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

Chapter 8. Switching: Battery Switches, Two Banks, Charging Both

Know what every switch on your boat does, and never end up unable to start

Every battery switch, relay and charger between your banks decides two things: what still has power when you turn a switch, and whether a battery is left to start the engine. This chapter shows you how to read each of them on your own boat, how to start on both banks when the start battery is low, and how to judge an upgrade or a part before you pay for it.

AFTER THIS CHAPTER YOU CAN

- read each battery switch on your boat — its positions, the bank each position connects, and its working position — and find where the alternator's output lands;
- say what stays live with every battery switch OFF, and what each circuit wired around the switch means for you;
- tell a charging relay, a diode isolator and a DC-DC charger apart by what you can see, and say what each does to your banks;
- know when a charging relay keeps two banks apart, and when it does not;
- recognize your boat's layout and the protection each part of it needs;
- start the engine on both banks with a means its maker gives, or with a jump pack, and part the banks again;
- plan the upgrade of an old 1-2-BOTH layout, and accept the work;

- judge a household disconnect or a vehicle battery cut-off against what a battery switch on a boat must be.

Read first: → 1.7, → 2.1, → 2.2, → 6.3, → 6.4

8.1 The battery switch
8.2 What is wired around the switch
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8.8 On board

8.1. The battery switch

What does your battery switch disconnect, and what stays live when it is OFF? A battery switch is the switch in the positive cable between a battery bank and the boat's loads. Turned OFF with the engine stopped, it removes current only from what is wired after it: the DC panel, and the starter cable where the starter is fed from the switch (→ Fig. 8.1 · p. 3). Everything on the battery side of the switch stays live — the battery's terminals, the cable from the battery to the switch, every circuit wired around the switch (→ 8.2 · p. 11), a charging relay or a DC-DC charger fed from the battery positives (→ 8.3 · p. 14), and the alternator's output where it lands at a battery. The source map of → 1.7 shows the whole boat.

The 2003 edition of ABYC E-11 requires a battery switch in the positive conductor from each battery or battery bank with a CCA rating greater than 800 A, mounted in a readily accessible location as close as practicable to the battery; "readily accessible" means, in that text, that you can reach it quickly and safely in an emergency without tools. A bank rated 800 CCA or less needs no switch under that text — a battery with no CCA rating, rated only in amp-hours, is not sorted by it either way — and boats with no battery switch at all exist: on such a boat each circuit is switched off at its own breaker or fuse (→ 8.4 · p. 24). ABYC

The negatives are not switched in the layout one switch maker calls the most common: its answer to its own question, whether its battery switches switch the negative, is that the most common battery systems switch the positives and bus the negatives — every negative runs to a negative bus with no switch in it. That maker's answer leaves room for a boat built another way. Which cable runs through your switch, you see on its studs (procedure "What each battery switch connects", in this section). PRACTICE

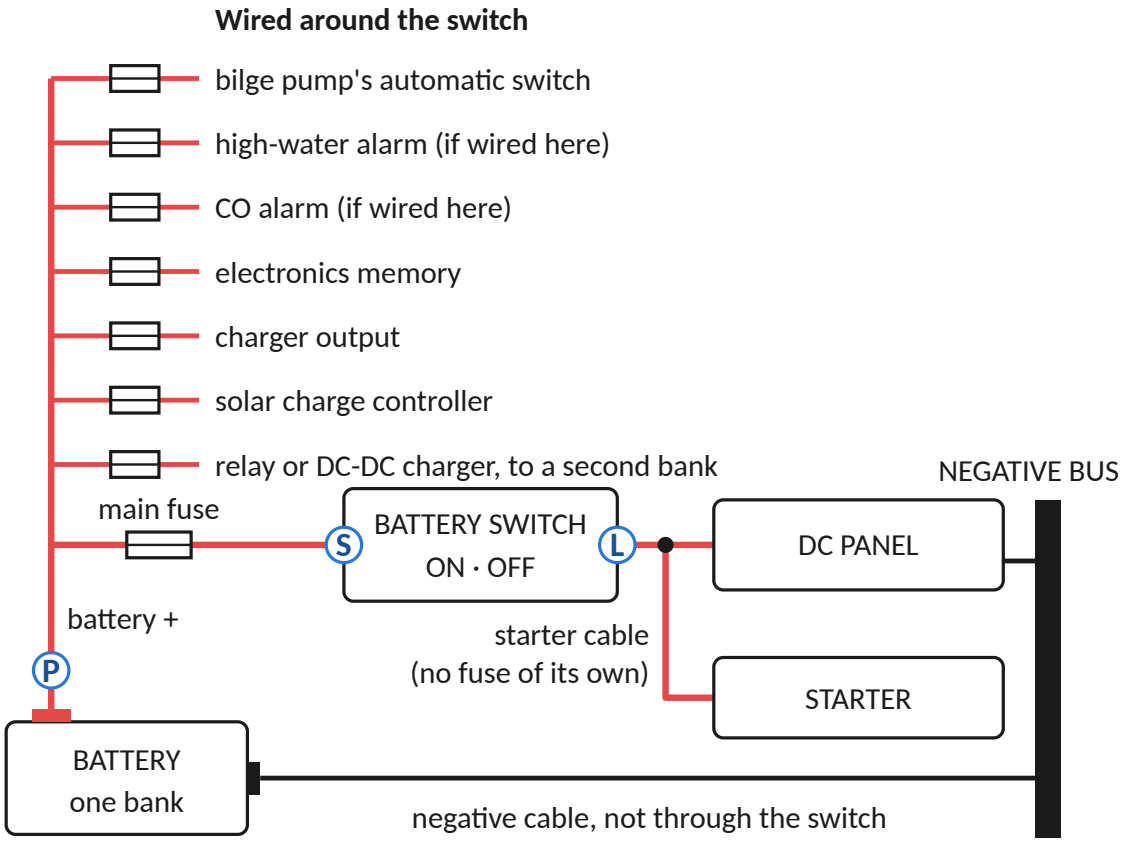


Fig. 8.1. One bank and its battery switch, on one typical boat. The switch is in the positive cable; the negative cable runs to the negative bus without it. With the switch OFF, only point L and what it feeds — the DC panel and the starter cable — lose this bank's voltage. Points P and S, and every circuit wired around the switch on its own fuse at the battery, stay live. Your boat can be wired differently.

Switch types, and what each position connects

Battery switch makers' documents show four kinds of switch, and a remote-operated version of them; the same printed word means

different things on two of them (→ Table 8.1 · p. 4, → Fig. 8.2 · p. 6). Read which kind you have before you read its positions.

Table 8.1. Battery switches, their positions, and what each position connects MFR

Switch	Positions as printed	What each position connects	Joins the banks at
ON/OFF switch, one for each bank	ON · OFF	ON connects its bank to what is wired after the switch; OFF disconnects it	Never by itself
Selector	1 · 2 · BOTH · OFF; also printed 1 · ALL · 2 · OFF, or 1 · 2 · 1+2 · OFF	Everything after the switch hangs on one common terminal; the position chooses which bank feeds it	BOTH, ALL, 1+2
Dual-circuit switch	ON · OFF, or ON · COMBINE · OFF	ON connects the start battery to the start circuit and the house bank to the house circuits, each to its own	COMBINE
Parallel switch, beside an ON/OFF switch on each bank	ON · OFF; one maker labels it EMERGENCY PARALLEL	ON joins the positives of the two banks	ON
Remote-operated battery switch	A switch at the helm; on one maker's series, a manual knob on the unit as well	A heavy contact near the battery does the switching, as the switch kind it replaces	As that kind

On a selector, the loads keep their power while you move between banks. Two makers build theirs make-before-break: the contacts of the new bank close before those of the old one open, and one of them writes that its design allows switching between battery banks without power interruption. What that does for a running alternator is physics, and it is the subject of "Why it works" in this section; it changes nothing about when a switch is turned (→ 1.7). MFR

On a dual-circuit switch, ON keeps the banks apart. One maker writes that at ON, current flows from the start battery to the start circuit and from the house battery to the house circuits, and that at COMBINE BATTERIES current flows from both. On an ON/OFF switch, ON MFR

connects the one bank it serves. The same word, two meanings: the kind of switch decides.

A remote-operated battery switch is a heavy contact near the battery that a switch at the helm commands. One maker's series has a manual knob on the unit, with positions marked LOCKED-OFF (open) and ON (closed), and its LED double-blinks while the knob overrides the helm switch; on that series the state is read at the knob, not at the helm. A remote-operated battery switch without such a knob gives you no position to read when its control has no power: what its heavy studs connect is traced, and until you know, field 15 of the Boat Passport holds a "?". MFR

Some switches lock: one maker's models lock only in the OFF position. A boat left with its switch locked OFF has lost everything wired after the switch — the bilge pump's automatic switch and the CO alarm among them where they are wired after it (→ 8.2 · p. 11). MFR

The positions as printed, the bank each one connects, and the position the boat runs in — the working position — go into field 6 of the Boat Passport (→ 2.3). BOTH, ALL, 1+2, COMBINE and a parallel switch ON join the banks; why a switch is not left there is in → 8.5 · p. 28.

