastened on a battery terminal, installing it is work at a battery terminal (→ 1.8). MFR

Outputs: one bank or several

A charger with several outputs charges each bank through a positive output of its own, and what the outputs share differs from charger to charger. One maker writes that each output of one of its chargers is fully isolated, and gives another of its chargers one common negative for its positive outputs ("one common battery ground", in its words); a second maker's charger has one negative and three positive outputs; a third maker writes that each output bank of its chargers is independent and isolated from one another and from the AC input. One charger's manual adds that in its LiFePO4 mode its DC terminals are powered whenever AC is present. MFR

"Isolated" therefore means what the charger's own manual says, and this book counts a charger as joining the banks it charges unless its manual says its outputs are isolated from one another (→ 1.8, → 6.5). Which output feeds which bank is followed by eye from the charger to each battery and goes into field 9 of the Boat Passport; an output landed after a battery switch reaches its bank only while that switch connects it (→ 8.1).

Table 9.2. What five chargers' makers write about settings, outputs and the battery's

temperature MFR

Charger	Battery types it offers	Its outputs	Temperature sensor for the battery
Maker 1, charger A	Flooded, AGM, high-performance AGM, LiFePO4 (approved lithium batteries only); not for gel, 4D or 8D batteries	In LiFePO4 mode, its DC terminals powered whenever AC is present	None in its manual
Maker 1, charger B	Flooded, sealed, AGM, gel, LiFePO4, custom	One common negative for its positive outputs ("one common battery ground", in its maker's words)	Comes with one
Maker 1, charger C	Its manual	Each output fully isolated	Its manual
Maker 2, three-output charger	AGM, flooded, gel, thin-plate pure lead; one type for the whole system	One negative, three positive	Comes with one
Maker 3, onboard charger line	Its manual	Independent and isolated from one another and from the AC input	Its manual

Mounting and protection on the DC side

Where the charger goes, and how its DC leads are protected, its maker's manual says. One maker mounts its charger in a compartment that can be properly ventilated during use, not on or over combustible surfaces, and lists ignition protection among the charger's features; another maker's data name its charger ignition protected, to SAE J1171. Where gasoline vapor can reach it (→ 4.6), a charger needs that protection by its maker's statement or marking (→ 9.6 · p. 38). MFR

Each positive lead from the charger to a battery has its own fuse at the battery. One charger maker writes that each positive conductor from the charger to the battery or battery bank must be fused, and another puts an in-line fuse near the end of each positive cable; the fuse's rating

is the charger maker's. How far from the battery that fuse may sit MFR is the rule of → 4.2, and a charger output with no fuse at the battery is an unprotected positive (→ 4.2). Connecting a charger's leads at a battery terminal is work at a battery terminal (→ 1.8); a portable charger's clamps are connected and disconnected by the procedure "A battery on a portable charger" (→ 6.6).

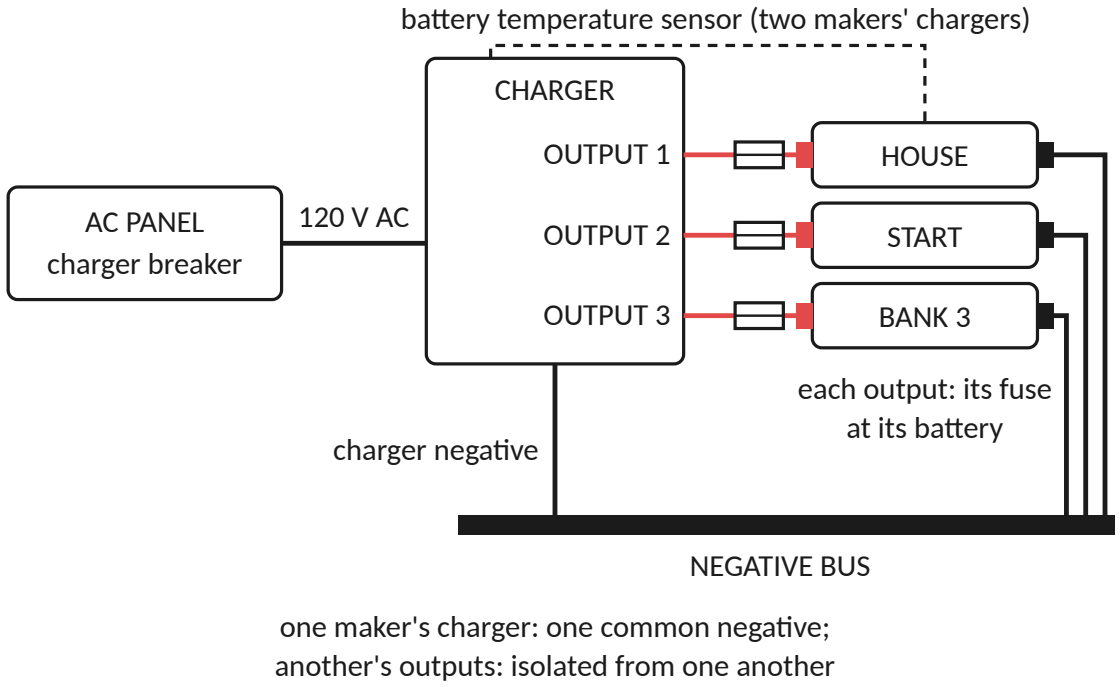


Fig. 9.3. An onboard charger with three outputs, on one typical boat. Each output runs to its own battery through its own fuse at that battery; the charger and the batteries return to the negative bus. Whether the outputs are isolated from one another is in the charger's manual. The dashed lead is a temperature sensor on the battery, which two makers' chargers have. The AC side, from the charger breaker on the AC panel, is in → 17.2.

Route: the bank does not charge from the charger

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → the charger's setting and which output feeds which bank: step 4
- after charging → what its light showed at the end, and what "charge complete" means: step 3
- after rain or washing the boat → the output fuses and their holders at the batteries, by eye: step 5
- after the boat sat unused → the bank's own condition (→ 6.6), then step 1
- after switching sources (shore power, generator, inverter) → whether shore power reaches the charger, and an inverter/charger's own mode: step 1
- nothing you noticed → step 1

ROUTE: THE BANK DOES NOT CHARGE FROM THE CHARGER — → FIG. 9.3 · P. 21

SHOCK IN WATER · AC — PRO · HOT BATTERY · GASOLINE VAPOR · METER LEADS · SHORT CIRCUIT · BLOWN FUSE · BILGE PUMP · CARBON MONOXIDE

1. With shore power connected the way you use it, look at the AC panel: its meter or its lights show whether shore power is on the boat.
   You will see: Shore power on the boat: step 2 — on an inverter/charger, with its own switch and mode set to charge, as its manual says. None: the AC side — the card "Shore power tripped and won't come back on" (→ emergency card) where it tripped, otherwise → 17.3.
2. Look at the charger's breaker on the AC panel.
   You will see: ON: step 3. Tripped: → 17.3, where a breaker on the AC panel is treated.
3. Read the charger's own lights, display or its maker's app, with the meaning of each from its manual.
   You will see: Charging: step 4. Complete: it has ended its profile — step 6 first, then step 7. A fault shown: its manual says what it means and what to check first. Dark, with shore power on the boat and its breaker ON: the charger's AC input or the charger itself — a pro.

