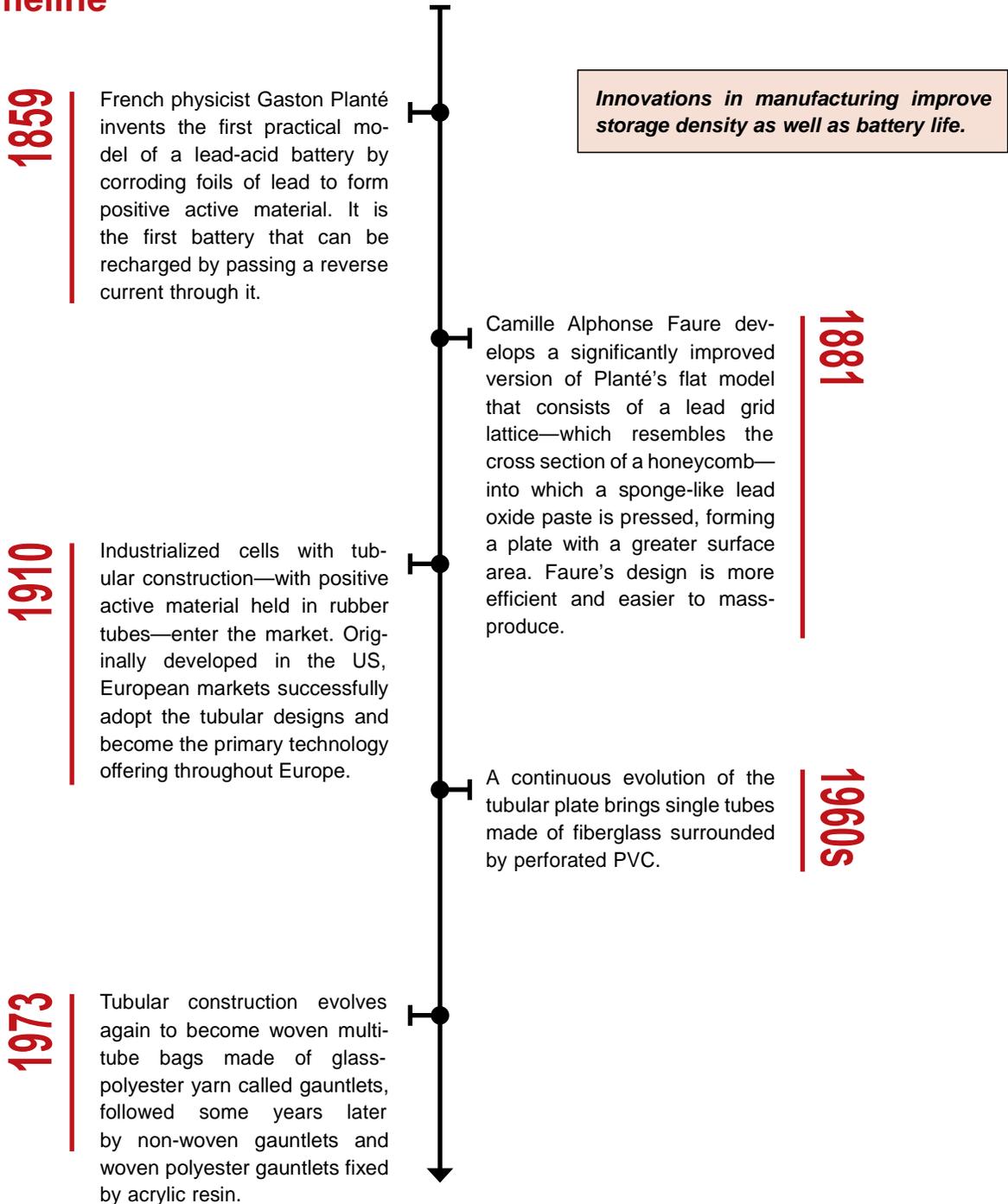


## Introduction

Lead-acid batteries have been around for more than 150 years. While flat plate models with a lattice grid represented a technological leap forward in 1881, tubular construction is a more robust technology with many advantages. With advancements such as the use of non-woven gauntlets encasing the positive spine plate to more advanced manufacturing techniques, tubular batteries provide enhanced performance and improved reliability as compared to flat plate technology.

