ArresterHistory

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The Electrolytic Arrester Story

By Jonathan Woodworth 2008

The Battle

During the winter of 1906/1907 the battle for dominance in the arrester world was waging at full pace. Charles Steinmetz, the august leader of the team at GE, had just completed construction of his famous high voltage laboratory in Schenectady NY. He could for the first time simulate lightning with a capacitor bank for testing arresters. At the same time 265 miles to the southwest in Pittsburgh Pennsylvania, at Westinghouse Electric, a formidable team was making progress on their concepts. Both teams had been developing arresters for power systems for almost two decades. Unfortunately since early 1905 there had been little activity in the high voltage arrester patent arena. Both teams were in need of something new to take the technology to the next level.

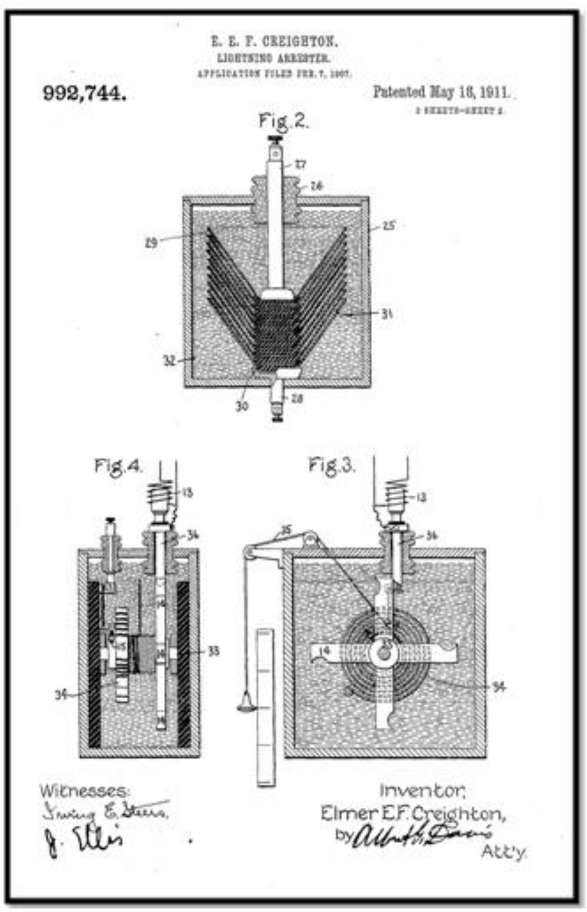


Figure 1: First patent application on Electrolytic Arrester that became a patent

Back in New York, on those short cold days of a Schenectady winter, the recently hired engineer Elmer Ellsworth Farmer Creighton believed he had answer.

Creighton had been added to the GE team two years earlier with the acquisition of the Stanley Electric Company. For this new position, he had moved to the GE Schenectady complex from Pittsfield Massachusetts where he had worked for Stanley the prior 3 years.

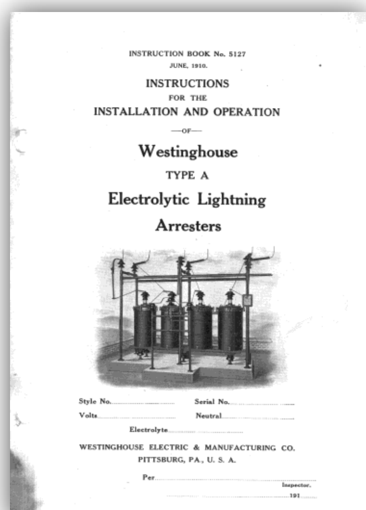
The Surprise

On February 7th 1907, Creighton filed the first application for an altogether new type of high voltage arrester. A design that he had been working on behind closed doors since joining GE. The patent application described an Aluminum Cell Electrolytic Arrester. The application became patent 992,744 in 1911. By the time the patent was issued, product had already been introduced to the surge protection market.