4. Find which output feeds which bank, on the charger's label and by following each output lead by eye to its battery, and compare with field 9 of the Boat Passport.
   You will see: The bank on an output of its own: step 5. No output of its own, or its output landed after a battery switch: that bank charges only through what joins it to a bank that has one (→ 8.1, → 8.3) — write it into field 9, and step 5 for the output it does have.

5. Look, by eye, at the fuse on that output's lead at the battery.
   You will see: Whole: step 6. Blown: it has found a fault — the route "A branch breaker trips or a fuse blows" (→ 4.8). No fuse at the battery: an unprotected positive (→ 4.2) — switch the charger off and leave it off, write that lead on the first line of the Boat Passport, and a pro protects it.

6. Compare the charger's battery-type setting with the label and the maker's charge numbers of every battery on that charger (→ 6.1). A wrong setting that the charger lets you change — on a charger whose manual lets each output be set apart, or whose banks are all of one type: change it as its manual says, and write the new setting into field 12 of the Boat Passport.
   You will see: The setting right for every bank on it: step 7. Changed: the bank takes a charge on the new setting — step 7. One setting for all the outputs, and banks of different types on them: the setting is not changed to suit one bank — the case is for a charger whose manual lets each output be set apart, or a charger for each bank (→ "The profile" · p. 17, above), and a pro where you cannot tell; until then, the charger runs only on a setting that every bank on it allows, by its manual and the battery makers' numbers, and otherwise stays off. A setting you cannot read or cannot change, or a charger with no setting for this battery's type: a pro, or the charger that has one (→ 9.6 · p. 38); until then, the same — the charger runs only on a setting you can read that every bank on it allows, and otherwise stays off. A bank this charger does not charge meanwhile takes its charge another way — from the engine (→ 9.2 · p. 8), solar panels or a wind generator (→ 10.1, → 10.5), or a portable charger (→ 6.6) — and how long it lasts on its own charge is worked out by → 7.4.

7. With the charger charging, read the bank's voltage and current on the battery monitor, or the voltage at its battery terminals, the meter set as the entry of the METER LEADS sign says. With its charge complete, read whether the battery

monitor has set itself to full (→ 7.6), or take the battery's resting voltage by the procedure "A battery's resting voltage" (→ 3.5).

You will see: The voltage rises toward the charger's setting and the current falls as the bank fills (→ 9.4 · p. 24): the charger charges, and a bank that still does not come full after the charge and its rest has its own condition to check (→ 6.6). Complete, with the monitor set to full by its tail current or the resting voltage at its maker's 100 % row: the bank is full. Complete, with neither, on a setting step 6 found right: where the charger reads the voltage, as its manual says, or the bank's own condition (→ 6.6). The charger shows charging, but the voltage stays at the battery's resting voltage and the monitor shows nothing going in: the output lead, its connections or the charger itself — a pro. On a lithium bank, the charger's voltage at the terminals with nothing going in on the monitor can also be its BMS refusing the charge, or having disconnected the bank (→ 11.4): not a charge — the BMS as its maker's manual says.

PUT THE BOAT BACK IN SERVICE

- The charger left off where step 5 found an output with no fuse at its battery, or where step 6 found no setting you can read that every bank on it allows — one bank or several; otherwise its setting as step 6 left it, written into field 12 of the Boat Passport.
- A lithium bank its BMS disconnected: reconnected as its maker's manual says (→ 11.4) — steps that take cables off the battery are work at a battery terminal (→ 1.8); the entries of the BILGE PUMP and CARBON MONOXIDE signs say what to check then.
- Shore power as you found it.
- The meter's dial at OFF.

9.4. Several sources at once

When the alternator, the charger, the solar panels and a DC-DC charger all feed one bank, which one is in charge, and what does your battery monitor show? Unless their maker networks them, as below, none of them is in charge of the others. Each runs its own profile by the voltage it reads, and the bank's voltage is the one thing they all read (→ Fig. 9.4 · p. 26).

Joined to one bank, the sources push their currents into it together, and the bank's voltage rises with the total. While the bank is low, their currents add, and the battery takes the sum; for a lithium bank, the regulator maker of → 9.2 · p. 8 asks that the alternator not be able to exceed the battery's maximum continuous charge current. The source with the highest setting keeps pushing current after the bank has reached the setting of another; that other source then reads a bank that looks full to it and steps its own current down, or ends its stage, by its own rules. That is why a solar charge controller can show its float stage while the engine runs, and why the alternator's current on the monitor falls when the charger has already filled the bank. PRACTICE

One maker networks its chargers so that they charge a battery as if they were one large charger: they elect a master that sets the charge stage for all of them and switch from one stage to the next together, and each charger still controls its own current; that maker asks that every charger in the network have the same battery settings. MFR Without such a network, each source follows its own settings, which is why every source on a bank is set for that bank's battery — its maker's charge numbers in the regulator, the charger, the solar charge controller and the DC-DC charger, written into field 12 of the Boat Passport.

Some makers build an order into the path itself. One outboard maker's charging system charges the starting batteries first and then switches the charge to the house batteries (→ 9.1 · p. 2); one relay maker's charging relay senses a charging source on either bank, combines the batteries while they charge, and isolates them while they discharge — and, where it is wired for that, as its instructions show, while an engine starts. The same voltage can also keep a unit running that ought MFR to stop: a DC-DC charger that starts by its input voltage stays on in a loop where a relay joins the same two banks, as its maker warns (→ 8.3).

What the monitor shows

A battery monitor reads the current through its shunt in the bank's negative cable: the sum of every source's charge, less every load on that bank (→ 7.6). It cannot tell which source gave what. The voltage it

shows is the bank's, held by the source with the highest setting that is still pushing current. Each source's own display shows its own current, so the displays added up and the monitor's figure differ by the loads — and by any output that goes to another bank, and any current that does not pass the shunt (→ 7.3).