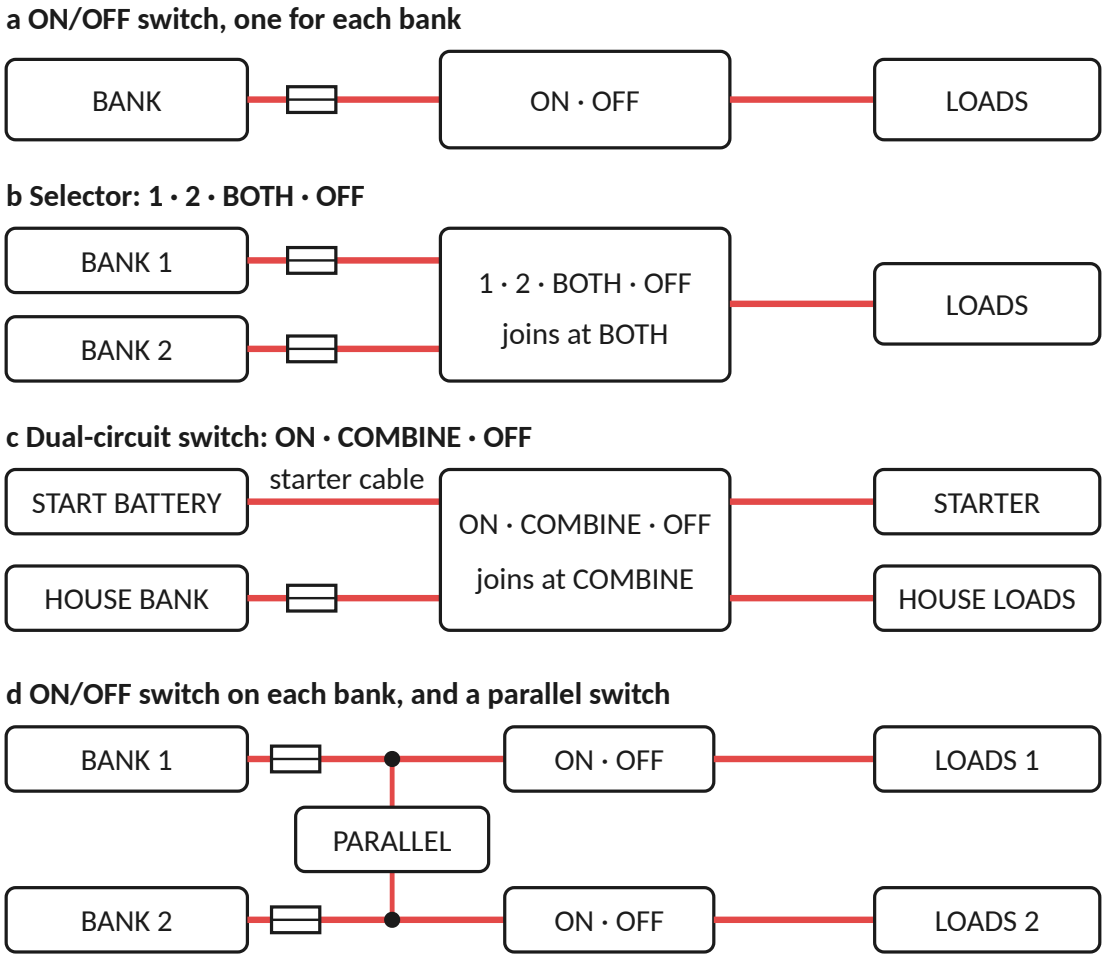


Fig. 8.2. Four kinds of battery switch. On a selector (b), BOTH joins the banks on one common terminal. On a dual-circuit switch (c), ON keeps each bank on its own circuit and COMBINE joins them. With an ON/OFF switch on each bank (d), a separate parallel switch joins them when it is ON. Every positive from a bank has its own fuse, except the starter cable.

Where the alternator lands, and why OFF with the engine running is a load dump

Which batteries a running alternator keeps when a switch turns is set by where its output lands. One battery-switch maker's instructions show four wirings: at the starter, on the engine terminal of the battery switch, at the start battery, and at the house battery (→ Fig. 8.3 · p. 8). On the second, the switch stands between the alternator and every battery: turned OFF with the engine running, it takes away the battery the alternator was charging, and the voltage jumps — the load dump of → 1.7, which a battery-switch maker warns quickly destroys the diodes MFR

in the alternator. On the third and the fourth, one battery stays on the alternator whatever the switch does. On the first, the starter's own feed decides. You find your landing by following the heavy output wire from the alternator by eye (procedure "What each battery switch connects", in this section; → 9.2), and it goes into field 8 of the Boat Passport. The rule of this book on turning a switch does not change with the landing (→ 1.7).

Some switches carry an alternator field disconnect (AFD), an extra contact that opens the alternator's field circuit slightly before the main contacts open. Two makers write that it works only on an alternator with an external regulator; one of them, that on an alternator with a built-in regulator a field disconnect cannot be installed. Whether your switch has one is a line in its model's data, not a mark on its knob. It protects the alternator from a mistake; it is not a permission to turn the switch (→ 1.7). MFR

The battery switch of a running outboard is not touched. The outboard's charging output reaches its start battery through the boat's cables, and where that switch stands between them, turning it OFF while the outboard runs takes away the battery that output pushes its current into: a load dump of the same kind. What an outboard's charging output is allowed to charge is in → 9.1. PRACTICE

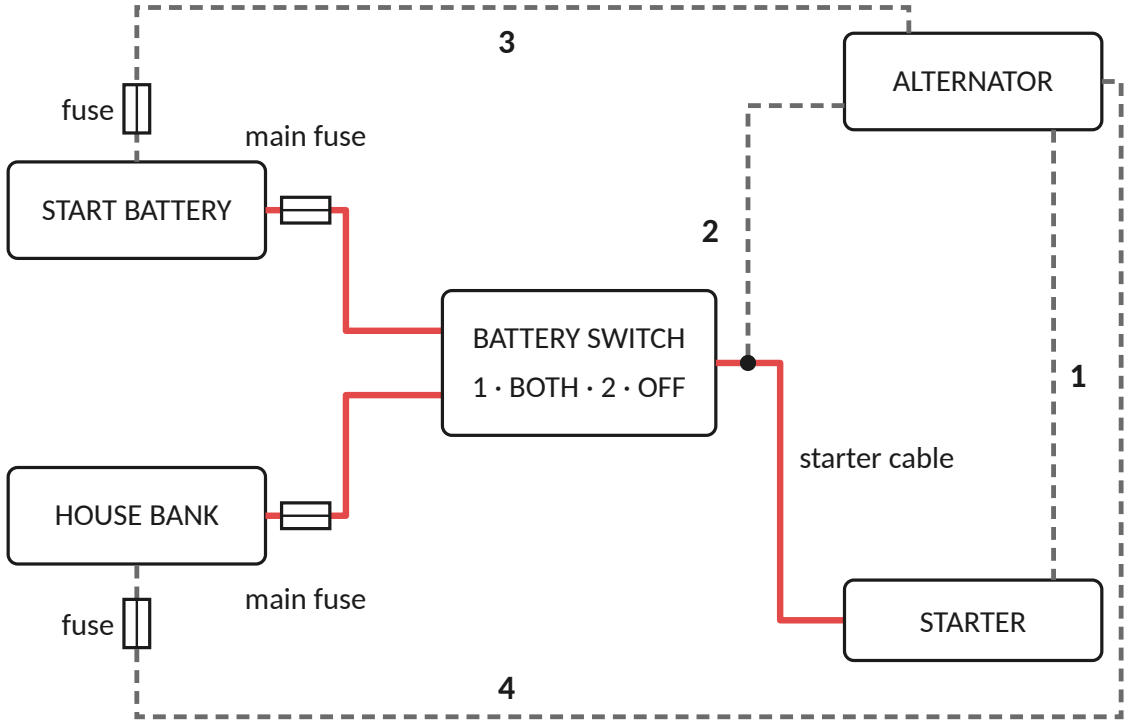


Fig. 8.3. Four places an alternator's output can land, as one battery-switch maker lists them, drawn here on a selector: 1, at the starter; 2, on the engine terminal of the battery switch; 3, at the start battery; 4, at the house battery. None of them is the rule: the one on your boat is found by tracing the output wire. On landing 2 the switch stands between the alternator and every battery. Landings 3 and 4 are drawn with a fuse at the battery each reaches; landings 1 and 2 without one, which an output there may lack only under the conditions of → 4.2.

A charger reaches which bank by the same logic. The 2003 edition of ABYC E-11 lets battery charging equipment be connected on the battery side of the switch. A charger whose outputs are wired that way, each to its bank's battery through its own fuse, reaches its banks whatever the switches do; an output landed after a switch reaches only the bank that switch connects — on a selector, the bank its position chooses, and none at OFF. Your source map shows which (→ 1.7; Boat Passport fields 8 and 9). ABYC

Procedure: What each battery switch connects

For every battery switch on the boat, with the panel lit — a dark panel is the card "The panel went dark — no lights, no electronics" (→ emergency card) — and with the engine stopped from the first step to the end of the restore. It is done at the dock, or at anchor by day with

every switch that feeds the anchor light or the radio left as it is in step 7; never under way. You need the Boat Passport (fields 4, 6, 8 and 15) and a pencil; for step 7, a battery monitor that reads each bank's current, where the boat has one. Nothing is opened with a tool: a switch whose back you cannot see without one gets a "?" for what you could not see.

 **GASOLINE VAPOR**  **BILGE PUMP**  **CARBON MONOXIDE**

1. Find every battery switch: at the helm, beside the batteries, in the engine space, behind a locker door; for a remote-operated switch, its switch at the helm and the unit itself near the battery, with its manual knob where it has one. Write where each one is into field 6.
2. Write each switch's positions as printed on its face, and the position it is in now. That position is the working position as you found it; the boat's papers can name another. A separate switch marked PARALLEL or EMERGENCY PARALLEL goes on the same line, with its position.
3. Look at the back of each switch by eye: the heavy cables on its studs, and the stud markings where it has them — 1, 2 and COM on a selector; START and HOUSE on a dual-circuit switch.
4. Follow each heavy cable by eye from its stud to where it goes: a battery — which bank —, the starter, or the DC panel. Write which bank each position connects into field 6. A cable you cannot follow by eye: a "?" for that position in field 6, and in field 15, in words, as you saw it.
5. Follow the heavy output wire of the alternator by eye to where it lands — the starter, the engine terminal of the battery switch, the start battery or the house battery (→ Fig. 8.3 · p. 8) — and write it into field 8. On an outboard, follow the engine's positive cable to the battery it reaches. A landing you cannot see: a "?" in field 15.
6. Where field 6 still holds a "?": switch off every charging source at its own control — the charger at its own switch, solar panels covered or their controller's own switch OFF. A source you cannot switch off this way: the "?" stays, and step 7 is not done.

7. With the engine stopped, switch on one cabin light and take each battery switch through its positions, one switch at a time. A selector goes from one bank to the other through OFF; one whose dial reaches the other bank only past BOTH, ALL or 1+2 is not turned, and its "?" stays. An ON/OFF switch found ON: turn it OFF, see what goes dark, and turn it back ON before the next switch; one found OFF stays OFF. A parallel switch, a dual-circuit switch and a relay's remote control stay as you found them. Read which bank's monitor shows the light's current: one monitor names the bank; both, or neither, leave the "?" — and so does a boat with voltmeters only, for a selector. Write what each position connects into field 6.
8. Write into field 6 the position each switch stays in while you use the boat: its working position. Where that position joins the banks, write that beside it; why such a position is not left for the night is in → 8.5 · p. 28.

PUT THE BOAT BACK IN SERVICE

- With the engine stopped, every battery switch, every control and every charging source you changed back to the position you found it in; the cabin light off.
- A CO alarm wired after a switch that was at OFF in step 7, even for a moment, lost its power for that time; the entry of the CARBON MONOXIDE sign says how you see that it is working again.
- Check that the bilge pump's automatic switch has power, by the procedure "The check that the automatic switch has power" (→ 12.2).

WHY IT WORKS

A running alternator pushes current into whatever battery its output reaches, and the battery holds the voltage down, the way a large tank holds a water level. Take the battery away while the current flows and nothing holds the voltage: it jumps until the current finds a way, and the alternator's diodes and everything on its output see the jump. That is why the landing matters. A make-before-break selector with the alternator on its common terminal never leaves the alternator without a battery as it moves between banks, because the new bank is connected before the old one leaves. Turning to OFF is different: there is no next bank, the contact opens, and the alternator loses its battery at that instant. Where the explanation stops working: a dial that passes OFF on its way between two banks opens the circuit too; a dual-circuit switch and an ON/OFF switch on each bank have no make-before-break path between banks at all; and with the alternator landed at a battery, a switch can take that battery's loads away from it, but not the battery from the alternator. This is physics, not a schedule for turning switches: when a switch is turned is set in → 1.7.