## Origin / Timeline



## Description of positive plate construction types

A clear understanding of the different types of construction is required to adequately compare and contrast the differing technologies employed by lead-acid battery manufacturers.

### Explanation of lead-acid positive plate technologies:

**Reminder:** the negative plates in all lead-acid cells are the flat, pasted type

- **Planté plates** are positive plates made with pure lead versus a lead alloy. The active mass is formed by a corrosion process out of the grid. The demand for Planté plate is declining. Costly and challenging production techniques, and the requirement to use more lead in construction, do not deliver significant benefits as compared to alloyed tubular or flat plate batteries. **Figure 1** shows Planté plate
- **Pasted plates** are flat, positive plates made by pasting the lead oxide active mass on a mesh grid. **Figure 2** shows classic pasted plate
- **Tubular plates** use a frame structure consisting of a series of vertical spines connected to a common bus bar. The tubular design keeps the active material mechanically together and presses it onto the grid. The paste is held in micro-porous, non-conductive tubes (gauntlets), which are placed over the individual spines. Assembling the spines, gauntlets, lead oxide, and end cap together makes a positive plate. Volume changes during discharge and charge are mostly compensated by a high mass porosity, and gas bubbles help to distribute remaining free particles in the cell. Pressing the PbO<sub>2</sub> corrosion layer onto the grid surface also helps to protect the lead grid against further corrosion. **Figure 3** shows classic tubular plate

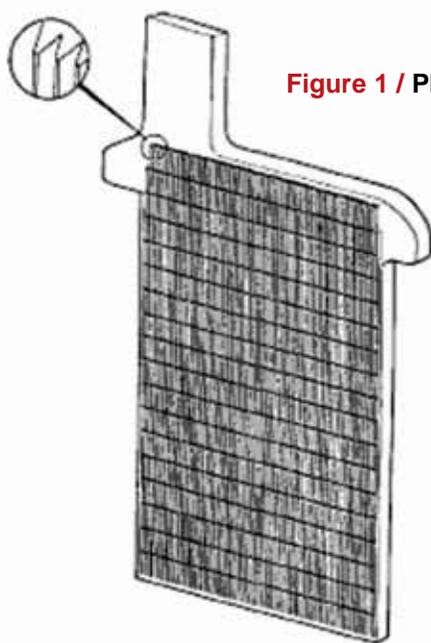


Figure 1 / Planté plate

Figure 2 / Pasted plate

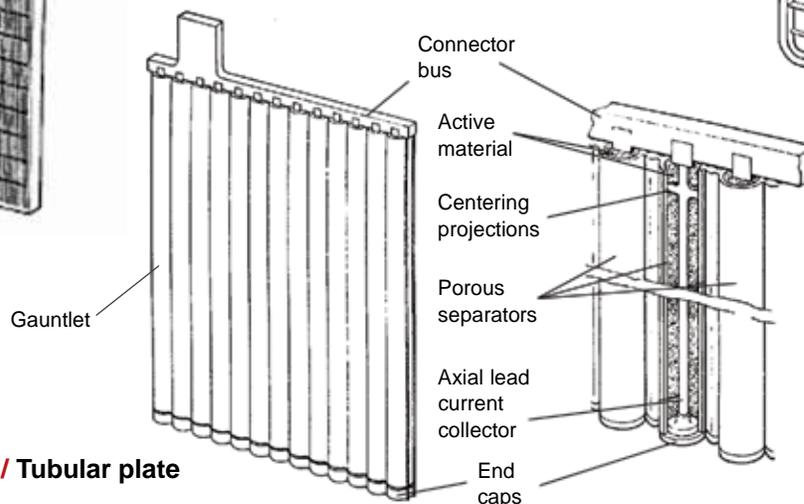
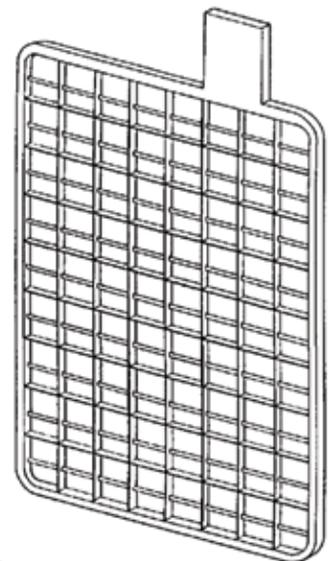