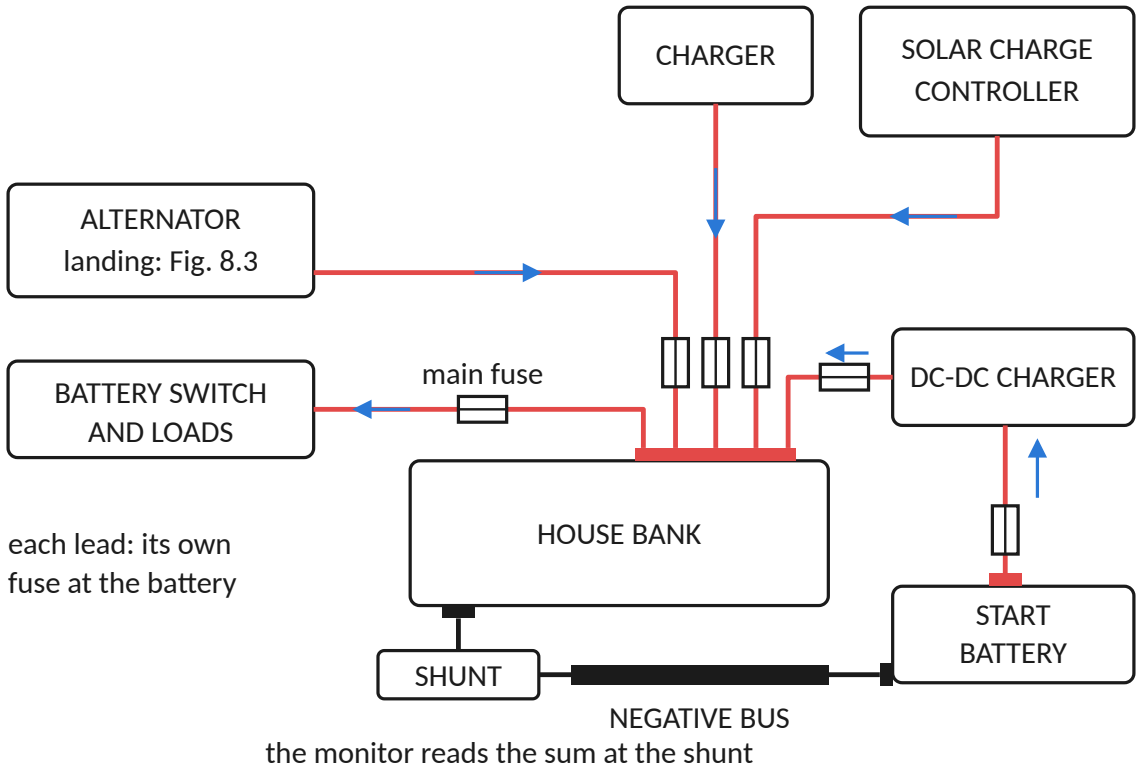


Fig. 9.4. One house bank with four sources on it — the alternator, the charger, the solar charge controller and a DC-DC charger fed from the start battery — and the lead to the loads; every lead has its own fuse at the battery. The arrows show which way the current flows. The battery monitor's shunt in the bank's negative cable sees the sum: what the sources push in, less what the loads take. One typical arrangement: your boat can be wired differently.

The taper as the bank fills

A lead-acid bank takes a large current while it is low and less and less as it fills. Once the sources have brought it up to their absorption voltage, they hold that voltage, and the current falls by itself as the battery's own voltage rises toward theirs; a battery monitor uses that falling current — its tail current — to set itself to full (→ 7.6). The end of a charge is therefore slow whatever you add: a second source shortens the part of the charge where the bank is low, and adds little in the

hours when the bank is nearly full. That is why an hour of engine running puts back more into a low bank than into one the charger filled the night before (→ 7.5). A lithium bank charges in another way, and its charging is in → 11.3.

> **WORKED EXAMPLE: WHAT THE MONITOR SHOWS WITH THREE SOURCES ON**
>
> Suppose the charger's display shows 20 A going out, the solar charge controller's 8 A and the DC-DC charger's 12 A, and the house loads take 6 A. The monitor shows 20 + 8 + 12 − 6 = 34 A going into the bank. Suppose an hour later the bank has reached the chargers' absorption voltage: the charger's display now shows 9 A, the controller's 2 A and the DC-DC charger's 5 A, with the same loads. The monitor shows 9 + 2 + 5 − 6 = 10 A. What the number means: the sources have not failed — the bank is filling, and each source has stepped its current down by its own profile.

9.5. Starting the engine

Engine won't crank? With the key at OFF, look at the DC panel first. A dark DC panel is the card "The panel went dark — no lights, no electronics" (→ emergency card), not this section. A lit panel, or a boat with no DC panel: the route below starts with the three things you set by hand, lets the sound the starter makes — nothing, a click, a slow turn — narrow the search, and looks at the battery and the heavy circuit before any part a pro replaces.

Route: the engine does not crank — nothing happens, a click, or a slow turn

Under way, first anchor or keep the boat in safe water; there, every step of this route that ends at a pro means a tow, called as the top of → If It's Happening Now says.

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → the connections you touched, by eye with the key at OFF: step 5
- after charging → whether the charge reached the start battery: step 4
- after rain or washing the boat → the connections the water reaches, by eye with the key at OFF: step 5
- after the boat sat unused → the start battery's resting voltage: step 4
- after switching sources (shore power, generator, inverter) → the battery switch's position: step 2
- nothing you noticed → step 1

ROUTE: THE ENGINE DOES NOT CRANK — → FIG. 9.5 · P. 33

GASOLINE VAPOR HOT BATTERY BILGE PUMP CARBON MONOXIDE

1. With the key at OFF, look at the DC panel.
   You will see: Lit: step 2. Dark: not this route — the card "The panel went dark — no lights, no electronics" (→ emergency card). A boat with no DC panel — an engine fed through its own harness and key, or no panel at all: step 2.

2. Check the three things you set by hand: the shift lever, the engine's stop switch — its lanyard clip, which one maker calls the lock plate — and the battery switch.
   You will see: A lever in gear: put it in neutral; a neutral-start interlock keeps the engine from starting in gear. A clip off its switch: put it back as the engine's manual shows; on one maker's outboard the starter does not crank without it. A battery switch away from the working position your Boat Passport records (field 6): turn the battery switch back to that position as → 1.7 shows. Then step 3.

3. On an inboard with a water-lift muffler that was cranked many times without starting, its raw-water seacock open, before this route, water may have reached a cylinder (→ 3.4): no crank — a pro looks at the engine first. Otherwise, turn the key to START once, or press the start button, as the engine's manual says, and listen.
   You will see: It cranks and starts: the route ends with its restore, and a fault that returns is followed from step 4. It cranks at its normal speed but does not start: the engine's stop control — a stop knob, lever or button — at its run position, and the stop switch's clip on (step 2); then the list in the engine's manual for an

engine that will not start, whose checks are yours where that manual gives them to the owner — one outboard maker's list includes the starting procedure, the fuel tank, its vent, the fuel line and the fuel filter. An engine whose fuel pump stops on a low battery is in "How long to crank, and what a low battery stops", below; on an inboard with a water-lift muffler, that part's crank time and seacock come with every try. The list done and the engine still not starting: a pro. Nothing at all — no click, nothing turns: step 4. One click, or a rattle of clicks, and nothing turns; or a slow turn: step 4.

4 Take the start battery's resting voltage by the procedure "A battery's resting voltage" (→ 3.5), where its rest is possible now; a lithium start battery's voltage means what its maker's manual says (→ 6.2). A gauge at the helm, or a reading with a charger, the solar panels or a running engine on that battery, is not that voltage.

You will see: At or above its maker's 100 % row: step 5. Below it: charged fully, as that procedure says, then step 5. Below it, with nothing aboard to charge it now, after nothing at all — not on an engine step 3 sent to a pro: another bank, as step 2 of the route "The engine cranks slowly or only clicks" says (→ 3.8), or the procedures "Starting the engine on both banks" and "A start with a jump pack" (→ 8.5); with none of them, a call for a tow or for help to a place where the battery can be charged. After a click or a slow turn — below its 100 % row with nothing aboard to charge it now, no rest possible now, or the engine has to start before the battery can be charged — not on an engine step 3 sent to a pro: the procedures "Starting the engine on both banks" and "A start with a jump pack" (→ 8.5) test the start battery; with neither possible, a call for a tow or for help to a place where the battery can be charged. The engine cranks normally from the other bank or the pack and starts: the start battery or its own cables, by the route "The engine cranks slowly or only clicks" (→ 3.8) once the battery can be charged. You come back here from those procedures with no start, after a turn at its normal speed: step 3's branch for an engine that turns at its normal speed but does not start. You come back with no start, after a turn no better than before or no sound at all: step 5. After nothing at all, with no rest possible now: step 5.