8.2. What is wired around the switch

What still has power on your boat when every battery switch is OFF, and is that what you want? A circuit wired around the battery switch is connected on the battery side of the switch, so it stays live in every switch position, and it needs its own fuse at the battery. The 2003 edition of ABYC E-11 names what may be connected there: conductors supplying electronic equipment with continuously powered memory; safety equipment such as bilge pumps, alarms, CO detectors and bilge blowers; and battery charging equipment. That is a permission, ABYC not a description of your boat: any of these can also be wired after the switch, and a boat can have none of them wired around it. Stop 7 of the walk-through finds what is wired around yours (→ 2.1); this section says what each finding means (→ Table 8.2 · p. 12).

The same text lets the conductors of a trolling motor run to dedicated trolling-motor batteries without the switch, where those batteries have

overcurrent protection at the battery and a manual means of disconnect separate from the motor's controls. That circuit is a system of its own (→ 6.4, → 14.3). ABYC

Table 8.2. What can be wired around the battery switch, and how you tell on your boat

Circuit	How it can be fed	What you see with the switch ON and with every switch OFF (Stop 7, → 2.1)	Boat Passport
The bilge pump's automatic switch	From the battery through its own fuse, or after the switch	Around: its automatic switch keeps power, by the check of → 12.2. After: it has none	Field 11
High-water alarm	Around the switch, after it, or no alarm	Its test sounds with every switch OFF: around (→ 12.5). It sounds with the switch ON and is silent with every switch OFF: after. Silent on its test with the switch ON: no power, or a dead alarm — its manual	Field 11
CO alarm	Around the switch, after it, or on its own battery	Its test button sounds it with every switch OFF: around, or its own battery. It sounds with the switch ON and is dark with every switch OFF: after. Dark on its test with the switch ON:  **CARBON MONOXIDE** no power, or a dead alarm — its manual	Field 10, the line "CO alarm: what feeds it"
Electronics memory — a stereo, a chartplotter	Directly to the battery, or through a breaker or a switch of its own	Its clock or its presets survive	Field 10
Bilge blower	Around the switch, or after it	Around: it runs from its own switch. After: it has no power	Field 10
Solar charge controller, charger outputs	At the battery, each through its own fuse; a charger output or a controller can also land after the switch (→ 8.1)	Where each cable lands, followed by eye (→ 8.1)	Fields 8, 9, 10

Circuit	How it can be fed	What you see with the switch ON and with every switch OFF (Stop 7, → 2.1)	Boat Passport
Charging relay or DC-DC charger	At both batteries' positives, each through its own fuse	Its LED or display, where it has one, can stay lit	Field 9

The bilge pump: wired from the battery through its own fuse, its automatic switch keeps power whatever the switch does (→ 1.7). A pump wired after the switch stops with the switch OFF, and its automatic switch has no power then. Which one you have goes into field 11; the pump circuit wired around the switch, and how it is checked, are in → 12.1 and → 12.2.

The CO alarm has three variants. ABYC A-24 (July 2020) permits the alarm's power to come from the energized side of the battery switch, and takes a detector powered by a self-contained battery out of its wiring requirement; where a circuit breaker feeds the alarm, it asks for a block or another multistep means that keeps the breaker from being turned off by mistake. One alarm maker allows its alarm after the battery switch, where it loses power with the switch, and that maker then says the boat must not be occupied while the switch is off (→ 1.7). Which one yours is goes on the line "CO alarm: what feeds it" of field 10. ABYC

Electronics memory: one stereo maker has the power wire of one of its models connected directly to the battery, for a constant standby feed; for another of its models, the same maker routes that wire through a 15 A breaker or a manual switch, turned off when the boat is not in use, so that it does not drain the battery. What such a feed draws with everything off is in → 7.3, and where it is taken from, → 13.3. MFR

A bilge blower wired around the switch keeps its power with every switch OFF; one wired after the switch has none then.

The charging units are connected at the batteries by their makers' instructions: one charge-controller maker has the battery cable protected by a fuse or a breaker close to the battery terminal or a power distribution block, and one relay maker recommends connecting

its relay directly to the battery positive terminals through appropriately sized fuses. Wired at the battery, they keep their side of the battery live and stay sources with every switch OFF (→ 1.7). MFR

Each circuit wired around the switch has its own fuse at the battery, and how far from the battery that fuse is allowed to sit is the rule of → 4.2. A circuit wired around the switch with no fuse of its own at the battery is an unprotected positive, and it goes on the first line of the Boat Passport, field 1 (→ 4.2). When you look for such a wire, the one positive that leaves a bank without a fuse of its own is the starter cable, identified by tracing it to the starter, not by its size; the cables that join the batteries of one bank are part of the bank.

On a lithium bank, its battery management system (BMS) can disconnect the whole bank: everything on it goes dark at the same moment, wired around the switch or not — the bilge pump's automatic switch, the high-water alarm and the CO alarm among them, where that bank feeds them (→ 11.4).

A battery switch turned OFF when you leave the boat stops only what is wired after it. Your Boat Passport says whether the pump and the alarms are among what keeps working (fields 10 and 11).

8.3. Charging two banks: relay, diode isolator, DC-DC charger

Which unit charges your second bank, how do you tell which one it is, and what does it do to your banks when nothing is charging? Three units can sit between a start battery and a house bank, and from across the compartment they look alike (→ 2.2). A charging relay — an automatic charging relay (ACR) or a voltage-sensitive relay (VSR) — joins the two banks while it is closed, as a battery switch at BOTH does. A diode isolator never joins them: it lets current flow from the alternator to each bank and never between the banks. A DC-DC charger takes power from one bank and delivers a controlled charge to the other through its electronics; it does not join them the way a relay does. Which one you have decides what a turn of a battery switch, a

battery change and a voltage reading mean on your boat (→ Table 8.3 · p. 15). Behind an outboard, the house bank can also take its share from the engine itself, through the engine maker's own isolator or accessory charging lead, as the engine's manual says (→ 9.1).

Table 8.3. Three units between two banks: what you see, and what each does MFR

Unit	What you can see	What it does to the banks	With nothing charging
Charging relay (ACR, VSR)	Two heavy studs, one to each bank through its own fuse; a thin wire to the negative; on some models an LED, a remote control or a knob	Joins them while it is closed, as BOTH does	Can stay closed: three makers' relays stay joined above their open setting
Diode isolator	One or two input studs for alternators, two or three output studs, one for each bank	Never joins them; each bank gets the alternator's voltage less the diodes' drop	Nothing flows between the banks
DC-DC charger	Terminals marked for input and output; charge-stage lights or a display; on some models an ignition or D+ wire	Moves energy from the input bank to the output bank while its run conditions are met	Off on one maker's unit when it detects the engine off; set to forced charging, it draws from the start battery anyway

How to tell which one you have

The label decides: the maker and the model, then the data sheet. Thresholds in volts mean a relay; one or two inputs for alternators and two or three outputs mean a diode isolator; an output current and charge stages mean a DC-DC charger (→ 2.2). Without a readable label, three things tell you more, and none of them needs a probe. An LED: one maker's relays light theirs while the banks are combined; another maker's 120 A combiner has no LED, and its 230 A model has one. A click: a relay's contact clicks when it changes state, and one maker's troubleshooting chart for its heavy-duty relay starts with that click. And the battery monitor, where each bank has one: while the first bank charges in the relay's join range, the second bank's current turns to

charge when the relay joins. A DC-DC charger shows what it does MFR on its own lights or its maker's app; a diode isolator shows nothing. Until you know which unit it is, every heavy stud on it is live with every battery switch OFF (→ 2.2).

These observations need no meter beside a turning belt: the LED, the click and the monitor at the helm are enough to tell the three apart, and readings taken in the engine space with the engine running are a pro's (→ 3.4). A starter solenoid or a remote-operated battery switch also has two heavy studs and a small control terminal, so the case alone never decides.

When a relay joins and when it parts

A relay joins the banks when the voltage it senses stays in its join range for the delay its maker gives at that voltage, and parts them when the voltage stays below its open setting for its delay. The numbers belong to the model (→ Table 8.4 · p. 16). One maker's relay senses a charge on either bank, so a charger on either one closes it; the same relay will not close while the lower battery is below 9.5 V, its undervoltage lockout, and its LED then flashes. MFR

Table 8.4. When three makers' relays join and part two 12 V banks MFR

Relay	Joins the banks	Parts them	With nothing charging
Maker 1, one model	13.6 V for 30 s, or 13.0 V for 2 min	12.75 V for 30 s, or 12.35 V for 10 s	Stays joined until the voltage falls to its open setting for its delay
Maker 1, heavy-duty model	Above 13.5 V for 30 s, or above 13.0 V for 90 s	Below 12.75 V for 30 s, or below 12.35 V for 10 s	The same
Maker 2, 120 A combiner	From 13.0 to 13.2 V after about 10 min; 13.2 to 13.4 V, about 5 min; 13.4 to 13.6 V, about 1 min; 13.6 to 13.8 V, about 4 s; below 13 V it stays open	From 12.4 to 12.8 V after about 3 min; 12.2 to 12.4 V, about 30 s; 12.0 to 12.2 V, about 10 s; 11.0 to 12.0 V, about 1 s; below 11 V at once	Above 12.8 V it remains closed

Relay	Joins the banks	Parts them	With nothing charging
Maker 3, relay in a battery cluster	13.7 V	12.8 V	After a long run the battery's residual voltage can hold it above 12.8 V for a time; its maker: not a fault

One relay's numbers are not another's, which is why your relay's thresholds come from its own label or data sheet. One of them can be set by its installer to stay joined lower: a model of maker 1 has a setting that keeps the batteries paralleled down to 12.25 V, either while the ignition is on or permanently — a setting nobody sees on the case. MFR Two relays of maker 1 are not intended to carry starting currents, its maker writes, and a battery switch with a combine position does that job (→ 8.5 · p. 28).

NUMBERS · WHAT A RELAY DRAWS

A relay is a load of its own while it holds its contact. One maker's relay draws 175 mA joined and 15 mA open; for the same maker's heavy-duty relay, its page gives 13 mA as the operating current and less than 40 mA to monitor its terminal voltage; another maker's 120 A combiner 220 mA joined and less than 4 mA open, at 12 V. MFR

Suppose a relay that draws 0.22 A stays joined around the clock: 0.22 × 24 = 5.28 Ah a day. Suppose one that draws 0.013 A: 0.013 × 24 = 0.312 Ah a day. What that share means for your bank is in → 7.3.

