BATTERY BENCH BLUEPRINT

Building a Century-Cell Lead-Acid Storage System
From Materials You Can Salvage and a Recipe
Refined Across Two Generations of Amish Craft

A free companion document to the video
This $5 Amish "Century-Battery" Beats $10K Lithium

FOR EDUCATIONAL USE ONLY
Sulfuric acid and molten lead are hazardous.
Read the Safety section before building anything.

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1. How to Use This Blueprint

This blueprint is a technical companion to the video on the Amish century-cell lead-acid bench. It is not a substitute for the engineering literature listed in Section 11, and it is not a substitute for the apprenticeship tradition that has refined this technology in plain communities across Pennsylvania, Ohio, and Indiana for three generations.

What this blueprint provides is the consolidated specifications drawn from the video — alloy ratios, cure times, hydrometer protocols, wiring layout — in a format you can hold open on a workbench while you build. Every number in this document can be cross-referenced against the published lead-acid chemistry literature cited in Section 11.

If you have never cast metal, never handled sulfuric acid, never wired a low-voltage DC system, do not start with a full twelve-cell bank. Build one cell first. Live with it. Cycle it. Read its hydrometer for a month. Only then expand.

2. Safety First — Read This Before You Build

Three categories of hazard are present in this build. Each has a non-negotiable minimum standard of personal protective equipment.

Sulfuric acid (battery electrolyte)

Use acid-resistant nitrile or neoprene gloves rated to 98% H_2SO_4. Wear a full face shield, not just safety glasses. Work in a well-ventilated outdoor area or under a fume hood. Keep a five-gallon bucket of baking soda and water solution within arm's reach for neutralization of spills. Never add water to concentrated acid. Always add acid to water, slowly, and stir.

Molten lead and lead oxide dust

Wear a respirator rated N100 or P100 for lead particulates. Use a heavy leather apron and gauntlets. Melt lead outdoors only, never near food preparation areas, never indoors. Lead absorbed through inhalation or ingestion accumulates in the bone and nervous system. Wash hands and face thoroughly before eating or touching your face. Children and pregnant women must not be present during melting operations.

Electrical hazards during charging

A 24-volt bank delivering 240 amp-hours can produce short-circuit currents in the thousands of amps. A dropped wrench across the bus bar will weld itself to the terminals and spray molten copper. Always work on the bank with at least one terminal disconnected. Remove all jewelry, watches, and metal rings before approaching the bus bar. Keep a Class C fire extinguisher rated for electrical fires nearby.

If you are not confident performing any of the above safely, find a local experienced lead-acid restorer or a community college metalworking instructor before attempting a full build.

3. Materials and Tools List with 2026 Prices

The following is a complete bill of materials for one twelve-cell, twenty-four-volt, 240 amp-hour bank — equivalent to the bench documented in the video. Prices are approximate United States figures as of 2026.

Per-cell materials (one of twelve)

Item	Specification	Approx. Price
Glass mason jar	Half-gallon, wide-mouth, borosilicate	$3.50
Lead alloy (plates)	~2 kg salvaged wheel weights + type-metal	Free / $5
Red lead oxide	Pb_3O_4, 200 g for active paste	Skim from melt / $8
Sulfuric acid	30% H_2SO_4, ~600 ml per cell	$2.00
Cedar separators	Eastern red cedar, 1.5mm thick, hardware grade	Free from offcuts
Glass fiber insulation	Borosilicate, ~30 g per cell as backup separator	$0.50
Distilled water	For electrolyte mix and ongoing top-up	$1.00 per gallon
Copper terminal posts	1/4-inch lead-coated copper studs	$1.20 per pair

Per-cell rough total in 2026 dollars: approximately $12 to $20 depending on how much material is salvaged versus purchased new. A full twelve-cell bank lands between $150 and $250 in materials, with tools amortized across many future builds.