5. With the key at OFF, look by eye at the heavy circuit: the battery's terminals and the lugs on them, the engine's negative cable at its lug on the engine block (N on → Fig. 9.5 · p. 33), and both ends of the starter cable; on an outboard, under its cover, taken off as its manual shows.
   You will see: A lug loose, corroded or off: who repairs it is step 4 of the route "The engine cranks slowly or only clicks" (→ 3.8); after that repair, an outboard's cover back on, as its manual shows, and this route again from step 3. Nothing seen, after nothing at all: step 6. Nothing seen, after a click or a slow turn: step 7.

6. Nothing at all: find the fuse the engine's manual names for its start circuit, and check it as that manual shows.
   You will see: One outboard maker's list for a starter that will not crank names, besides the lanyard and the shift lever, a blown 15 A fuse in the remote control harness or the main power relay circuit, a failed key switch, faulty wiring, and a failed starter solenoid or slave solenoid (→ Table 9.3 · p. 34). A fuse found blown has found a fault: the route "A branch breaker trips or a fuse blows" (→ 4.8). The fuse whole, or no fuse named in the manual: the procedure "The starter circuit's drop map" (→ 3.4) as far as its reading at rest, before the first crank — battery voltage there shows the path between the battery and the starter's battery stud open, as that step says; about 0 V there: the key switch, the interlock, the start relay, the solenoid and their wiring, or a break inside a cable that the eye does not see — a pro (What to tell the pro, → 9.7 · p. 41).

7. A click or a slow turn: the starter circuit, by the route "The engine cranks slowly or only clicks" (→ 3.8) from its step 3.
   You will see: On an inboard with a water-lift muffler that was cranked many times without starting, its raw-water seacock open, before the crank failed, water may have reached a cylinder (→ 3.4): no more cranks — a pro looks at the engine first. The drop map within its figures and the battery passing its load test: the starter, its solenoid or the engine itself — a pro.

PUT THE BOAT BACK IN SERVICE

- The key at OFF, where the engine did not start.
- A battery switch you put back in step 2 stays at its working position. A CO alarm wired after a battery switch you found at OFF had no power until step 2; the entry of the CARBON MONOXIDE sign says how you see that it is working again.

- If you ran the bilge blower before the start, its switch back where you found it; an outboard's cover back on, as its manual shows. The procedures of steps 4, 6 and 7 end with their own restore blocks.
- Where step 2 or step 4 moved a battery switch: check that the bilge pump's automatic switch has power, by the procedure "The check that the automatic switch has power" (→ 12.2).

How the engine is started

The starter is a motor that turns the engine through its flywheel, and for the seconds it turns it draws one of the largest currents on the boat. On the circuit of → Fig. 9.5 · p. 33 that current never passes the key switch. It runs from the start battery through the starter cable to the starter's battery stud (F), across a heavy contact inside the starter solenoid to the motor terminal (M), through the motor, and back through the engine block to the negative lug (N) and the battery's negative terminal (K). The key switch commands only the solenoid: at START, a small current — from the panel, or from the engine's own harness, as the boat is wired — goes through the key switch, and through whatever the engine puts in that path — a neutral-start interlock, a stop switch, a fuse, a start relay — to the solenoid's control terminal (G). The solenoid's coil pulls its plunger in, and the heavy contact closes.

The sound tells you where to look first. Nothing at all, with the panel lit: the solenoid's coil got no current — something is open on the control side, or in the heavy circuit, because the coil's current, too, returns through the engine block and the negative cable; and a lit panel can be fed by another bank than the start battery. One click and nothing turns: the solenoid pulled in, and the motor did not turn — too little voltage at the motor under its current, from a low battery, a connection that loses volts or the solenoid's own contact; a failing motor; or an engine that resists turning. A rattle of clicks: the solenoid pulls in, the battery's voltage collapses under the motor's current, the solenoid lets go, the voltage recovers, and the solenoid pulls in again — a low battery, or a

connection that loses volts. A slow turn: the motor turns with too little voltage, or the engine is hard to turn (→ 3.4). PRACTICE

The engine block returns current only for equipment mounted on the engine, and it is tied to the negative by its own cable; the hull, the mast, the outboard bracket and the bonding wires never carry a load's return current.

So the starter's current comes back through the block and through the negative lug on it (→ 1.4), and a poor lug costs the starter volts on the negative side of the drop map (→ 3.4). Cleaning and tightening that lug is the procedure "The negative lug on the engine block" (→ 3.8).

Every positive wire that leaves a battery bank is protected, except the starter cable: only the cable that carries the starting current from the battery to the starter, directly or through the battery switch — found by tracing it, never by its size; a wire taken off the starter's battery terminal to feed anything else is not. The cables that join the batteries of one bank to each other are part of the bank.

That exception and its reason are in → 4.2. Where the main fuse at the battery stands ahead of the battery switch, as on the boat of → Fig. 9.5 · p. 33, it carries the starting current too. On a boat with more than one gasoline engine, where the regulation applies (→ 1.9), 33 CFR 183.415 asks that their "grounded cranking motor circuits" be connected to each other by a common conductor circuit that can carry the starting current of each of them: that cable between the engines belongs to the starting system. CFR