When a relay keeps the banks apart

The banks are apart across a relay only while it is open, and you cannot see its contact. Three makers' relays stay closed with nothing charging, as long as the banks rest above their open setting: one maker's relay parts the banks when the voltage falls to 12.75 V for 30 seconds; another maker's 120 A combiner remains closed above 12.8 V; a third maker writes that after a long run the battery's residual voltage can hold its

relay above 12.8 V for a time, and that this is not a fault. Two full banks at rest can stay joined with nothing charging. MFR

Some relays also have a control that joins the banks on purpose. One maker's heavy-duty relay has a remote control whose ON position combines the banks for hard starting; another maker's combiner engages for 30 seconds after its start-assist terminal is momentarily connected to the battery positive — by a push button wired to it, where one is fitted — or for as long as a switch its maker calls a parallel connect switch stays closed. A control left at ON overrides the relay's automatic settings and keeps the banks joined. MFR

One maker gives a way to hold its relay open. Its heavy-duty relay, with a remote control of the kind that stays where you set it, keeps the banks isolated while that control stays at OFF; its maker describes the relay's manual knob as offering LOCK OFF capability for servicing. A remote control of the momentary kind springs back, and gives no held OFF. The instructions of two of that maker's smaller relays, and those of the other maker's 120 A combiner, give no position that holds them open. A relay at its maker's hold-open position keeps the banks apart unless its contacts have welded together: a relay maker, writing of windlass and thruster relays whose contacts chatter, says that a long string of opening and closing heats the contacts and can weld them together in the ON position, and the heavy-duty relay's LED double-blinks both for a manual override and for a mechanical failure of the relay. Neither that relay's instructions nor its troubleshooting chart say that the hold-open position opens welded contacts. MFR

 **SHORT CIRCUIT**  **GASOLINE VAPOR**

Where the relay is connected at each battery through its own fuse, as one relay maker recommends, that fuse out of its holder at one of the two banks takes the relay out of the circuit, welded or not: nothing flows between the banks through the relay. A relay wired another way — to the studs of a battery switch, for example — is traced before this applies. Where that fuse sits in a holder that opens by hand, taking it out and putting it back, in the state the entry of the SHORT CIRCUIT sign gives for a fuse between two banks, is yours; a fuse held PRACTICE

under a nut on a stud is a pro's job (→ 1.8). On someone else's boat a fuse is not touched (→ 2.6). While the fuse is out, the second bank gets no charge through the relay; with the fuse back in its holder, the relay joins and parts by its own settings again.

So, across a relay connected at each battery through its own fuse, two means keep the banks apart: a position its maker gives for holding it open, on a relay whose maker gives one, set to that position — unless its contacts have welded; or the relay's own fuse out at one of the banks, which keeps them apart whatever the contacts do. Nothing else does — not a dark LED, not a low voltage, not the fact that nothing is charging. Field 9 of the Boat Passport records which of the two your relay allows: its model, whether it has a hold-open control and where that control is, and the holder of its fuse at each bank.

> **WHY IT WORKS**
>
> A closed contact with sound connections cannot hold two batteries at different voltages, apart from the small drop of the current flowing through it: joined, they read the same. So two banks at clearly different resting voltages are apart at that moment, unless a corroded lug or a failing fuse holder in the relay's path holds the difference — and a relay can close a minute later, when a charger starts. Every other reading has more than one cause. A bank below the relay's open setting: the relay is open; or its control holds it closed and both banks have sagged together; or its contacts have welded. Two banks at the same voltage: joined, or apart and equally charged. Where the rule stops working: a relay in its lockout, below its undervoltage or above its overvoltage setting, stays open whatever the other bank reads, and on one maker's relay its LED says so by flashing.

The diode isolator

A diode isolator passes current one way only. One maker writes that its isolators allow simultaneous charging of two or more batteries from one alternator without connecting the batteries together, and gives the drop across the diodes as about 0.3 V at low current and about 0.45 V at the rated output; inserting the isolator slightly reduces the charge voltage, and the batteries can then stay short of a full charge and age

prematurely. Its isolators carry a compensation diode that can be used to raise the alternator's output slightly to make up for the drop; and some alternators need a voltage on their output to start charging, which the diodes block from the batteries. A house bank that never gets full behind an isolator has three candidates: that drop, the alternator's own setting (→ 9.2), and the charging time (→ 9.4). MFR

The DC-DC charger

A DC-DC charger runs only when its maker's conditions are met. One maker's unit has an engine-running detection: it separates the start and house batteries when the engine is not running, and with its input below its shutdown voltage for longer than one minute it detects "engine off" and stops charging. Set to forced charging, the same unit draws current from the start battery with the engine not running; a signal on its remote input overrides the engine detection and forces charging on, and its maker does not recommend the ignition switch for that signal. Its input and output are galvanically isolated and do not necessarily share the same negative. MFR

A second maker's unit is voltage sensitive and needs no ignition feed: it starts when its input rises above 13.3 V and switches off when the input stays below 13.0 V for more than 2 minutes, an adjustable delay. That maker warns of a loop where a voltage-sensitive relay joins the same two banks as well: 13.3 V from the house side then reaches the start battery, the charger stays on, and in the end it depletes both banks; its ignition-feed mode overrides that, its maker writes. A third maker's unit does not power on or operate until its D+ ignition wire is connected; it isolates the banks, and it does not charge the start battery back from the house battery. Which of these your unit is — engine detection by voltage or by a wire, forced charging set or not, isolated or with a common negative — is in its manual, and goes into fields 9 and 12; until you have read it, the unit counts as a charging source between the banks (→ 1.7). MFR

What an outboard's own charging output is allowed to charge is in → 9.1; a lithium house bank and how it is charged, in → 11.3.

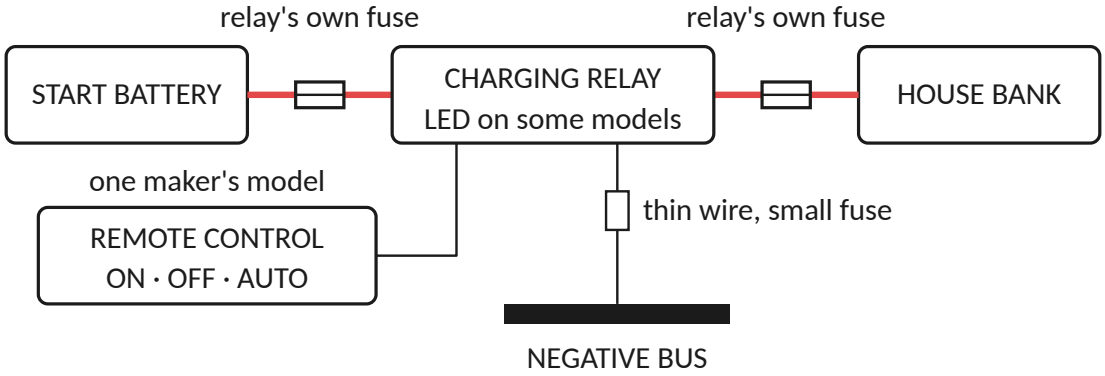


Fig. 8.4. A charging relay between two banks: its own fuse at each battery, its thin wire to the negative, and, on one maker's model, a remote control and an LED. When its contact closes, the two positives are joined. Which of its parts can hold it apart is in the text.

Route: the second bank does not charge

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → its wiring and its settings, and field 9 of the Boat Passport: step 1
- after charging → whether the charge reached the first bank at all: step 2
- after rain or washing the boat → the unit's own fuses and connections, by eye: step 1
- after the boat sat unused → the second bank's own condition (→ 6.6), then step 1
- after switching sources (shore power, generator, inverter) → which bank the charger reaches (→ 8.1 · p. 2): step 2
- nothing you noticed → step 1

ROUTE: THE SECOND BANK DOES NOT CHARGE

HOT BATTERY GASOLINE VAPOR METER LEADS SHORT CIRCUIT BILGE PUMP CARBON MONOXIDE

1. Read field 9 of the Boat Passport, or the unit's label: which unit sits between the banks (→ Table 8.3 · p. 15), and which source charges the first bank — the engine, or a charger on

shore power.

You will see: Every kind of unit, and one you cannot identify by eye: step 2. A unit you cannot identify: the boat's papers or its wiring diagram can name it (→ 2.4); otherwise a "?" in field 15.

2. Charge the first bank. At the dock with shore power already connected, switch the charger on at its own switch: the bank it is wired to goes on charge. At anchor or under way, the engine runs as you use the boat. Watch the first bank's battery monitor or voltmeter from the helm, outside the space with the turning belts; where the helm has neither and the first bank's battery is outside that space, read the voltage at its battery terminals, the meter set as the entry of the METER LEADS sign says.

   You will see: The first bank rises — for a relay, into its join range (→ Table 8.4 · p. 16): a relay, step 3; a diode isolator, step 4; a DC-DC charger, step 5; a unit you could not identify, step 6. It does not rise: the charging source is what to follow, not the unit between the banks — the charger (→ 9.3), the engine (→ 9.1, → 9.2). You cannot watch it — no instrument at the helm, and the battery in the space with the turning belts: step 6. A charger with its own output to each bank charges the second bank by itself, with or without the relay: then only the engine, as the source, shows what the relay does.

3. A relay: once the first bank has stayed in its join range for the delay its maker gives at that voltage, watch its LED where it has one, listen for its click, and read the second bank's monitor — with no switch joining the banks and no other charging source on the second bank: solar panels on it covered, or after dark, and a charger's own output to it as step 2 says. Where there is no monitor and the second bank's battery is outside the space with the turning belts: read the voltage at the battery terminals of the second bank, the meter set as the entry of the METER LEADS sign says.

   You will see: The second bank's monitor shows a charge going in, or its voltage rises with the first bank's: the relay joins — the second bank's own condition is next (→ 6.6). The LED lights or the contact clicks, but no charge reaches the second bank: the relay's fuse and lead at the second bank, by eye — a fuse out of its holder, as the end of this step says; a fuse blown, a lead loose, or nothing seen: step 6. Nothing — the LED dark, no click, no charge: the relay's lockout (on

one maker's relay, a flashing LED; its manual says which state it is in); a control left at OFF — set to AUTO as its manual says, and you watch again; a fuse out of its holder at one of the banks, as the end of this step says; a fuse blown, the thin wire to the negative, or the relay itself: step 6. A double blink on one maker's heavy-duty relay: a manual override or a mechanical failure, and its manual says what to check first. No monitor, and the second bank's battery in the space with the turning belts: step 6. A battery switch at BOTH, ALL, 1+2 or COMBINE, or a parallel switch ON, joins the banks by itself, and this step then says nothing about the relay: the next time the engine is stopped, turn the battery switch from BOTH, ALL or 1+2 to the first bank alone on a selector, or from COMBINE to ON on a dual-circuit switch, or turn the parallel switch OFF, and start the route again at step 2. A boat that runs with its banks joined that way charges the second bank through the switch, not through the relay; a second bank that still does not charge: → 6.6, and step 6. A relay's fuse out of a holder that opens by hand goes back in only in the state the entry of the SHORT CIRCUIT sign gives for a fuse between two banks; then the route starts again at step 2. A holder that does not open by hand, or a state you cannot reach: the fuse stays out, and step 6.