Required tools (one-time purchase)

Tool	Purpose	Approx. Price
Cast iron melting pot	Lead melting, 8 lb minimum capacity	$35
Propane burner ring	Outdoor casting, 50,000 BTU	$45
Wooden plate molds	Hand-carved or purchased grid molds	$20 (DIY)
Hydrometer	Battery-grade, range 1.100 to 1.300 sp.gr.	$15
Digital multimeter	DC voltage and current measurement	$30
DC charge controller	Adjustable voltage, 24V, 30A min	$80

Tool	Purpose	Approx. Price
Respirator (N100/P100)	Lead dust filtration	$40
Face shield + gloves	Acid and thermal protection	$50

4. Method One — The Lead-Antimony Alloy

The single decision that determines whether your bench lasts five years or fifty is the alloy of the grid. Lead-antimony at four to six percent antimony by weight is the chemistry that powered every Bell System telephone central office for half a century. It is also the chemistry the consumer battery industry walked away from in 1971.

Target alloy composition

Element	Target %	Acceptable Range	Function
Lead (Pb)	94-96%	Balance	Base metal, primary conductor
Antimony (Sb)	4-6%	3.5-7.0%	Grid hardening, anti-shedding
Tin (Sn)	0.3-0.5%	0.2-0.8%	Castability, fluidity in mold
Arsenic (As)	0.1-0.2%	<0.3%	Grain refinement

Sourcing the alloy from salvage

Pre-2011 American wheel weights (manufactured before the EPA leaded-ballast phaseout) typically run 2-4% antimony, with trace tin. Used alone, this is below the Bell System target. To bring the antimony content up to the 4-6% range, blend with traditional printer's type-metal (which contains approximately 12-25% antimony) at a ratio of roughly four parts wheel weight to one part type-metal. Always verify the final melt with a small test cast and visual inspection before pouring the full plate set.

Casting temperature and procedure

Bring the cast-iron pot to 650°F (343°C), measured with an infrared thermometer or a high-temperature thermocouple. Lower temperatures produce incomplete fills in the grid mold; higher temperatures produce excess oxidation and grid porosity. Skim the dross — the dark oxidized layer on top of the melt — and reserve it. It is the red lead oxide you will use for the active paste. Pour into preheated wooden molds packed with compacted foundry sand. Let cool slowly, in air, for forty-five minutes before demolding.

Maintenance-free is not a feature. It is a business model.

5. Method Two — The Cedar Wood Separator

Every commercial lead-acid battery built between 1859 and the end of the Second World War used wood separators. The reason was not nostalgic. It was biochemical. Wood in sulfuric acid slowly releases lignosulfonates, which adsorb onto forming lead sulfate crystals during discharge, forcing the sulfate to crystallize in fine, easily reversible grains rather than the dense glass-like deposits that permanently kill a modern sealed battery.

Wood selection

Species	Lignin %	Suitability	Notes
Eastern red cedar	~32%	Excellent	Traditional Bell System choice; high lignin yield, acid-stable
Northern white cedar	~30%	Very good	Slightly softer; replace every 25-30 years
Port Orford cedar	~31%	Very good	West Coast alternative if eastern is unavailable
Douglas fir	~28%	Acceptable	Lower lignin yield, requires more frequent refresh
Pine (any)	~26%	Avoid	Resin content interferes with electrolyte chemistry
Treated lumber	N/A	Never use	Chemical preservatives are toxic in acid

Preparation procedure

Cut strips to 1.5 mm thick, slightly larger than your plate dimensions in both height and width to allow trimming. Soak in distilled water for forty-eight hours, changing the water every twelve hours to leach out free tannins and resins. Air dry for twelve hours before insertion. The wood should be flexible, slightly damp, and noticeably lighter in color than the dry stock. Slot one separator between every adjacent pair of plates in the cell — for a typical seven-plate cell, this means six separators per cell.

Service life and refresh schedule

Cedar separators release their available lignin at a rate measurable in micrograms per cycle. In practical terms, a well-built cedar separator will continue to dose the electrolyte with expander compounds for thirty to fifty years. When the bank shows gradual capacity loss across multiple cells with no other identifiable cause, add fresh cedar strips alongside the old. Do not remove the original wood — it is still doing structural work as a plate spacer.

6. Method Three — The Maintenance Routine

A century-cell is not a sealed appliance. It is a relationship. Three scheduled interventions, performed consistently across decades, are what separate a bench that runs for fifty years from one that fails in five.