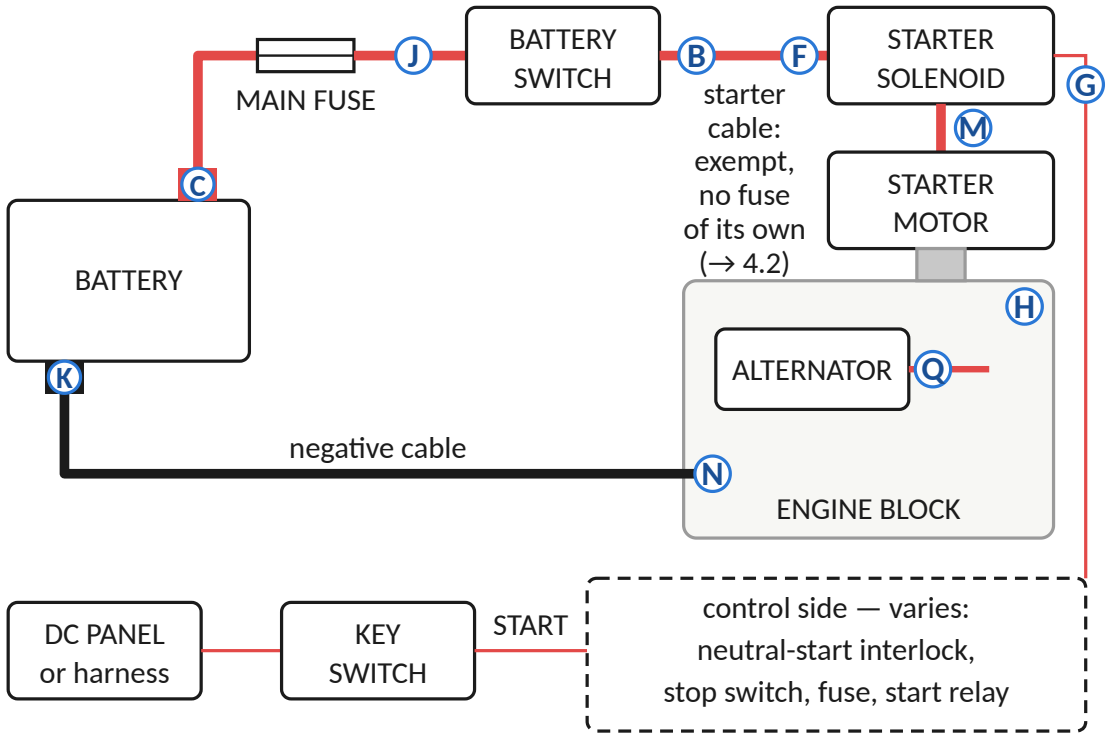


Fig. 9.5. The starting circuit of the boat drawn in Fig. 1.4 and Fig. 3.5, with its control side; your boat can be wired differently. The heavy circuit — C, J, B, the starter cable, F, the solenoid's contact inside it, M, the motor, the block, H, N and K — carries the starting current; the key switch commands the solenoid through the control side to G, whose parts vary by engine. The starter cable is exempt from a fuse of its own (→ 4.2).

The neutral-start interlock and the stop switch

A neutral-start interlock keeps the engine from starting unless the shift control is in neutral. One outboard maker writes that its start-in-gear protection device prevents the engine from starting except when in neutral, on motors that carry its label or have its approved remote control units, and that when the emergency starter rope is used, the device does not operate; a second outboard maker's list for a starter that will not crank includes an outboard not shifted to neutral. MFR

Federal rules ask for it on larger outboard motors: any outboard motor capable of developing a static thrust of 115 pounds or more must be equipped with a device to prevent the motor being started when its controls are set to reach that thrust, and a motor designed for local starting must have a built-in start-in-gear protection device (33 CFR

183.710). Where the interlock sits differs — in the remote control box, in the engine — and a motor below that thrust is not required to have one: your engine's manual says what yours has. CFR

The engine's stop switch is the second thing you set by hand. One outboard maker lists a lanyard stop switch not in its RUN position among the causes when the starter will not crank; another writes that the engine cannot be started with the lock plate removed, without saying whether the starter turns. On the first engine the clip stops the starter too; on the second its manual says only that the engine will not start. Which yours does is in its manual, and the answer matters for a crank without starting, below. MFR

Table 9.3. Why a starter does not crank: one outboard maker's list, and where the route above meets each cause MFR

Cause, as the maker lists it	Part of the circuit	Route step
Lanyard stop switch not in its RUN position	Control side	2
A blown 15 A fuse in the remote control harness, the cowl trim switch or the main power relay circuit	Control side	6
Outboard not shifted to neutral	Control side (the interlock)	2
Weak battery, or loose or corroded battery connections	Battery and heavy circuit	4 and 5
Key switch failure	Control side	6
Faulty wiring or electrical connection	Either side	5, 6 and 7
Starter motor solenoid or slave solenoid failure	Heavy circuit, or the control side's start relay	6 and 7

How long to crank, and what a low battery stops

> **NUMBERS · CRANK TIME AND REST**
>
> Each engine's maker sets its own crank time and rest. One outboard maker: the key held at START for a maximum of 5 seconds, then a wait of 10 seconds before the next try. One diesel maker: 10 seconds of cranking and 30 seconds of rest. A diesel maker's manual of 1980: no more than 20 seconds of cranking, and a rest of at least twice the cranking period between tries. MFR Your engine's manual gives yours.

On an inboard with a water-lift muffler, every crank without a start pumps cooling water into the muffler (→ 3.4). One diesel maker writes that if the engine does not start after cranking for 10 seconds, the thru-hull water intake valve is closed to avoid filling the muffler with water; its later manual gives 15 seconds, then has the starter cranked 10 seconds at a time until the engine starts, the engine stopped immediately when it does, and the seacock re-opened before the engine is restarted. Your engine's manual says when its seacock is MFR closed and what comes next; where it says nothing about it, the crank after a try that does not start comes only as step 2 of the procedure "A crank without starting" (below) says — the seacock closed first, and a seacock that cannot be closed means no more cranks and a pro — and if the engine then starts with the seacock closed, it is stopped at once and started again only once the seacock is open.

A low battery can stop more than the starter. One outboard maker writes, for one of its fuel-injected models, that with the battery discharged to 9 volts or below the electric fuel pump will not operate, and that the engine cannot be started by hand with its emergency rope when the battery voltage is low. On such an engine the rope does MFR not replace a charged battery.

A start battery that is too low to start the engine is joined to the other bank for the start, or helped by a jump pack, by the procedures of → 8.5 — except on an inboard with a water-lift muffler that was cranked many times without starting, its raw-water seacock open: water may have reached a cylinder there, and a pro looks at the engine before any

crank (step 3 of the route above). Jumper cables from another battery or another boat are not one of them: one sterndrive engine maker's manual says not to use jumper cables and a booster battery to start its engine. MFR

Starter, solenoid and interlock repair, and the way each engine model is kept from starting while it cranks, with its crank times, are the subject of → module "Engines".

A crank without starting

Some readings need the starter to turn the engine while the engine does not start: the drop map of → 3.4, taken out of the water, or on an inboard with a water-lift muffler whose raw-water seacock is closed for the cranks. How an engine is kept from starting while it cranks belongs to its maker, model by model, and the way its manual shows is the one this book uses.

One diesel maker's manual gives two ways within one family of engines: on two models, operate the starter while pushing in the emergency stop button on the back of the fuel pump, which stops the fuel supply; on three others, operate the starter while moving and holding the stop lever on the governor to stop fuel flow. The same manual has the start switch on the instrument panel crank the engine while the emergency button is pushed in. The stop control is held for as long as the starter turns, by a person at the engine. MFR

One older maker's engines without a stop lever have a fuel solenoid or an electric fuel pump that shuts off the fuel supply when the key switch is turned to OFF. Such an engine, like one stopped by its electronics, has a way to crank without starting only where its manual gives one. MFR

A gasoline outboard in the water, with its cooling-water intake under water, needs no such way for a measurement crank: if it starts, it is stopped immediately, as its manual says (→ 3.4). Out of the water, it gets cooling water as its manual says, or it is kept from starting the way its manual shows; its stop switch's clip is such a way only where the manual says the starter turns with the clip off. A gasoline inboard or

sterndrive that must not start — out of the water without cooling water, or with the raw-water seacock of a water-lift muffler closed — and whose manual shows no way leaves the measurement crank to a pro (→ 3.4).

Procedure: A crank without starting

For the measurement cranks of → 3.4 on an engine that must not start: out of the water without cooling water, or an inboard with a water-lift muffler whose raw-water seacock is closed for the cranks. You need the engine's manual and a helper at the key; on an engine whose stop control is on the engine, a person at the engine holds it while the starter turns.