4. A diode isolator: with the engine running, read the second bank's monitor, or the voltage at its battery terminals where that battery is outside the space with the turning belts, the meter set as the entry of the METER LEADS sign says.
   You will see: No charge going in, while step 2 showed the first bank charging: the isolator's output fuse to that bank, by eye, or the isolator itself: step 6. Charge going in, but the bank never gets full: the diodes' drop keeps it below the alternator's voltage unless the alternator is set to make up for it (→ 9.2); a pro reads that drop at the isolator with the engine running — step 6. Neither readable: step 6.

5. A DC-DC charger: read its own lights or its maker's app, with the meaning of each from its manual.
   You will see: Charging: the second bank's own condition is next (→ 6.6), and its charge settings for that bank's chemistry (→ 9.3). "Engine off" detected with the engine running: its input stays below its maker's start voltage, or its run signal — an ignition or D+ wire, on a model that needs one — is missing; one maker's unit does not run until its D+ wire is connected. Nothing lit: its fuses at both banks, by eye, and its own switch or remote input: step 6.

6. What is left goes to a pro, with what you saw: a relay that does not join with its fuses whole and no lockout shown, a relay that closes while no charge reaches the second bank, an

isolator's drop, a DC-DC charger's wiring, a unit you could not identify, a bank you could not watch.

You will see: A fuse you found blown has found a fault: the route "A branch breaker trips or a fuse blows" (→ 4.8). Until the pro has found the fault, the second bank is charged only by what still reaches it — the charger's own output to it, where it has one — and how long it lasts on that is worked out by → 7.4.

PUT THE BOAT BACK IN SERVICE

- A charger you switched on in step 2, back as you found it, at its own switch; solar panels you covered, uncovered.
- A relay's remote control you changed in step 3: left as it is now only where you mean the relay to charge the second bank from now on, and field 9 says so; otherwise back as you found it. A relay's fuse you put back: the same, and out again only in the state the entry of the SHORT CIRCUIT sign gives for a fuse between two banks — where you cannot reach that state, it stays in, and field 9 says so. The loads and the charging sources you turned off for that fuse, back as you found them.
- A battery switch or a parallel switch you moved in step 3: with the engine stopped, back to the position you found it in — a position that joins the banks, left overnight with the engine stopped, is the trap of → 8.5 · p. 28. A CO alarm wired after a battery switch that passed OFF lost its power for that moment; the entry of the CARBON MONOXIDE sign says how you see that it is working again.
- The meter's dial to OFF.
- Where step 3 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).

8.4. Typical layouts

Which layout does your boat have, and what does each part of it do? This section describes five arrangements, each from makers' documents: one battery; a start battery and a house bank; two house banks on a selector; a battery of its own for a windlass or a thruster;

and a trolling-motor bank beside any of them. A boat can combine them, and its builder can have wired any of them another way: the layout of your boat is the one you trace and write into the Boat Passport (→ 8.1 · p. 2, → 2.3).

In every layout, each positive that leaves a bank does so through its own fuse at the battery; the cables that join the batteries of one bank are part of the bank; and the one exception is the starter cable, identified by tracing it to the starter, not by its size (→ 4.2). The figures of this chapter draw the starter cable without a fuse, and name it; Fig. 8.3 draws the alternator's output with a fuse where it lands at a battery, and without one where it lands at the starter or on the battery switch, under the conditions of → 4.2; every other positive on them has its fuse at the battery.

One battery

A small outboard boat can have one battery that starts the engine and runs the loads, with an ON/OFF battery switch or none: the 2003 edition of ABYC E-11 asks for a switch only above 800 CCA (→ 8.1 · p. 2). One outboard maker's manual, for two of its models, sends you to its dealer for the wiring of a battery selector switch; for a second, accessory battery it asks for a cable between the negative terminals of the two batteries, made from wire thicker than the starting battery cable, and its diagram shows an optional lead from the outboard for charging that accessory battery. One battery doing both jobs is the compromise of → 6.3; what that outboard's charging output is allowed to charge is in → 9.1. MFR

A start battery and a house bank

A start battery and a house bank are two banks, each with its own cables to the switch (→ 6.3). Two makers' arrangements show how they are joined for a charge and kept apart for a start (→ Fig. 8.5 · p. 26). In one, a dual-circuit switch at ON connects the start battery to the start circuit and the house bank to the house circuits, and a charging relay connected at both batteries' positives, each through its own fuse, charges the house bank; COMBINE joins the banks for an emergency

start. That maker gives the reasons for the design: switch settings people forget, and the chance of discharging both batteries. MFR

In the other, each bank has its own ON/OFF switch, a voltage-sensitive relay charges the second bank, and an EMERGENCY PARALLEL switch joins the two for a start. Its maker writes that the arrangement eliminates the possibility of draining the wrong battery, and keeps engine start-up spikes away from sensitive equipment on the house battery. What an outboard's charging output is allowed to charge MFR is in → 9.1; an inboard with an external regulator can charge the house bank directly (→ 9.2).

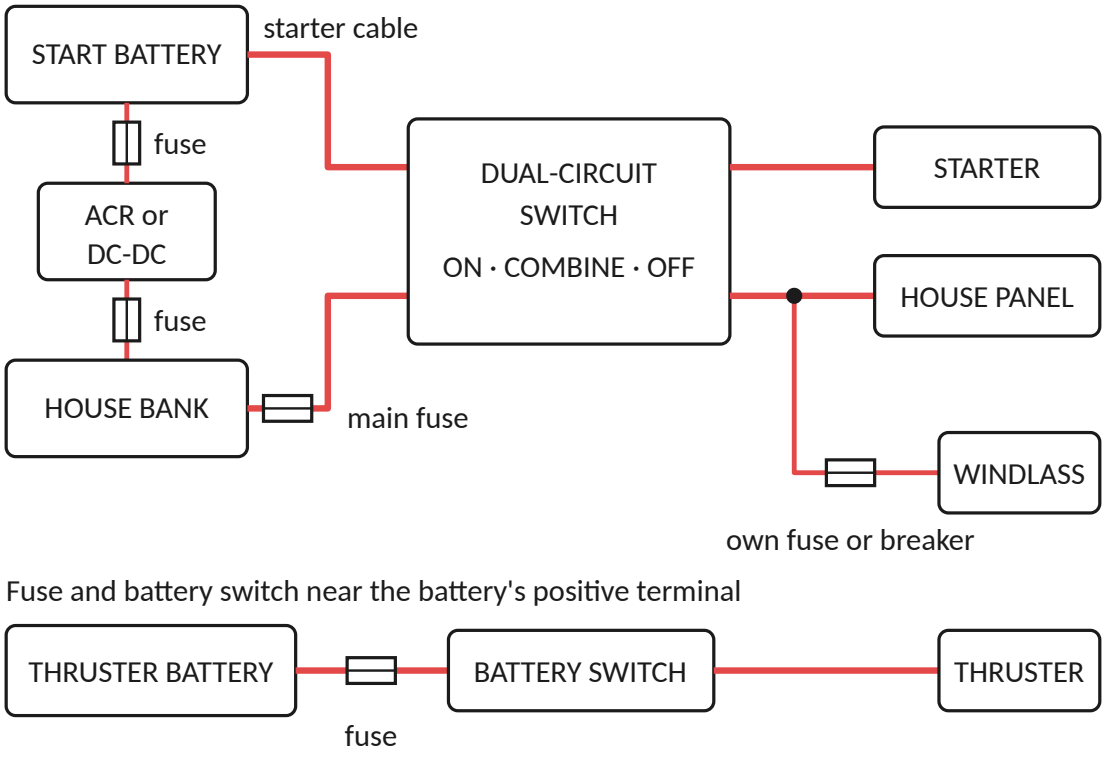


Fig. 8.5. A start battery and a house bank on a dual-circuit switch, with a charging relay or a DC-DC charger between them, fused at each battery; the windlass on the house side through its own fuse or breaker. Below, a thruster battery with its fuse and battery switch near its positive terminal. One typical arrangement: your boat can be wired differently.

Two house banks on a selector

A boat can carry two banks on a selector, each able to start the engine and run the loads. One selector maker's diagrams show the switch

position as the battery connected to the engine — 1, ALL or 2: in its twin-engine diagram either engine can be started by either battery, and in its diagram with a separate bank of lighting batteries both engines can charge that bank. On such a boat the working position is one bank, with the other kept in reserve for the next start; why BOTH is not a place to leave the switch is in → 8.5 · p. 28, and what an upgrade changes, in → 8.6 · p. 35. Where a charging relay also sits between the two banks, what it does to them is in → 8.3 · p. 14. MFR

A battery for a windlass or a thruster

In → Fig. 8.5 · p. 26 the windlass is fed from the house side of the switch, through its own fuse or breaker. A thruster can have a battery of its own. One thruster maker writes that a battery close to the thruster shortens its power cables, and that on large boats with bow and stern thrusters a dedicated battery for each thruster is worth considering; it asks for a fuse and a battery switch — its "main switch" — on the power cables, as close as possible to the battery's positive terminal, the switch easy to reach so that the thruster can be disconnected when nobody is on board or in an emergency. The same maker writes, for its on/off thruster models, that high-capacity lithium batteries can supply a higher operating voltage than those thrusters are rated for, and that running a thruster above its rated voltage reduces its operating time, increases wear and damages it. How such a battery is charged is your boat's own wiring — a charging relay, a DC-DC charger, or an output of the charger: trace it and write it into field 9. MFR

A trolling-motor bank

A 24 V or 36 V trolling-motor bank is a circuit of its own beside these layouts: it ties to the rest of the boat at one point, or at none where the motor's or the charger's manual keeps it apart, and never at two (→ 6.4, → 14.3).

8.5. Paralleling in an emergency

The start battery is too low to start the engine: how do you start on both banks, and why is BOTH the wrong place to leave the switch afterward? Joining two banks for a start is a short, deliberate act with a means its maker gives, and it ends the next time the engine is stopped, when the switch or the control that joined them is put back. Left joined, the same position turns two batteries into one, and the house loads then discharge both together.

A low start battery, or a dark panel

A start battery that is too low reads below its maker's 100 % row at rest (→ 3.5), with the panel and the house loads working, whatever the starter did — turned slowly, only clicked, or did nothing at all; where it cannot be rested now, a starter that turns slowly or only clicks points to it. Below that row a battery is not full, and that does not make it the cause: the same signs come from a poor connection in the starter circuit, the battery's own cables among them, from a part on the starter's control side, or from the starter itself (→ 9.5). The two procedures below test the start battery: where the engine cranks at its normal speed from the other bank, both banks or the jump pack and starts, the start battery or its own cables come next, by the route "The engine cranks slowly or only clicks" (→ 3.8) once the battery can be charged. A dark panel is another problem with another order: the card "The panel went dark — no lights, no electronics" (→ emergency card), never a joined position first.