Monthly: hydrometer reading

Once per month, on the same day of the month if possible, draw a sample from each cell in rotation with a battery-grade hydrometer. Record the specific gravity in a permanent logbook with date, ambient temperature, and approximate state of charge. Healthy cells should read 1.265 ± 0.010 at full charge, dropping no lower than 1.150 at 50% discharge. A cell drifting more than 0.030 below the others should be flagged for further investigation but not yet replaced.

Monthly: distilled water top-up

After the hydrometer reading, inspect electrolyte levels. The fluid should cover the tops of the plates by approximately 1 cm. Top up only with distilled water — never tap water, never rainwater collected from a roof. Chlorine and dissolved minerals in non-distilled water poison the negative plate over years of accumulation. Typical loss is 50-100 ml per cell per month under regular cycling.

Annual: equalization charge

Once per year, in late autumn when the charging source is running strong and the bank is at full conventional charge, perform a controlled overvoltage equalization. Raise the per-cell charging voltage to 2.45 V (58.8 V for a 24-cell bank, 29.4 V for a 12-cell bank). Hold this voltage for four hours. The cells will bubble vigorously and produce hydrogen and oxygen gas — perform this only in a well-ventilated space with no ignition sources. The bubbling mixes the electrolyte and dissolves soft sulfation that has accumulated along the lower portions of the plates over the year. After the four hours, return the charge voltage to normal float (2.25 V per cell) and let the bank stabilize for twenty-four hours before drawing significant load.

A device that cannot be opened cannot be repaired.
A device that cannot be repaired cannot be inherited.

7. Specific Gravity Reference Tables

Specific gravity readings must be temperature-corrected for accurate state-of-charge interpretation. The hydrometer is typically calibrated to 25°C (77°F). For each degree Celsius above or below this reference, add or subtract 0.0007 from the reading.

State of charge vs. specific gravity

State of Charge	Sp. Gravity @ 25°C	Open-Circuit Voltage	Action
100% (full)	1.265 - 1.275	2.10 - 2.13 V/cell	Normal float, no action needed
75%	1.225 - 1.235	2.07 - 2.09 V/cell	Within normal cycling range
50%	1.190 - 1.200	2.03 - 2.05 V/cell	Acceptable; recharge soon

State of Charge	Sp. Gravity @ 25°C	Open-Circuit Voltage	Action
25%	1.155 - 1.165	1.99 - 2.01 V/cell	Deep discharge; recharge immediately
Discharged	<1.120	<1.97 V/cell	Risk of sulfation; recharge urgently
Sulfated (hard)	<1.100, won't rise	Variable, often low	Run extended equalization at 2.55 V

Temperature correction example

A hydrometer reading of 1.240 taken at an electrolyte temperature of 5°C: the correction is 20 degrees below the 25°C reference, so subtract 20 × 0.0007 = 0.014. Corrected reading is 1.226. This places the cell at approximately 75% state of charge, not the 85% the uncorrected reading would suggest. Cold-weather readings always look better than they are.

8. Wiring Diagram and Bank Layout

A standard 24-volt, 240 amp-hour bank uses twelve cells wired in series. Each cell contributes a nominal 2.0 V at 240 Ah. For higher current capacity, two or more series strings are wired in parallel, doubling Ah with each additional string while keeping voltage at 24 V.

Series wiring layout (one 12-cell string)

```
+24V BUS  ■■■■
             ■
   [+]■■[1]■■[■] ■■■
                   ■  jumper
   [+]■■[2]■■[■] ■■■
   [+]■■[3]■■[■] ■■■
                   ■
   [+]■■[4]■■[■] ■■■
   [+]■■[5]■■[■] ■■■
                   ■      (Each [N] is one mason jar cell, ~2.0 V)
   [+]■■[6]■■[■] ■■■
   [+]■■[7]■■[■] ■■■       Total of 12 cells in series = 24 V nominal
                   ■      Total capacity = 240 Ah at the C/20 rate
   [+]■■[8]■■[■] ■■■
   [+]■■[9]■■[■] ■■■
                   ■
   [+]■■[10]■■[■] ■■
   [+]■■[11]■■[■] ■■
                   ■
   [+]■■[12]■■[■] ■■
             ■
0V BUS    ■■■■
```

Inter-cell connections

Use lead-coated copper bus bar stock, 1/4-inch thick by 3/4-inch wide, cut to length for each inter-cell jumper. Tin both ends with pure lead solder before bolting to the terminal posts. Untinned copper in contact with sulfuric acid mist will corrode rapidly and develop high-resistance joints that heat under load. Torque each bolt to 8 N·m (approximately 70 in-lb). Re-check torque annually as part of the equalization service.