Public Disclosure

A month and a half after the patent application he presented a paper titled "New Principles in the Design of Lightning Arresters" to the American Institute of Electrical Engineers at the annual winter meeting in NY City. At that meeting he presented and defended his new invention. Proceedings of the meeting give excellent details of the written discussion that resulted from the presentation. I'm sure that Westinghouse engineers were not pleased to see this turn of events. Several contributors in the written discussions gave , RP Jackson, a recognized expert in the area of surge protection from Westinghouse, credit for the actual introduction of the concept a few months earlier. However, if Jackson was the first to introduce the concept, he was outflanked in the patent battle by Creighton and GE since there are no patents in his name.

The Feb. 1907 patent application was just the first of many that Creighton filed over the next 18 years. GE had won the patent campaign, but that was all they won. Over the next 20 years, GE and Westinghouse both marketed and sold electrolytic arresters despite the fact that GE had been granted patent rights. Figure 2 is the cover of a 1910 installation instruction brochure that shows that Westinghouse had product to the market before the 1911 GE patent was issued. Westinghouse did finally receive a patent on this type of arrester in 1919 with inventor Joseph Slepian (1,456,941).



INSTRUCTION BOOK No. 5127
JUNE, 1910.
INSTRUCTIONS
FOR THE
INSTALLATION AND OPERATION
—OF—
Westinghouse
TYPE A
Electrolytic Lightning
Arresters

Style No.............. Serial No..............
Volts.............. Neutral..............
Electrolyte..............
WESTINGHOUSE ELECTRIC & MANUFACTURING CO.
PITTSBURG, PA., U. S. A.
Per..............
Inspector.
..............191......

Figure 2: 1910 Westinghouse Instruction Manual on Type A Electrolytic Arrester

So the battle raged on with no clear winner in this arrester type.

Theory of Operation

The theory of the Electrolytic Arrester (also known later as the Aluminum Arrester) can best be understood by considering a single aluminum cell. The cell consisting of an electrolyte into which extends two aluminum plates with a microscopically thin film of aluminum hydroxide. The electrolyte was the same as that used in the formation of the film. When the voltage was applied to the cell and gradually increased, the current through the cell was very small until a critical voltage was reached. At that point, the current flowed freely being limited only by the internal

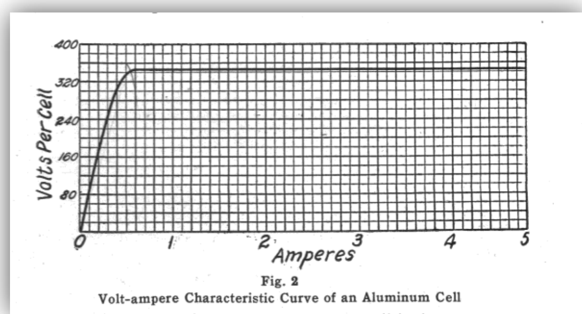


Figure 3: Voltage Current I Curve of Electrolytic Arrester

resistance of the cell which was very low. The Figure 3 VI Curve illustrates this turn on point. The current which flowed above the critical voltage was equal to the excess voltage (voltage above the critical voltage) divided by the resistance, not the total voltage applied across the arrester.

The vital characteristic of the Electrolytic Arrester was due to the thin film of hydroxide of aluminum. When the critical voltage was reached a myriad of minute punctures were created in the oxide layer that allowed the current to flow. When the excess voltage was removed, the minute punctures sealed up at once. The original resistance reasserted itself and no discharge of dynamic (power frequency) current followed. This was a major step forward in overvoltage protection because breakers were not needed to terminate the surge event.

Construction

The commercial electrolytic arresters used aluminum trays as seen in Figure 4. These

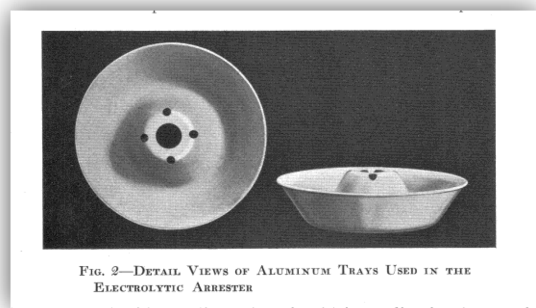


Figure 4: Aluminum Plates used in the Electrolytic Arrester

aluminum trays were present in all designs. The trays were spaced a few millimeters apart with insulators. An electrolyte was poured between the plates as shown in Figure 4a.