 MOVING PARTS  GASOLINE VAPOR

1. Open the engine's manual at its starting and stopping pages, and find the way it gives to keep the engine from starting while the starter turns: a stop button or lever held on the engine, the stop switch's lanyard off where the manual says the engine still cranks with it off, or another way the manual names. Out of the water, find also how the engine gets cooling water. A way shown: step 2. Out of the water with cooling water supplied as the manual says, and no seacock closed: the engine may start, and the cranks of → 3.4 need no way — if it starts, it is stopped immediately, as step 5 of that procedure says. No way shown, where the engine must not start: no measurement crank — the drop map is a pro's.
2. On an inboard with a water-lift muffler, close the raw-water seacock before the first crank. A seacock you cannot close: no measurement crank — a pro.
3. Set the way before each crank: the stop button pushed in, or the lever held in its stop position, for as long as the starter turns; the clip off its switch where the manual allows. A stop control that cannot be held without a hand near a belt, a pulley or the flywheel is not a way to use: another way the manual shows, or no measurement crank — the drop map is a pro's.

4. With the clips on as steps 1 to 3 of the procedure "The starter circuit's drop map" (→ 3.4) say, the helper cranks when you say so, for the first reading of that procedure, while you watch the engine. It turns and does not start: the way works — the cranks of that procedure continue, with the way set for each. It starts: the helper stops it immediately, as its manual says; that way does not keep this engine from starting, the cranks end here, and the drop map is a pro's.

PUT THE BOAT BACK IN SERVICE

- The stop button or lever released to its run position, as the engine's manual shows; a clip back on its switch.
- A raw-water seacock you closed: open again before the engine runs.
- Any cooling-water supply removed as the engine's manual shows; an outboard's cover back on.
- If you ran the bilge blower before the cranks, its switch back where you found it.

9.6. Marine-grade or not? Automotive charger, automotive alternator

A charger from an auto parts store, or an alternator built for a truck engine, costs less and can look the same as the marine part. Can it be used on your boat? The answer is in the part's own data, not in its name. A charger has to offer your battery's setting, take your shore power, keep your banks apart where they must stay apart, and be ignition protected where gasoline vapor can reach it. An alternator has to be ignition protected on a gasoline inboard or sterndrive, and to suit your regulator and your bank.

Ignition protection comes from two texts. 33 CFR 183.410 asks that each electrical component not ignite a propane and air mixture around it at each of its maker's rated voltages and current loadings, unless it is isolated from gasoline fuel sources — engines, and the valves, connections and fittings of fuel lines and tanks — in the ways that

section describes; 33 CFR 183.405 leaves out components that are part of an outboard engine or part of portable equipment. Both sections are addressed to the builder, and the boats they apply to are named in → 1.9 (→ 4.6). CFR

The 2003 edition of ABYC E-11 asks for ignition protection of potential sources of ignition located in spaces containing gasoline-powered machinery, gasoline fuel tanks, or joint fittings or other connections between components of a gasoline system, unless the component is isolated from a gasoline fuel source; it excepts boats using diesel fuel as the only fuel source, and outboard engines mounted externally or in compartments open to the atmosphere. Such a space includes, on an outboard boat too, a closed compartment that holds a gasoline tank — built in or portable — as → 1.1 and → 4.6 read it; a charger or an alternator in such a space is such a source. ABYC

The alternator

An alternator is ignition protected only where its maker certifies that part. One maker of marine alternators and starters certifies a selection of the part numbers in its marine line as ignition protected to SAE J1171, marks those part numbers in its cross-reference table, and writes that the certification helps prevent explosions caused by fuel vapors that may accumulate in confined engine compartments. The certification belongs to the part number, not to the word “marine”: a part whose maker’s data name no ignition protection is not shown to have it, and on a gasoline inboard or sterndrive the replacement alternator is one whose maker’s data name it (→ 4.6). MFR

The alternator also has to suit the rest of the charging system: a field disconnect works only with an external regulator (→ 8.1), what a house bank needs from the regulator is in → 9.2 · p. 8, and what the alternator gives hot, at the speed your engine turns it, is in its maker’s data (→ 7.5).

The charger

A charger where gasoline vapor can reach it (→ 4.6) is ignition protected by its maker’s statement or marking: one marine charger

maker lists ignition protection among its charger's features, and another's data name its charger ignition protected to SAE J1171. MFR Two makers of portable chargers ask that a marine battery be removed and charged on shore, and charged aboard only with equipment made for marine use; the procedure "A battery on a portable charger" (→ 6.6) follows them.

A charger is right for your boat when it passes all five checks:

- ☐ a setting for your battery's type, in its maker's list (→ 9.3);
- ☐ an input on its label that takes your shore power's 120 V AC (→ 9.3);
- ☐ an output for each bank it charges, with outputs isolated from one another in its manual where your banks must stay apart (→ 9.3);
- ☐ where gasoline vapor can reach it, ignition protection in its maker's statement or marking (→ 4.6);
- ☐ each output lead with its own fuse at the battery, of the rating its maker gives (→ 4.2).

MARINE-GRADE OR NOT? · AUTOMOTIVE BATTERY CHARGER

A plug-in charger made for car batteries. Two makers of portable chargers ask that a marine battery be charged on shore, and aboard only with equipment made for marine use. Its data decide the rest: MFR without a setting for your battery's type it is not that battery's charger (→ 9.3 · p. 17), and without its maker's statement of ignition protection it has no place where gasoline vapor can reach it (→ 4.6).

Verdict: Only by its data

MARINE-GRADE OR NOT? · TRUCK ALTERNATOR

An alternator built for a truck engine. On a gasoline inboard or sterndrive it needs ignition protection that its maker certifies for that part number; on a boat whose only fuel is diesel, the 2003 edition of ABYC E-11 does not ask for it. Either way, its regulator and its output, hot and at your engine's speed, decide what it gives your bank (→ 9.2 · p. 8). ABYC

Verdict: Only by its data

9.7. On board

What charges each of your banks, and by which path, is something you can find and write down; why the engine will not crank, you can narrow to one part of its circuit. This section turns what you notice into a first check, says which of this work is yours, gives you the words for a pro, and says what to look for on an older boat.

ON BOARD: GOLDEN RULE

Know what charges each bank and by which path — the outboard's charging path or the alternator's landing, the unit between the banks, each charger output — and set every source for the battery it charges, by that battery maker's numbers. When the engine will not crank, let the sound narrow the search, and look at the start battery and the heavy circuit before any part a pro replaces.

What it means

Each first check below names the procedure or route that carries it out; the signs at the start of that procedure go with it.