Makers give their own means of joining two banks for a start, and one maker writes that two of its relays are no such means (→ Table 8.5 · p. 29). On a selector, the other bank alone comes first: one selector maker's twin-engine diagram has either engine started by either battery (→ 8.4 · p. 24). A switch that joins banks for a start carries the starter's current: the 2003 edition of ABYC E-11 asks a paralleling switch to be capable of carrying the largest cranking motor current; that clause stands among its rules for the cranking circuits of several inboard engines, and as a yardstick for any switch that joins banks for a

start it is accepted practice (→ 8.7 · p. 37). By that yardstick, a combiner rated 180 A for 5 seconds behind fuses of 120 A at most is not a means in this book's procedure: a fuse of the relay that opens on a starter's current ends the second bank's charge through the relay until someone finds it (→ 8.3 · p. 14). PRACTICE

Table 8.5. The makers' means of joining two banks for a start MFR

Means	What its maker writes	A means for a start
A selector at BOTH, ALL or 1+2	Its selectors put batteries in parallel for emergency starting when one or both batteries are substantially discharged	Yes
A dual-circuit switch at COMBINE	It combines the two banks in the event of a low start battery; that maker has its combine position used for an emergency start	Yes
An EMERGENCY PARALLEL switch	Only if both batteries need to be combined for an emergency start; a start on it leaves the house loads unprotected from engine spikes	Yes
A heavy-duty relay's remote control at ON	It combines the banks for hard starting; the relay allows paralleling for emergency starting, with a cranking rating of 1,450 A for 30 seconds	Yes
A combiner's start-assist terminal, or the switch its maker calls a parallel connect switch	The relay engages for 30 seconds after the terminal is momentarily connected to the battery positive, or while that switch stays closed; its cranking rating is 180 A for 5 seconds, and its fuses are sized no larger than 120 A	No, in this book's procedure
Two smaller relays of one maker	Not intended to carry starting currents; a switch's combine position does that	No

Procedure: Starting the engine on both banks

For an engine that will not start on its own start battery while the panel is lit, on a boat with one of the means of → Table 8.5 · p. 29. An inboard with a water-lift muffler that was cranked many times without starting, its raw-water seacock open: not this procedure — water may have reached a cylinder (→ 3.4), and a pro looks at the engine first. You need fields 4, 6 and 9 of the Boat Passport, which name each bank's

chemistry and the switch or the control that joins your banks, and the engine's manual. The entry of the HOT BATTERY sign says whether a lithium bank, or a bank whose chemistry you cannot tell, may be joined to a lead-acid bank (→ 11.3) — one lithium maker advises against an emergency parallel switch with its batteries and names a DC-DC charger in its place; where that entry does not allow the join, the procedure "A start with a jump pack", in this section, is the way.

PRACTICE









1. With the key off, look at the panel. Lit, the house loads working, and the starter turned slowly or only clicked — or did nothing at all, with the start battery's resting voltage below its maker's 100 % row (→ 3.5): continue. A dark panel, or you cannot tell: not this procedure — the card "The panel went dark — no lights, no electronics" (→ emergency card).
2. Find the means your boat has, in fields 6 and 9 or on the switch and the relay themselves (→ Table 8.5 · p. 29). A relay or a control that table marks "No" is no means. No means at all: the procedure "A start with a jump pack", in this section, or a pro.
3. Switch off the electronics on the house circuits at their own switches — the chartplotter, the radios, the stereo — except a radio you need for a call.
4. On a selector found on one bank, with the engine stopped, turn the battery switch to the other bank alone — through OFF where its dial allows; a dial that passes BOTH, ALL or 1+2 on the way joins the banks for that moment, as step 5 does. Start the engine the way its manual says; on an inboard with a water-lift muffler, the crank time and seacock of "How long to crank, and what a low battery stops" (→ 9.5) come with every try. It runs: step 7. It does not start on that bank either; a selector found at BOTH, ALL or 1+2; every other kind of switch: step 5.
5. With the engine stopped, join the banks with that means: turn the battery switch to BOTH, ALL or 1+2 on a selector, or to COMBINE

on a dual-circuit switch; or turn the EMERGENCY PARALLEL switch ON; or set the relay's remote control to ON.

6. Start the engine the way its manual says; on an inboard with a water-lift muffler, the crank time and seacock of step 4 come with every try. It runs: step 7. It does not start on both banks either: the cause can be elsewhere — the starter circuit (→ 9.5), or both batteries low; with the engine stopped, the switches go back as step 8 says, and the procedure "A start with a jump pack" or a pro comes next.
7. While the engine runs, leave every switch and control as it is (→ 1.7). The electronics you switched off go back on at their own switches.
8. The next time the engine is stopped, put the switches back: a selector to the position you found it in — where you found it at BOTH, ALL or 1+2, to one bank alone, the other kept for the next start; a dual-circuit switch from COMBINE to ON; the EMERGENCY PARALLEL switch OFF; the relay's remote control to the position you found it in — at AUTO, the relay then joins and parts by its own settings (→ 8.3 · p. 14).
9. Before the next start, find out why the start battery was low: a draw with everything off, or a switch left joined overnight (→ 7.3); a charge that never reached it (→ 8.3 · p. 14, → 9.1, → 9.2); or the battery itself (→ 6.6).

PUT THE BOAT BACK IN SERVICE

- With the engine stopped, every switch and control as step 8 left it.
- The electronics you switched off, back on as you found them.
- The CO alarm: the entry of the CARBON MONOXIDE sign says how you see that it is working again.
- Check that the bilge pump's automatic switch has power, by the procedure "The check that the automatic switch has power" (→ 12.2).

Procedure: A start with a jump pack

For a start battery too low to start the engine — the starter turned slowly or only clicked, or did nothing at all with the start battery's resting voltage below its maker's 100 % row (→ 3.5) — with a jump pack and its manual: on any boat, and this section's way where the banks cannot be joined — no means its maker gives, a join the entry of the HOT BATTERY sign does not allow, or both banks low. An inboard with a water-lift muffler that was cranked many times without starting, its raw-water seacock open: not this procedure — water may have reached a cylinder (→ 3.4), and a pro looks at the engine first. The panel is lit — or the card "The panel went dark — no lights, no electronics" (→ emergency card) has found the battery switch, the main panel breaker and the main protection intact and the start battery discharged; any other dark panel is that card first. You need the pack, charged as its manual says, and its manual.



1. With the key off, open the jump pack's manual at its jump-start pages: the battery types it names, the order of its clamps, and the places it gives for the black clamp. Find the start battery's terminals and that place on your boat. Where the entry of the MOVING PARTS sign rules the pack out for your start battery, or where the pack's leads do not reach the black clamp's place: not this procedure — a pro, or a tow.
2. Connect the jump pack's clamps in the order its manual gives: the red clamp on the start battery's positive terminal; the black clamp on its negative terminal where the pack's manual allows that, otherwise at the place the entry of the MOVING PARTS sign names.
3. Start the engine with the jump pack as its manual says, with its wait before the start where it gives one; on an inboard with a water-lift muffler, the crank time and seacock of "How long to crank, and what a low battery stops" (→ 9.5) come with every try.
4. The engine runs: disconnect the jump pack's clamps in the order its manual gives. It does not start within the pack's limits:

disconnect the clamps the same way; the cause can be elsewhere (→ 9.5).

5. Find out why the start battery was low, as in step 9 of the procedure "Starting the engine on both banks".

PUT THE BOAT BACK IN SERVICE

- The jump pack recharged as its manual says, and stowed.
- Whether the start battery now takes a charge depends on where the alternator lands and on the unit between the banks (fields 8 and 9): with the engine running, its monitor or its voltage, read as → 8.3 · p. 14 says, shows it, and the route "The second bank does not charge" finds why not; once it is full, its condition is checked by → 6.6.

NUMBERS · TWO JUMP PACKS

Two packs' makers give different limits. One writes that some vehicles need the pack connected for up to 30 seconds before the start, gives a wait of 20 to 30 seconds before the next try and no more than five starts in a row within 15 minutes, and names 12 V lead-acid batteries only; the other has the engine crank for no more than 5 to 8 seconds, then a wait of at least one minute, and no more than three tries in a row. MFR Your own pack's manual gives yours.

Why BOTH left on after the engine stops is a trap

Under way, with the engine running, two banks joined at BOTH both take the alternator's charge, and nothing is lost while the engine runs. The trap closes when the engine stops and the switch stays joined: the night's house loads draw from both batteries at once, as from one battery, and by morning both can be too low to start the engine (→ Fig. 8.6 · p. 34). The dual-circuit switch was designed for this: its maker writes that people forget to reset their battery switches every time they stop or start their engines, or forget how to set the switch, and that the design reduces the chance of discharging both batteries. MFR

Two more things happen on a joined switch. A failing battery joined to a healthy one takes current from it, and the healthy battery is discharged with it. And a start on a joined position puts the engine's start- PRACTICE

up spikes on the house circuits, which one maker's separate switches keep away from the house loads (→ 8.4 · p. 24).

So one bank carries the boat through the night, and the other waits for the morning's start. A charging relay joins them while a charge goes in, and parts them only once their voltage has stayed below its open setting for its delay — or not at all while its control holds it closed (→ 8.3 · p. 14). Far from help, the same applies every night (→ 7.8).

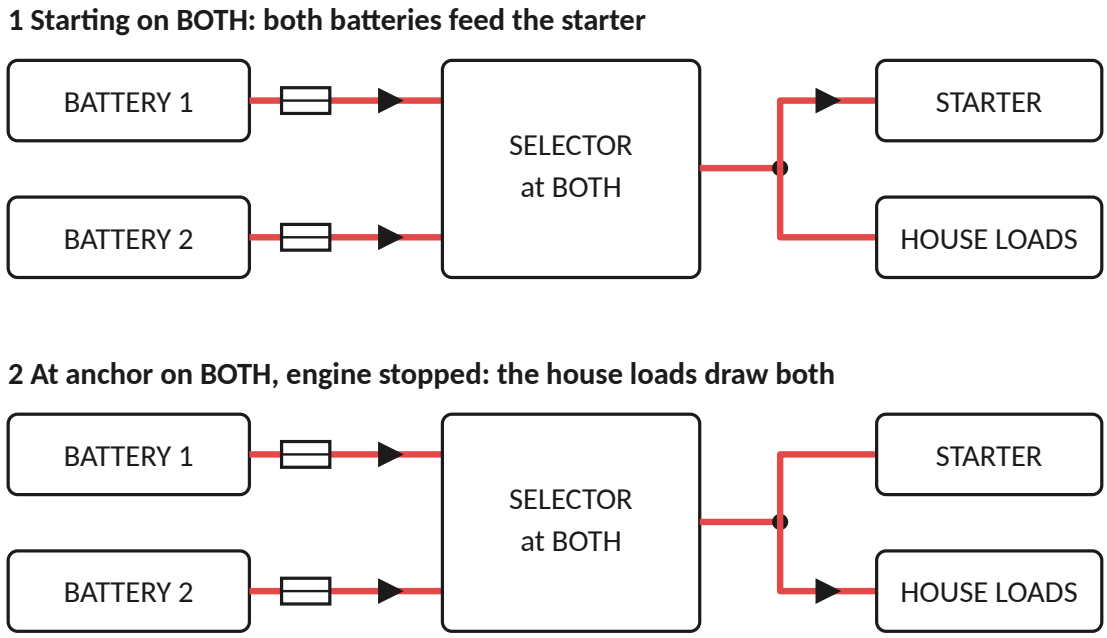


Fig. 8.6. The same selector at BOTH, twice. At the start (1), both batteries feed the starter: the point of joining them. At anchor with the engine stopped (2), the house loads draw from both batteries at once, and by morning both can be too low to start the engine.