Each set of plates was capable of withstanding several hundred volts. The arrester rating was directly proportional to the number of plates.

Figure 4a Tools for adding electrolyte

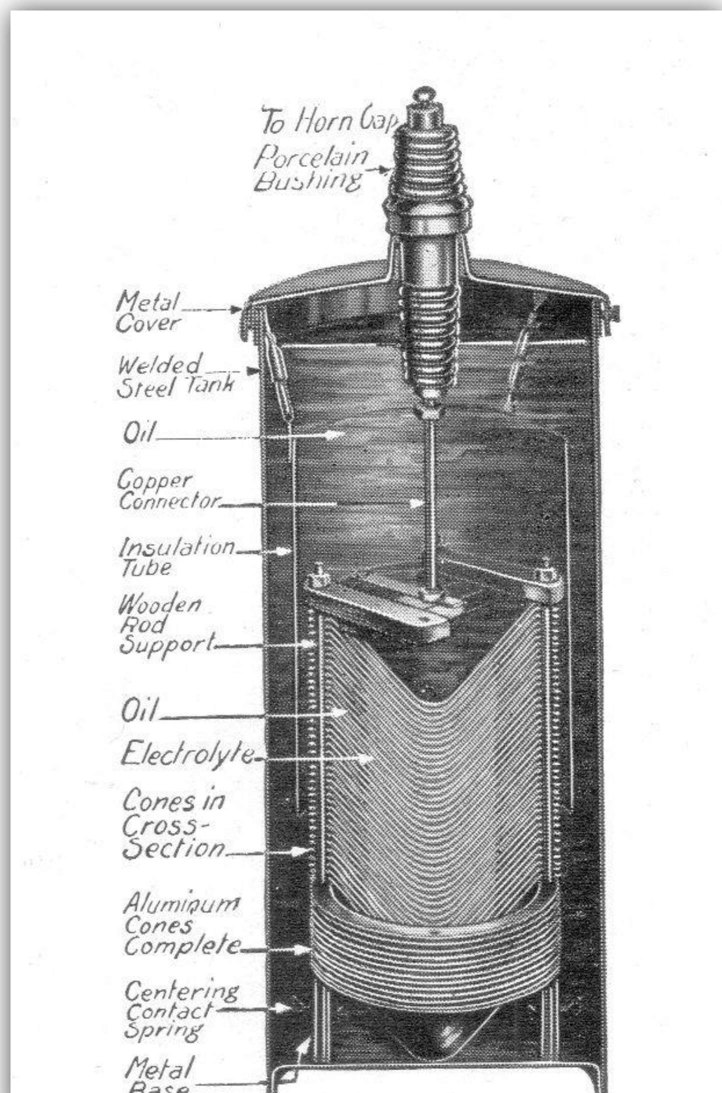


Figure 5: Cross section of Electrolytic Arrester

After the electrolyte was poured in the plates, the whole assembly was submerged into an oil tank. This insulated the plates from the metal tank and sealed the electrolyte from air. See Figure 5 for details.

The electrolyte was heavier than oil so it remained in the bottom of the trays even while submerged in the oil tank. Because of this sensitive construction of electrolyte and oil, this type of arrester required assembly on site. Figure 6 shows two laborers working on the construction of a new site. In this photo several parts of the arrester can be seen. The square boxes with a bottle protruding out the top are labeled Type A Electrolyte for Westinghouse Arrester. Directly behind the labeled box of electrolyte are two racks of aluminum plates. The two workers appear to be adding electrolyte to a third rack of aluminum plates. A pump and hose appears to be in place to pump oil into one of the cans at the edge of the roof.