Table 9.4. What it means

What you notice	What is happening	First check	Yourself or a pro
The house bank behind an outboard never gets full while the engine runs	No unit between the banks, a unit that does not pass the charge, an engine run short or at idle, or an outboard with no charging output	"A house bank behind an outboard" (→ 9.1); the route "The second bank does not charge" (→ 8.3)	**Do it yourself, if... you can do that route, with its signs; a new lead at a battery: Hire a pro**
With the engine running, the voltage at the helm stays where it was before the start	A belt, the output wire or its fuse, the regulator, the alternator — or an instrument that reads another bank	The route "The bank does not charge from the engine" (→ 9.2)	**Do it yourself, if... you can do that route, with its signs**
With the engine running, the voltage climbs above the battery maker's charge voltage	A setting made for another battery type, the regulator raising the voltage for a cold battery, a regulator that does not regulate, or a gauge that reads high	Step 2 of the route "The bank does not charge from the engine" (→ 9.2); the regulator's settings in field 12	**Do it yourself, if... you can read and change the regulator's program as its manual says; a setting you cannot read or change, or a regulator that does not regulate: Hire a pro**
The house bank never gets full behind a diode isolator	The diodes' drop, not made up by the regulator's sense lead or a compensation diode	Where the regulator reads (→ 9.2); the route "The second bank does not charge" (→ 8.3)	**Hire a pro: a reading at the isolator with the engine running, beside turning belts**
The charger shows "charge complete", and the bank is not full	A setting for another battery type, a charger reading the voltage away from the battery, or a battery that no longer takes a full charge	Steps 6 and 7 of the route "The bank does not charge from the charger" (→ 9.3); the battery's resting voltage (→ 3.5)	**Do it yourself, if... you can do that route, with its signs**

What you notice	What is happening	First check	Yourself or a pro
The charger is lit, and one bank does not charge	No output for that bank, its output fuse blown, or its output landed after a battery switch	Steps 4 and 5 of the route "The bank does not charge from the charger" (→ 9.3)	**Do it yourself, if… you can do that route, with its signs**
The charger's display shows a fault	What its manual says that fault means	Its manual; step 3 of the route "The bank does not charge from the charger" (→ 9.3)	**Do it yourself**
With the engine running, a solar charge controller shows float, or the alternator's current is small	Another source holds the bank at its setting, or the bank is nearly full — or, with the bank's voltage still low, the alternator does not charge	"What the monitor shows" (→ 9.4); with the bank's voltage low, the route "The bank does not charge from the engine" (→ 9.2), the other sources off	**Do it yourself, if… you can do that route, with its signs**
The key does nothing, and the panel is lit	The lever in gear, the stop switch's clip off, a battery terminal or the engine's negative cable open, a start battery apart from the bank that lights the panel, a fuse in the start circuit, the key switch, the interlock or a start relay	Steps 2, 4, 5 and 6 of the route "The engine does not crank" (→ 9.5)	**Do it yourself, if… you can do that route, with its signs; the key switch, the interlock or a start relay: Hire a pro**
One click, or a rattle of clicks, and nothing turns	A low battery, a connection that loses volts, the solenoid, the starter, or an engine that resists turning	Steps 4, 5 and 7 of the route "The engine does not crank" (→ 9.5)	**Do it yourself, if… you can do that route, with its signs**
The engine turns slowly	A low battery, a connection that loses volts under the starting current, the starter, or the engine	The route "The engine cranks slowly or only clicks" (→ 3.8)	**Do it yourself, if… you can do that route, with its signs**

What you notice	What is happening	First check	Yourself or a pro
The engine cranks at its normal speed and does not start	The engine does not get what it needs to run — its fuel, or on a gasoline engine its spark — or a stop control or a clip is at stop	Step 3 of the route "The engine does not crank" (→ 9.5): the stop control, the clip, then the list in the engine's manual	**Do it yourself, if... that manual gives the check to the owner; when its list is done: Hire a pro**
Everything went dark	A dark panel has its own order	The card "The panel went dark — no lights, no electronics" (→ emergency card)	**The card**
The alternator or the charger, where gasoline vapor can reach it, has no ignition-protection data	A part with nothing to show that it does not ignite gasoline vapor	Its maker's data and marking (→ 9.6, → 4.6)	**Hire a pro**

IF YOUR BOAT IS 20 TO 40 YEARS OLD

1. **Check first:** where the alternator's output lands, and whether its wire has a fuse where it lands at a battery (→ 9.2); a charger with no setting for the battery type now in the boat — a charger older than an AGM, gel or lithium bank it charges (→ 9.3).
2. **Replace first if you find it:** a charger or an alternator where gasoline vapor can reach it (→ 4.6) whose data or marking name no ignition protection (→ 9.6); a charger output with no fuse at the battery (→ 4.2). Both are a pro's work.
3. **What may be missing, and how you can tell:** the regulator's sense lead on the battery side of a diode isolator — a house bank that never gets full from the engine (→ 9.2, → 8.3); a temperature sensor for the battery on the charger or the regulator — no thin lead from them to the bank (→ 9.3); the unit between an outboard's start battery and the house bank — no relay, DC-DC charger or maker's lead in field 9, and a switch left at BOTH to charge both (→ 9.1).

Do it yourself or hire a pro

DO IT YOURSELF OR HIRE A PRO · CHARGING AND STARTING

STOP · HOT BATTERY A battery that turns hot, swells, hisses or smells while a source charges it; smoke or a burning smell while the starter turns.

What to do this minute: The card "Battery smells, is swollen, or is hot" (→ emergency card); at smoke, the card "Smoke, a burning smell, or an overheated wire" (→ emergency card).

HIRE A PRO · A new lead, lug or fuse at a battery terminal — a charger's leads, an outboard maker's charging lead, a regulator's sense lead, a temperature sensor's lug (→ 1.8); a reading with the engine running beside turning belts — the charging circuit's drop, the alternator's output, the regulator's voltage, an isolator's drop (→ 3.4); a regulator that does not regulate; a regulator's or a charger's setting you cannot read or change; the key switch, the neutral-start interlock, a start relay, the starter and its solenoid; a measurement crank on an engine that must not start — out of the water without cooling water, or with a water-lift muffler's seacock closed — whose manual shows no way to keep it from starting (→ 3.4). Order the work in the words of "What to tell the pro" in this section, and accept it by the checks there.

If no pro is available: Until the pro comes, a bank the engine does not charge is charged by what still reaches it, and how long it lasts is worked out by → 7.4; a start on a low start battery is by → 8.5.

When a pro may do it differently: A pro may land the alternator's output, its sense lead or a charger's outputs differently from → Fig. 9.2 · p. 12 and → Fig. 9.3 · p. 21 where the engine's, the regulator's or the charger's manual asks for it. You see it in the labels, in the readings written down with the engine speed each was taken at, and in the Boat Passport the pro updates.

DO IT YOURSELF, IF…

- The routes and the procedure of this chapter, each with the signs at its start: "The bank does not charge from the engine" (→ 9.2 · p. 8), "The bank does not charge from the charger" (→ 9.3 · p. 17), "The engine does not crank" and "A crank without starting" (→ 9.5 · p. 27).

- **HOT BATTERY** A charger's battery-type setting that you can read and change, set to your battery maker's numbers as the charger's manual says — on a charger with one setting for all its outputs, only where every bank on it is of that type — then you change it by step 6 of the route in → 9.3 · p. 17.

DO IT YOURSELF · Reading the battery monitor and the voltmeter at the helm, and the charger's and the regulator's lights; looking at the belt, the output wire and the fuses with the engine stopped; checking the shift lever, the stop switch and the battery switch's position; writing the Boat Passport.