Charge controller settings (24 V system)

Function	Voltage Setting	Notes
Bulk charge	28.8 V (2.40 V/cell)	Until current tapers to ~3% of Ah rating
Absorption	28.8 V held	Hold for 1-2 hours at the bulk voltage
Float	27.0 V (2.25 V/cell)	Long-term standby maintenance level
Equalization (annual)	29.4 V (2.45 V/cell)	4 hours; ventilate well; remove loads
Low-voltage cutoff	22.8 V (1.90 V/cell)	Disconnect loads to prevent over-discharge

9. Step-by-Step Build Sequence

The full build of a single cell, from raw materials to formation cycling, is roughly a long weekend of work spread across four days to allow drying and curing intervals. A twelve-cell bank takes two to three weekends.

Day 1 — Morning — Cast the grids. Set up melting pot outdoors. Bring lead-antimony alloy to 650°F. Skim and reserve the dross (red lead oxide). Pour into preheated wooden molds packed with foundry sand. Let cool in air for forty-five minutes. Demold and inspect each grid for completeness and surface defects. Discard any with porosity or incomplete fills.

Day 1 — Afternoon — Mix the active paste. Combine reserved red lead oxide dross with dilute sulfuric acid (approximately 1.100 specific gravity) at a ratio that produces a stiff putty consistency. Press paste firmly into the lattice of each grid with a wooden spatula. Both faces of each grid must be filled. Wipe excess from the grid frame so paste sits flush with the grid surface.

Day 1 — Evening — Cure the plates. Place pasted grids in a closed wooden cabinet over a low kerosene heater set to maintain 90-100°F internal temperature. Leave for seventy-two hours. During this period the paste oxidizes further and chemically bonds to the grid lattice.

Day 4 — Morning — Prepare cedar separators. Cut cedar to size; soak in distilled water for forty-eight hours (start this on Day 2 to be ready on Day 4). On Day 4 morning, remove and air-dry for twelve hours.

Day 4 — Afternoon — Assemble the cell. Layer plates and separators in alternating positive-cedar-negative-cedar order. Bind the plate stack with a glass-fiber wrap to maintain compression. Lower the assembled stack into the mason jar. Bolt the lead-coated copper terminal posts to the plate lugs.

Day 4 — Evening — Fill the electrolyte. In a glass mixing vessel, slowly add concentrated sulfuric acid to distilled water until the mixture reaches 1.220 specific gravity. Let cool — acid mixing is strongly exothermic. Pour into the cell until the electrolyte covers the plates by 1 cm.

Days 5-7 — Formation cycling. Apply a low-current charge (approximately C/40, so 6 amps for a 240 Ah cell) for seventy-two hours continuously. During this period the lead oxide paste converts to active lead dioxide on the positive plates and to spongy lead on the negative plates. Specific gravity will rise as the conversion completes. Final reading should reach 1.265 ± 0.010.

Day 8 — Verify and place in service. Discharge the cell at C/20 (12 amps for 240 Ah) and confirm it delivers at least 90% of nominal capacity before the terminal voltage drops below 1.85 V. Recharge fully. Connect to the bank. Begin the monthly hydrometer log.

10. Troubleshooting and Failure Modes

Every failure mode this technology can produce has a documented cause and a documented fix. The table below summarizes the most common; the narrative below it covers diagnosis in more depth.