Figure 3 / Tubular plate

	Flat plate	Tubular	Explanation of tubular advantages
Reliability	Reliable	<b>Most reliable</b>	
Charge cycles (at 80% DOD)	50-1000	<b>1100-1800</b>	Lead selenium / low antimony alloy advantage
Electrolyte stratification risk	Medium	<b>Low</b>	The external shape of the positive plate allows for easier movement for the electrolyte
Float current	Medium	<b>Low</b>	
Thermal management	Medium	<b>High</b>	Because of the higher relative electrolyte amounts and easier convective heat transport
Interface surface area	Medium	<b>High</b>	
Electrical resistance	Mid-to-low	<b>Low</b>	Well defined pore sizes permit easy movement to the electrolyte
Life expectancy	15-18 years	<b>20+ years</b>	
Charge retention	Long	<b>Longest</b>	Because there is no electrolyte pollution from reinforcing agents

## Why tubular is better: The secrets are the multitube bag gauntlet and increased surface area of the positive plate

Advanced multitube bag gauntlets are constructed of 100% polyester high tenacity multifilament yarns that are impregnated with an acrylic resin system and fixed crosswise to the tubes, while spun yarn is used lengthwise.

### Gauntlet characteristics

- **High porosity and low electrical resistance** Low electrical resistance can determine a well-defined pore size that permits easy movement to the electrolyte, but at the same time reduces the active material shedding to a negligible amount
- **Good mechanical resistance and elasticity** The gauntlet resists the high pressure that the active material produces during its cyclical expansion. The fabric holds the paste pressed to the conductive lead spines ensuring stable performance. Mechanical resistance to abrasion during cell assembly reduces scraps and pollution
- **Reduced release speed of antimony** The fabric keeping the active material all around the spines acts as a filter for the electrolyte, reducing the release speed of antimony from positive grids. In contrast, for pasted plates there is almost no distance between grid wires and electrolyte
- **Semi-rigid stability** The semi-rigid woven fabric gives the multitube bag a stable shape that permits an easy and quick filling procedure with paste, powder or slurry methods
- **High short-circuit resistance** Furthermore, gauntlets can be supplied with a special solution for the two lateral tubes that result in dramatic increase in plate short-circuit resistance. In particular the ISM solution (where the external tubes have half of their fabric completely closed) gives the best protection against short circuits between positive and negative plates with only a minor increase in electrical resistance

Also, due to increased positive plate surface area, tubular batteries have up to 20% more electrical capacity than flat plate batteries of comparable size and weight. With less positive plate shedding, tubular batteries also provide up to a 30% longer service life than flat plate batteries. In addition, battery engineers in Europe attest that tubular cells are more widely used because they deliver energy at a faster rate.

## Other stationary tubular advantages

Doubters of tubular construction might argue that flat plate batteries—due to their simpler construction—are generally less expensive to make and maintain. However, tubular batteries have been shown to have both a longer life and supply more power faster in an equivalent size, while still being produced at a competitive cost.

### Tubular plates deliver energy faster due to:

- Compact structure
- Increased mass and surface area of the active material
- Ease with which acid circulates around the tubular plate design

**Perhaps most importantly to stationary applications**, the tubular positive grid does not require horizontal bars, which virtually eliminates positive plate growth and therefore post seal leaks and jar cracking. As a result, in applications which require a long service life, **tubular plate batteries provide the best and most reliable power for money spent.**

## Conclusion

The tubular plate design delivers energy faster, has at least 20% more electrical capacity and up to a 30% longer service life than flat plate. **The battery world favors tubular positive plate design** for flooded, Gel, and even AGM applications. In addition to the superior performance of tubular plate technology, advanced high-tech filling processes and machines have made the tubular design more efficient and reliable to fabricate, allowing tubular batteries to be manufactured at a competitive cost.

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