WHY IT WORKS

Joined, two batteries settle at one voltage and share every load by their own internal resistances: neither can be discharged without the other. A low battery joined to a charged one takes current from it until their voltages meet, which is what a start on both banks uses, and why the low battery is on charge from that moment. A battery with a shorted cell never reaches the other's voltage, so the healthy battery keeps feeding it. Where the explanation stops working: a lithium house bank rests at a higher voltage than a lead-acid battery and can push a large current into a low one the moment they are joined, and its BMS can disconnect the whole house bank on that current or on the starter's — the bilge pump's automatic switch, the high-water alarm and the CO alarm with it, where that bank feeds them (→ 11.4). That is why the lithium battery's own maker decides.

8.6. Upgrading an old 1-2-BOTH layout

What does an upgrade of an old selector layout change, in what order, and which part of it is yours? The old layout puts two banks on a 1-2-BOTH selector, with the alternator's output landed in one of the places of → Fig. 8.3 · p. 8. Which bank is charged, which one starts the engine, and whether both end the night flat are decided each time by the hand on the knob (→ 8.5 · p. 28). In an upgraded layout the switch and the unit between the banks make those decisions: the start battery stays on its own, and the unit charges both banks.

What the upgraded layouts look like

Two makers' arrangements are the usual targets, and both are in → 8.4 · p. 24: a dual-circuit switch with a charging relay at both batteries' positives (→ Fig. 8.5 · p. 26), or an ON/OFF switch on each bank with a voltage-sensitive relay and an EMERGENCY PARALLEL switch. The maker of the first writes that its switch handles two banks with one ON/OFF knob while it keeps them isolated, to reduce the risk of a dead start battery; that the way the alternator is wired does not affect where its relay goes; and that an alternator connected to the larger bank is the

most efficient. A DC-DC charger takes the relay's place where the house bank needs a controlled charge — a lithium house bank (→ 11.3), or an outboard whose manual limits what its charging output is allowed to charge (→ 9.1). MFR

The order of the work, and who does each step, follow from where the work is: the new switch's battery-side connections, the relay or the DC-DC charger at the batteries, and every new cable and lug sit on terminals and studs that stay live with every battery switch OFF (→ Table 8.6 · p. 36).

Table 8.6. An upgrade in order, and who does each step

Step	What it changes or records	Who
1. Your layout written down	Fields 4, 6, 8 (where the alternator lands), 9, 10 and 11 of the Boat Passport, by the procedure "What each battery switch connects" (→ 8.1) and Stop 7 of → 2.1	You
2. The target chosen	The switch and the unit between the banks, by the house bank's chemistry, the engine and its manual (→ 8.3, → 9.1, → 11.3)	You, with a pro
3. The new parts installed	The switch; the relay or the DC-DC charger with its own fuse at each battery; the cables, their lugs and the labels on every switch position	A pro (→ 1.8)
4. The work accepted	The checks of "What to tell the pro" (→ 8.8)	You
5. The new layout recorded	Field 16 of the Boat Passport, and the fields of step 1	You

A battery changed during an upgrade is the planned job on a battery of → 6.5, or a pro's where that procedure says so.

LOOKS LIKE THE FIX	FIND OUT FIRST	WHAT FIXES IT
An add-a-battery kit — a dual-circuit switch and a charging relay — for a start battery that keeps going flat.	Why it goes flat: a switch left at BOTH (→ 8.5), a draw with everything off (→ 7.3), a charge that never reaches it (→ 8.3), or	The cause found first; then the layout that fits the boat, installed by a pro and accepted by its checks. A kit takes away the risk of

	the battery itself (→ 6.6). Where the alternator lands (→ 8.1). The house bank's chemistry: a lithium house bank needs a controlled charge (→ 11.3). On an outboard, what its manual lets its charging output charge (→ 9.1).	a switch forgotten at BOTH; it does not fix a draw or a worn battery.

8.7. Marine-grade or not? Household disconnect, automotive battery cut-off

A disconnect from a hardware store or a truck parts store costs less and looks as solid as a marine switch. Can it be the battery switch on your boat? The question is not "automotive or marine". It is four properties of the part, each printed on it or given in its maker's data, and a switch is right only when it passes all four.

- ☐ A DC voltage rating not less than your system voltage. PRACTICE
- ☐ A continuous rating not less than the total of the ampacities of the main protection connected to the switch, or the ampacity of the feeder cable to the switch, whichever is less; and an intermittent rating not less than the largest cranking current of the starter it serves. ABYC
- ☐ In a compartment with a gasoline engine, a gasoline tank or the joints of a gasoline fuel system: an ignition-protection marking, or its maker's statement (→ 4.6).
- ☐ Mounted where you reach it quickly and safely without tools, as close as practicable to the battery. ABYC

The two ratings and the mounting come from the 2003 edition of ABYC E-11; the cranking current is the starter's, from the engine's maker. A rating means something only with its time, and only like compares with

like: the continuous rating with the current that flows for hours, an intermittent or cranking rating with the starter's current for its seconds (→ Table 8.7 · p. 38). A rating printed with no time compares with neither. A parallel switch used for a start carries the starter's current too (→ 8.5 · p. 28).

In a compartment with a gasoline engine, a gasoline tank or fuel fittings, a battery switch is an electrical component like any other. 33 CFR 183.410 asks for ignition protection there on the boats in its scope, unless the component is isolated from gasoline fuel sources as that section describes (→ 4.6). CFR

The 2003 edition of ABYC E-11 asks for it in every space that contains gasoline-powered machinery, a gasoline tank or joint fittings of a gasoline system — the closed tank compartment of an outboard boat included — unless the component is isolated from a gasoline fuel source. A charging relay or a DC-DC charger in such a compartment needs the same: one maker's data state that its relay is ignition protected, and a page that names no ignition protection tells you nothing either way. ABYC

Table 8.7. What four switches' data say MFR

Switch	Voltage rating	Current ratings, each with its time	Ignition protection
Marine selector, maker 1	6 to 32 V	250 A continuous; 360 A intermittent for 5 minutes	Its maker's data: "Ignition Protected"
Marine dual-circuit switch, maker 2	32 V DC maximum	350 A continuous; 525 A intermittent for 5 minutes; 700 A for 30 seconds, each circuit	"Ignition protected", for boats with gasoline engines
Vehicle battery disconnect, maker 3	36 V DC	300 A; a "maximum input current" of 2,000 A with no time given	None named in its data sheet
Household AC disconnect, maker 4	120/240 V; no DC rating stated	60 A	None named

WORKED EXAMPLE: IS THIS SWITCH ENOUGH FOR YOUR ENGINE?

Suppose your engine's maker gives a cranking current of 450 A for its starter, the main protection connected to the battery switch totals 200 A, and the feeder cable to the switch has an ampacity of 170 A. The switch needs a continuous rating of at least 170 A, the smaller of the two, and an intermittent rating of at least 450 A. Maker 1's selector of → Table 8.7: 250 A continuous passes, 360 A intermittent does not. Maker 2's switch: 350 A continuous and 525 A intermittent both pass. The vehicle disconnect: its 300 A comes with no time, so its data give neither a continuous rating to compare with 170 A nor an intermittent one to compare with 450 A, and no ignition protection. The household disconnect: no DC rating at all.

MARINE-GRADE OR NOT? · HOUSEHOLD DISCONNECT

An AC disconnect for an air conditioner. One maker's model is rated 120/240 V and 60 A and is UL listed; its data name no DC rating and no ignition protection. A DC circuit never passes through zero the way AC does, and a switch built for AC has to stop a DC arc it was not rated for (→ 4.7). With no DC rating in its maker's data, it cannot pass the first property of this section. MFR

Verdict: No DC rating

MARINE-GRADE OR NOT? · VEHICLE BATTERY CUT-OFF

A battery disconnect for trucks and buses. One maker's single-pole disconnect is rated 300 A and 36 V DC, for heavy-duty trucks, construction, emergency vehicles, buses and agriculture; its data sheet names no ignition protection and gives no intermittent or cranking rating with a time. Its DC rating passes; its 300 A, printed with no time, cannot be compared with your feeder or your starter until its maker gives the times, and without an ignition-protection marking it stays out of a compartment with a gasoline engine or tank. MFR

Verdict: Only with full data

8.8. On board

What each switch on your boat joins, and what it leaves live, is something you can read and write down. 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 changes on an older boat and on someone else's.

ON BOARD: GOLDEN RULE

Know what each switch joins and what it leaves live before you turn it: every battery switch and its working position, every circuit wired around it, where the alternator lands, and the unit between your banks, written in your Boat Passport. Join two banks only on purpose, with a means its maker gives, and part them again the next time the engine is stopped: while they are joined, they are one battery.