What to tell the pro

WHAT TO TELL THE PRO

For a bank that does not charge from the engine, ask for this: "With the engine running at a fast idle, the bank's voltage stayed where it was before the start and the monitor showed no charge going in; the belt and the output fuse looked whole; the regulator showed these readings with the key at ON and the engine stopped, and here is what feeds its ignition wire, as far as I could see. Find why, and give me the charging circuit's drop at full charging current, the alternator's output and the regulator's voltage, each with the engine speed it was taken at." For a house bank with no unit between it and the start battery: "Install a unit that charges the house bank from the engine — the engine maker's own isolator or charging lead where its manual has one, a charging relay or a DC-DC charger (→ 9.1; for a lithium bank, → 11.3) — with its own fuse at each battery." For an alternator output with no fuse, landed at the starter or on the battery switch: "Tell me whether it meets the conditions under which it may run without a fuse — a self-limiting alternator with an integral regulator, and its conductor within the length limit and in a sheath along its whole length (→ 4.2) — and fuse it where it does not." For an engine that does not crank: "With the panel lit, the lever in neutral and the stop switch's clip on, the key gives nothing, or one click, or a slow turn; the start battery's resting voltage, and the drop map where I could take it, are in the Boat Passport; the battery terminals, the cable ends and the negative lug on the engine block looked sound. Find why." Accept the work by these checks. With the engine running, the bank's

voltage rises toward the charge voltage its battery's maker gives, and the monitor shows a charge going in (→ 9.2); after a new unit between the banks, the house bank's does too, and once the engine has been stopped for a while, the start battery's voltage does not fall as the house loads run. Every new lead from a battery has its own fuse at the battery, except the starter cable, identified by tracing it to the starter, not by its size (→ 4.2); a new alternator or charger where gasoline vapor can reach it shows its maker's ignition-protection statement or marking (→ 9.6, → 4.6). The engine cranks at its normal speed with the lever in neutral, and the work is written into field 16 of the Boat Passport the same day.

REMEMBER

- An outboard with a charging output charges the start battery; a house bank gets its share through a unit between the banks (→ 9.1).
- Where the alternator's output lands, and where its regulator reads, decide which bank fills first; both are found by tracing.
- A regulator holds at its setting only the voltage it reads; a bank it does not read gets what the path between them leaves.
- A charger charges well only on its battery's own setting; "charge complete" is the charger's decision, not a measured full bank.
- "Isolated outputs" means what the charger's own manual says.
- Several sources on one bank share it by their settings: the bank's voltage is the one thing they all read, and the monitor shows their sum less the loads.
- With the panel lit, the starter's sound narrows the search, and the start battery's resting voltage and the heavy circuit come first, whatever the sound.
- An engine is kept from starting while it cranks only the way its manual shows.
- Ignition protection is a line in the part's own data or marking, not the word "marine".

Self-check

1. **Before you measure.** Suppose your alternator charges two banks through a diode isolator, its regulator reads on the alternator's side of the isolator and is set to 14.4 V, and the isolator drops 0.45 V at that charging current. What does each bank reach, and what changes when the sense lead is moved to the house battery's side of the isolator?

   Answer: 14.4 − 0.45 = 13.95 V at each bank, below the setting. With the sense lead on the house battery's side, the regulator raises the alternator's voltage until the house bank reads 14.4 V (→ 9.2 · p. 8, → 8.3).

2. **Several sources.** Suppose the charger holds the house bank at 14.4 V in its absorption stage, and the solar charge controller on the same bank is set to absorb at 14.2 V. Which source carries the current, and what does the controller show?

   Answer: the charger. The bank already reads above the controller's setting, so the controller reads a bank that looks full to it and steps its own current down by its rules; the monitor shows the sum of both, less the loads (→ 9.4 · p. 24).

3. **The sound.** Suppose the panel is lit, the lever is in neutral and the clip is on, and the key gives a rattle of clicks; after its maker's rest, the start battery's resting voltage is below its 100 % row. Where does the route send you?

   Answer: on an inboard with a water-lift muffler that was cranked many times without starting, its raw-water seacock open, to no crank at all — a pro looks at the engine first (→ 9.5 · p. 27, step 3). Otherwise, to a full charge, as the procedure "A battery's resting voltage" says (→ 3.5), then to the look at the heavy circuit and the starter circuit's route (→ 9.5 · p. 27, steps 4, 5 and 7); where the engine has to start before the battery can be charged, the procedures of → 8.5 start it and test the start battery at the same time.

4. **On your boat.** Find where your alternator's output lands — on an outboard, which battery its positive cable reaches — and what charges your second bank; write them into fields 8 and 9 of the Boat Passport.

   Answer: each named by what you followed by eye; a landing or a unit you could not see stays in field 15 with a "?" (→ 9.1 · p. 2, → 9.2 · p. 8, → 8.1).

5. **On your boat.** Read your charger's battery-type setting and compare it with the label of each bank it charges; write the charger's maker, model and setting into field 12.
   Answer: the setting names each bank's type; a charger with one setting for all its outputs suits every bank on it, or it does not, and a bank it does not suit needs an output it can be set for (→ 9.3 · p. 17).
6. **On your boat.** In your engine's manual, find how long the starter may turn at a time, the rest between tries, and the way it gives, if any, to keep the engine from starting while the starter turns; write them, with the manual's name and page, into field 15 of the Boat Passport, which holds each question put to the maker with its answer.
   Answer: the two times and the way, or "none shown"; with none shown, the starter circuit's drop map on an engine that must not start is a pro's (→ 9.5 · p. 27).

Terms

external regulator
A regulator mounted apart from the alternator that controls the alternator's field current to hold the voltage it reads at its setting.

sense lead
The wire through which a regulator reads the voltage it holds at its setting.

charging profile
The steps of voltage and current a charger or a regulator follows from a low battery to a full one, made for one battery chemistry.

bulk, absorption, float
The stages of a charging profile, in that order. In general: bulk, as much current as the source can give until the voltage reaches its setting; absorption, a set voltage held while the current falls; float, a lower voltage that keeps a full battery full. One maker's regulator holds each stage's voltage for a set time. On a display, each is a label, read as printed.

field (of an alternator)
The alternator's winding whose current sets its output; the regulator feeds it through the alternator's field terminal.

accessory charging lead
An outboard maker's own lead from the engine's charging system for charging a second battery.

load dump
The voltage spike when a running alternator suddenly loses the battery it was charging.

ACR (automatic charging relay)
A relay that joins two banks while it senses charging voltage and separates them when the voltage falls.

DC-DC charger
An electronic charger that takes power from one bank and delivers a controlled charge to another.

diode isolator
A unit that lets current flow from one alternator (or two) to two or three banks and never between the banks.

tail current
The charging current, as a percentage of the battery's capacity, below which a monitor counts the battery as full.

starter solenoid
The relay on the starter that the key switch commands; its heavy contact connects the starter cable to the starter motor.

key switch
The switch at the helm that, at START, sends the small current that commands the starter solenoid.

neutral-start interlock
The device that keeps the engine from starting unless the shift control is in neutral.

crank, cranking (the engine)
To turn the engine with its starter; for a measurement, with the engine kept from starting where it must not start.

ignition protected
Built so that, in its design operating conditions, it does not ignite the gasoline vapor around it.

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