Symptom	Likely Cause	Fix
Sp. gr. drops below 1.220 and won't recover after charge	Hard sulfation	Extended equalization at 2.55 V/cell × 6 hours, weekly
Electrolyte level drops too fast	Jar crack or overcharge	Inspect for crystalline seepage; reduce charge voltage 0.05 V
Single cell runs warm while charging	Internal short	Drain, replace damaged separator, refresh electrolyte, reform
Gradual capacity loss across whole bank	Cedar lignin depletion in oldest cells	Add fresh cedar strips alongside originals; do not remove old
Bubbling during normal charge (not equalization)	Charge voltage set too high	Reduce bulk voltage by 0.05-0.10 V; recheck float setting
Specific gravity uneven between cells	Acid stratification	Perform equalization; consider rocking the bank gently
Brown deposits forming on terminals	Copper corrosion at unsealed joints	Disassemble joint; clean; re-tin with pure lead solder; re-torque
Cell delivers <70% of nominal capacity	Plate shedding (end-of-life cell)	Rebuild: scrape plates, recast paste, repeat formation

Every fix above uses materials available at any rural hardware store. The system has no single point of failure that cannot be repaired in a weekend with hand tools.

11. Sources and Further Reading

All technical claims in this blueprint are drawn from peer-reviewed electrochemistry literature, historical engineering archives, and the standard reference works listed below. For deeper study, these are the primary sources.

On the invention and history of the lead-acid cell

Kurzweil, P. (2010). "Gaston Planté and his invention of the lead-acid battery — The genesis of the first practical rechargeable battery." *Journal of Power Sources*, Volume 195, Issue 14, pp. 4424-4434.

Planté, G. (1883). *Recherches sur l'Électricité* (English translation: *The Storage of Electrical Energy*). Primary source documenting Planté's experiments 1859-1879.

On lead-antimony grid metallurgy

Prengaman, R.D. (2001). "Challenges from corrosion-resistant grid alloys in lead-acid battery manufacturing." *Journal of Power Sources*, Volume 95, Issues 1-2.

Vinal, G.W. (1955). *Storage Batteries: A General Treatise on the Physics and Chemistry of Secondary Batteries and their Engineering Applications.* Fourth Edition. John Wiley & Sons. The standard mid-century reference work documenting Bell System telephone exchange battery service lives.

On cedar separators and lignosulfonate chemistry

Pavlov, D. (2017). *Lead-Acid Batteries: Science and Technology*. Second Edition. Elsevier. The definitive modern reference; the cedar separator and lignosulfonate mechanism is covered in detail in Chapter 4.

Pavlov, D., Petkova, G., Rogachev, T. (2009). "Influence of expander components on the processes at the negative plates of lead-acid cells on high-rate partial-state-of-charge cycling. Part I." *Journal of Power Sources*, Volume 191, Issue 1.

Boden, D.P. (1998). "Selection of pre-blended expanders for optimum lead/acid battery performance." *Journal of Power Sources*, Volume 73.

On stationary battery sizing and service life

IEEE Recommended Practice 485 — "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications." First published 1997, most recent revision 2020. Industry-standard reference document.

On Amish technology adaptation and the Ordnung

Kraybill, D.B. (2001). *The Riddle of Amish Culture*. Revised Edition. Johns Hopkins University Press.

Kraybill, D.B., Johnson-Weiner, K.M., Nolt, S.M. (2013). *The Amish*. Johns Hopkins University Press. Comprehensive treatment of Amish material culture, including off-grid energy systems.

12. Closing Notes

This blueprint is not a substitute for an apprenticeship. The Amish craftsmen who maintain century-cells in plain communities across Pennsylvania, Ohio, and Indiana learned this technology from grandfathers who learned it from theirs. Three generations of practice are embedded in the small judgments a builder makes — the texture of a paste that is ready to press, the smell of a cure that has gone too far, the sound of a cell that has begun to short.

What this blueprint can do is hand you the documented specifications, the verifiable chemistry, the sourceable materials. What it cannot do is hand you the practice. That comes from building, failing, rebuilding, and logging the results across years.

If you build a bench, keep a maintenance log. If you find a failure mode not documented in Section 10, write it down. If you refine a procedure, share it. The reason this technology survives in Amish basements is not that the Amish kept it secret. It is that they kept it alive, generation after generation, by doing it.

Brew the lead. Cut the cedar. Pour the acid.

This has been The Old-World Fix.

For more investigations into the engineering the modern economy quietly buried,
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