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 8.8. What it means

What you notice	What is happening	First check	Yourself or a pro
Every battery switch is OFF, and the stereo's clock, a charger's display or the bilge pump still works	Those circuits are wired around the switch	Stop 7 of → 2.1; Table 8.2 (→ 8.2)	**Do it yourself**
The bilge pump does not start by itself with the battery switch OFF	Its automatic switch is wired after the battery switch, or the pump's circuit has a fault	The check that the automatic switch has power (→ 12.2)	**Do it yourself, if... you can do that procedure, with its signs; moving the circuit: Hire a pro**

What you notice	What is happening	First check	Yourself or a pro
You do not know which bank a switch position connects	Cables not traced	The procedure "What each battery switch connects" (→ 8.1)	**Do it yourself, if... you can do that procedure, with its signs**
The relay's light stays on after the engine has stopped	A charge still going in on either bank — a charger, solar or wind; the banks resting above its open setting; its control holding it closed; or its contacts welded. A light that flashes means what its manual says — on one maker's relay, a lockout, with the relay open	The charging sources on either bank (→ 1.7); Table 8.4; its control's position; "When a relay keeps the banks apart" (→ 8.3)	**Do it yourself**
The house bank never gets full from the engine	A diode isolator's drop, a relay that does not join, a DC-DC charger that does not run, or a charge too short	The route "The second bank does not charge" (→ 8.3)	**Do it yourself, if... you can do that route, with its signs; a reading at the isolator: Hire a pro**
The start battery is flat after a night at anchor	A switch left joined overnight, a draw, a charge that never reached it, or a battery that has lost capacity	Fields 6 and 9; → 8.5; the route "The battery is dead in the morning" (→ 7.3)	**Do it yourself, if... you can do its procedures, with their signs**
The starter turns slowly or clicks, and the panel is lit	A low start battery, a poor connection in the starter circuit, or the starter itself	The procedure "Starting the engine on both banks" (→ 8.5); the starter circuit (→ 9.5)	**Do it yourself, if... you can do that procedure, with its signs**
Everything went dark	A dark panel has its own order	The card "The panel went dark — no lights, no electronics" (→ emergency card)	**The card**

What you notice	What is happening	First check	Yourself or a pro
A battery switch or its terminal is warm after a start or a long run	A connection or a contact with too much resistance, or a switch rated below its current	The route "A connection, a holder or a wire runs hot" (→ 4.8); the switch's ratings (→ 8.7)	**Do it yourself, if... you can do that route, with its signs; a wrench on the switch's battery-side terminal: Hire a pro**
The battery switch in a gasoline engine space has no ignition-protection marking	A part that can spark in gasoline vapor	Its marking and its maker's data (→ 8.7, → 4.6)	**Hire a pro**

IF YOUR BOAT IS 20 TO 40 YEARS OLD

1. **Check first:** a 1-2-BOTH selector, and where the alternator's output lands; on the selector's engine terminal, the switch stands between the alternator and every battery (→ 8.1).
2. **Replace first if you find it:** a battery switch with no ignition-protection marking in a compartment with a gasoline engine or tank (→ 8.7); a positive that leaves a bank with no fuse of its own at the battery — the starter cable, traced to the starter, is the one exception (→ 4.2). Both are a pro's work.
3. **What may be missing, and how you can tell:** a fuse at the battery on a relay's or a charger's leads — none in sight at the battery positive; labels on the switch positions — worn off the face; the alternator's setting made up for a diode isolator's drop — a house bank that never reaches a full charge from the engine (→ 8.3).

ON SOMEONE ELSE'S BOAT

1. **Find:** every battery switch and its positions, a parallel switch, and the unit between the banks by its label.
2. **Check:** the working position of each switch, as the base or the owner gives it, written down before anything changes (→ 2.6).

3. **Don't touch:** fuses, the relay's own included, wires or terminals. BOTH, ALL, 1+2 or COMBINE, a parallel switch ON and a relay's combine control only with the base's permission; with the panel dark, the card "The panel went dark — no lights, no electronics" comes first.
4. **What to tell the base or the owner:** which switch is in which position, what the panel and the monitor show, and what you changed.

Do it yourself or hire a pro

DO IT YOURSELF OR HIRE A PRO · SWITCHES, RELAYS AND TWO BANKS

STOP ·  **HOT BATTERY** A battery that turns hot, swells, hisses or smells while the banks are joined or while it charges; a panel that went dark.
What to do this minute: The card "Battery smells, is swollen, or is hot" (→ emergency card); for a dark panel, the card "The panel went dark — no lights, no electronics" (→ emergency card).

HIRE A PRO · A wrench on a battery switch's battery-side terminal, or on a stud of a relay, a diode isolator or a DC-DC charger that stays live with every battery switch OFF, as the entry of the SHORT CIRCUIT sign names them; every new battery cable, lug or fuse holder at the battery (→ 1.8); a relay's fuse held under a nut on a stud; the upgrade of → 8.6 · p. 35; a circuit moved from after the switch to around it; a reading in the engine space with the engine running (→ 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, the switches stay as you use the boat, and for the night one bank alone carries it, the other kept for the start (→ 8.5 · p. 28).

When a pro may do it differently: A pro may land the alternator, the relay or the charger outputs differently from → Fig. 8.5 · p. 26 where the engine's or the unit's manual asks for it. You see it in the labels, and in the Boat Passport the pro updates.

DO IT YOURSELF, IF…

- The procedures of this chapter, each with the signs at its start: "What each battery switch connects" (→ 8.1 · p. 2), the route "The second bank does not charge" (→ 8.3 · p. 14), "Starting the engine on both banks" and "A start with a jump pack" (→ 8.5 · p. 28).
- **SHORT CIRCUIT** **GASOLINE VAPOR** A relay's own fuse at one of the banks, where it sits in a holder that opens by hand — then you can take it out and put it back, by → 8.3 · p. 14.
- **SHORT CIRCUIT** **PROVE IT DEAD** A wrench on a negative connection — a relay's thin negative wire, a DC-DC charger's DC negative terminal — or work on a wire or a lug after the battery switch, its load-side terminal included: by the entries of these signs (→ 1.8).

DO IT YOURSELF · Reading the positions, the labels, the LEDs and the battery monitor; following cables by eye; writing the Boat Passport.

On someone else's boat there are three levels, not four: switches and buttons — yes; tools — no; the gray zone — only with the permission of the charter base or the owner, by phone (→ 2.6). There you turn a battery switch only to the position the base gives, leave a relay's fuse where it is, and tell the base or the owner what you saw.

What to tell the pro

WHAT TO TELL THE PRO

For an upgrade, ask for this: "Replace the 1-2-BOTH selector with a dual-circuit switch and a charging relay" — or the layout you chose — "connect the relay at both battery positives, each through its own fuse at the battery, label every switch position, and tell me where the alternator's output lands when you are done." For a second bank that does not charge: "The unit between the banks is this one; with the first bank in its join range for its delay, the second bank's monitor showed no charge going in, and its fuses looked whole. Find why, and write down what you measured." Accept the work by five checks. Every switch position is labeled, and the procedure "What each battery switch connects" (→ 8.1) gives the result the pro described. The new switch's

data show a continuous and an intermittent rating that pass the checks of → 8.7. Every new switch, relay or DC-DC charger in a space with a gasoline engine, a gasoline tank or the joints of a gasoline fuel system shows an ignition-protection marking or its maker's statement (→ 8.7). Every new positive that leaves a bank has its own fuse at the battery, except the starter cable, identified by tracing it to the starter, not by its size; the cables that join the batteries of one bank are part of the bank, and the alternator's output is as → 4.2 says. With a charge going into the first bank from the engine and no other charging source on the second bank, the second bank's monitor, or its voltage read as → 8.3 says, shows a charge going in. Then the Boat Passport (fields 6, 8, 9 and 16) is updated the same day.

REMEMBER

- A battery switch cuts only what is wired after it, and its battery side stays live; which cable runs through it, you see on its studs.
- BOTH, ALL, 1+2, COMBINE and a parallel switch ON join the banks; ON on a dual-circuit switch keeps them apart.
- Where the alternator's output lands decides which battery stays on it when a switch turns; it is found by tracing, never by assuming.
- What can be wired around a switch is a list of permissions; what is wired around yours is in your Boat Passport.
- A charging relay joins the banks while it is closed and can stay closed with nothing charging; its maker's hold-open position keeps them apart unless its contacts have welded, and its own fuse out at one bank keeps them apart whatever the contacts do. Two banks reading the same voltage are not shown to be apart.
- A diode isolator never joins the banks and costs voltage; a DC-DC charger does not join them as a relay does, and runs on its maker's conditions, some with the engine off.

- Banks are joined for a start with a means their maker gives — on a selector, after the other bank alone has been tried — and parted again the next time the engine is stopped; left joined for the night, they go flat together.
- A switch is marine-grade by its data: a DC voltage rating, a continuous and an intermittent rating for your boat, and, in a gasoline space, an ignition-protection marking or its maker's statement.

Self-check

1. **Before you measure.** Suppose your alternator's output lands on the engine terminal of a selector (landing 2 of → Fig. 8.3 · p. 8), and the selector is at 1. Which battery does the running alternator charge, and what would the switch at OFF do to it?
   Answer: battery 1, through the switch. At OFF the alternator would lose every battery at once — a load dump, which can destroy its diodes. With the alternator landed at a battery instead, that battery would stay on it (→ 8.1 · p. 2).
2. **Four relays.** Suppose two full banks rest at 12.9 V after a day's charge, with nothing on. Which relays of → Table 8.4 · p. 16 keep them joined?
   Answer: all of them. Each parts the banks only below its open setting — 12.75 V, 12.8 V — and 12.9 V is above every one; the relay with no LED gives no sign of it either (→ 8.3 · p. 14).
3. **A relay's day.** Suppose a relay that draws 0.175 A while joined stays joined 10 hours a day, and draws 0.015 A open for the other 14. How many amp-hours does it take in a day?
   Answer: 0.175 × 10 = 1.75 Ah, and 0.015 × 14 = 0.21 Ah: 1.96 Ah in all (→ 8.3 · p. 14).
4. **On your boat.** Fill in field 6 of the Boat Passport by the procedure "What each battery switch connects" (→ 8.1 · p. 2): each switch, its positions as printed, the bank each position connects, and the working position; then field 8, where the alternator lands.
   Answer: each position names one bank, or "joins the banks"; a cable or a landing you could not follow by eye stays in field 15, in words, for a pro to trace on the next visit.

5. **On your boat.** Read the label of the unit between your banks and write into field 9 what it is, its thresholds or its run signal, whether it has a hold-open control or an LED, and the holder of its fuse at each bank.

   Answer: compare with → Table 8.3 · p. 15 and → Table 8.4 · p. 16. A relay with no hold-open position and no fuse in a holder that opens by hand gives you no means of your own to keep the banks apart; at its hold-open position, a relay whose contacts have welded still joins them (→ 8.3 · p. 14).

6. **On your boat.** From field 10 of your Boat Passport, list what is wired around your battery switch, and check each line against → Table 8.2 · p. 12.

   Answer: every circuit on the list has its own fuse at the battery, or it goes on the first line of the passport (→ 8.2 · p. 11); the line "CO alarm: what feeds it" names one of the answers the passport gives for it, and "after the switch" only for an alarm that sounded on its test with the switch ON and was dark with every switch OFF.

Terms

battery switch
The switch in the positive cable between a battery bank and the boat's loads; with the engine stopped, OFF removes current only from the circuits after it.

working position
The position a battery switch stays in while you use the boat.

make-before-break switch
A switch that connects the new bank before it disconnects the old one.

dual-circuit battery switch
A battery switch that at ON connects each of two banks to its own circuit — the start battery to the start circuit, the house bank to the house circuits — and, on a model with COMBINE, joins both banks to both circuits.

parallel switch
A separate switch that joins the positives of two banks while it is ON.

emergency parallel (combine)
Joining two banks on purpose to start the engine from both when the start battery is too low — a selector at BOTH, ALL or 1+2, a dual-circuit switch at COMBINE, a parallel switch ON, or a charging relay's own combine control.

circuit wired around the battery switch
A circuit connected on the battery side of the switch, so it stays live in every switch position; it needs its own fuse at the battery.

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

AFD (alternator field disconnect)
An extra contact on some battery switches that opens the alternator's field circuit slightly before the main contacts open.

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

hold-open position
The position of a charging relay's own control that its maker gives for holding the relay open.

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

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

jump pack
A portable battery with clamps that starts an engine from its own charge.

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

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