Maintenance

Because this arrester required little

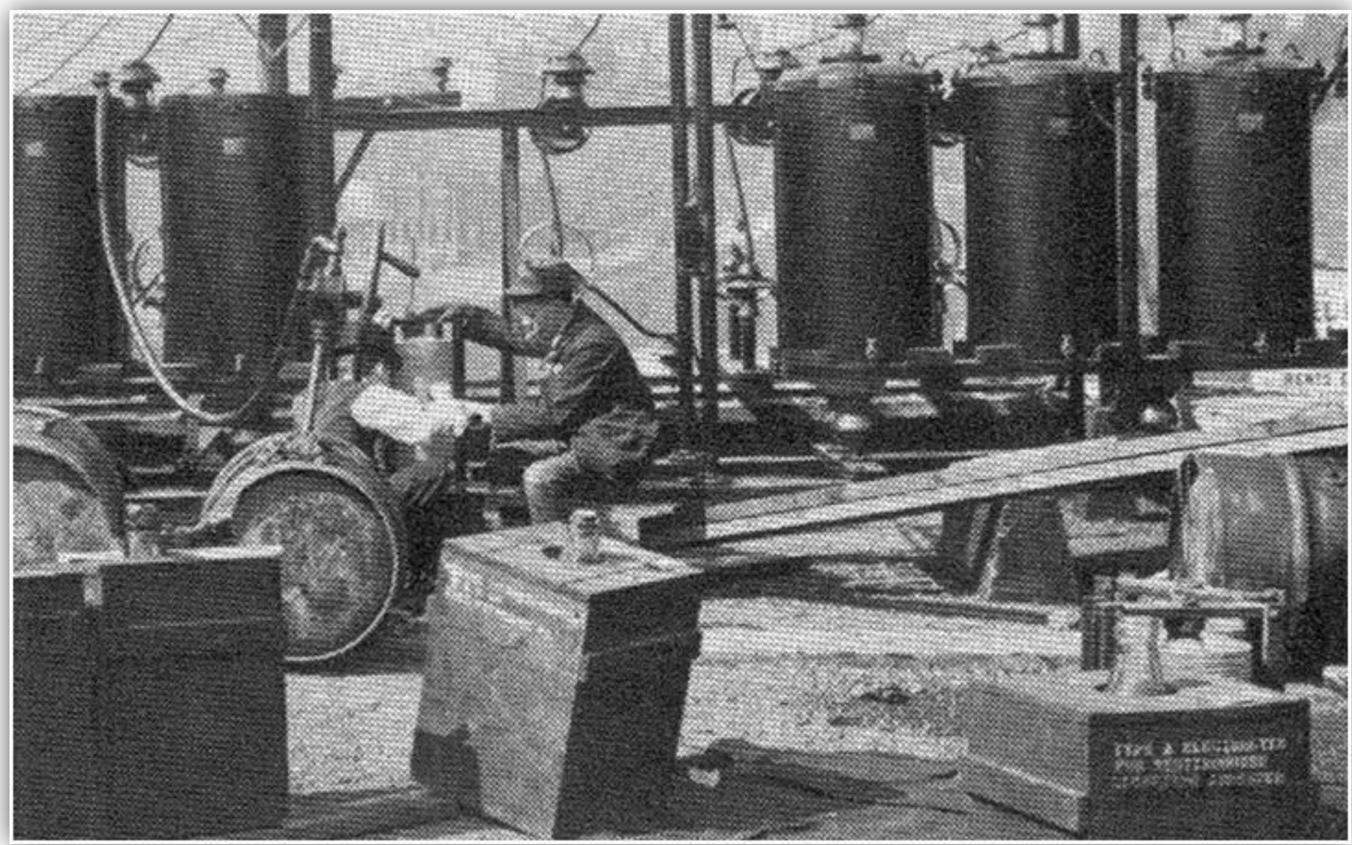


Figure 6: Two laborers adding electrolyte to an electrolyte arrester plate stack. Note the bottles of electrolyte in the square boxes, drums of oil, and stacks of aluminum plates. The construction is on the roof of the switch house of the north side substation of a Pittsburg Railroad building. Circa 1910

maintenance it was considered a benefit beyond the earlier generation of arresters. The only maintenance was a daily closing of the external gap to apply line voltage for a moment to rejuvenate the oxide film. The inspector was asked to record the time of charge, the size of the arc, the color of the arc, and the height to which it rose on the horns. In Figure 6 the external gaps in series with each tank can be seen. These are the gaps that were shorted on a daily basis to guarantee optimum operation by this arrester type.

The electrolytic arrester type dominated the substation and large equipment protection market until the late 1920's when the Silicon Carbide Type Arrester became dominate.

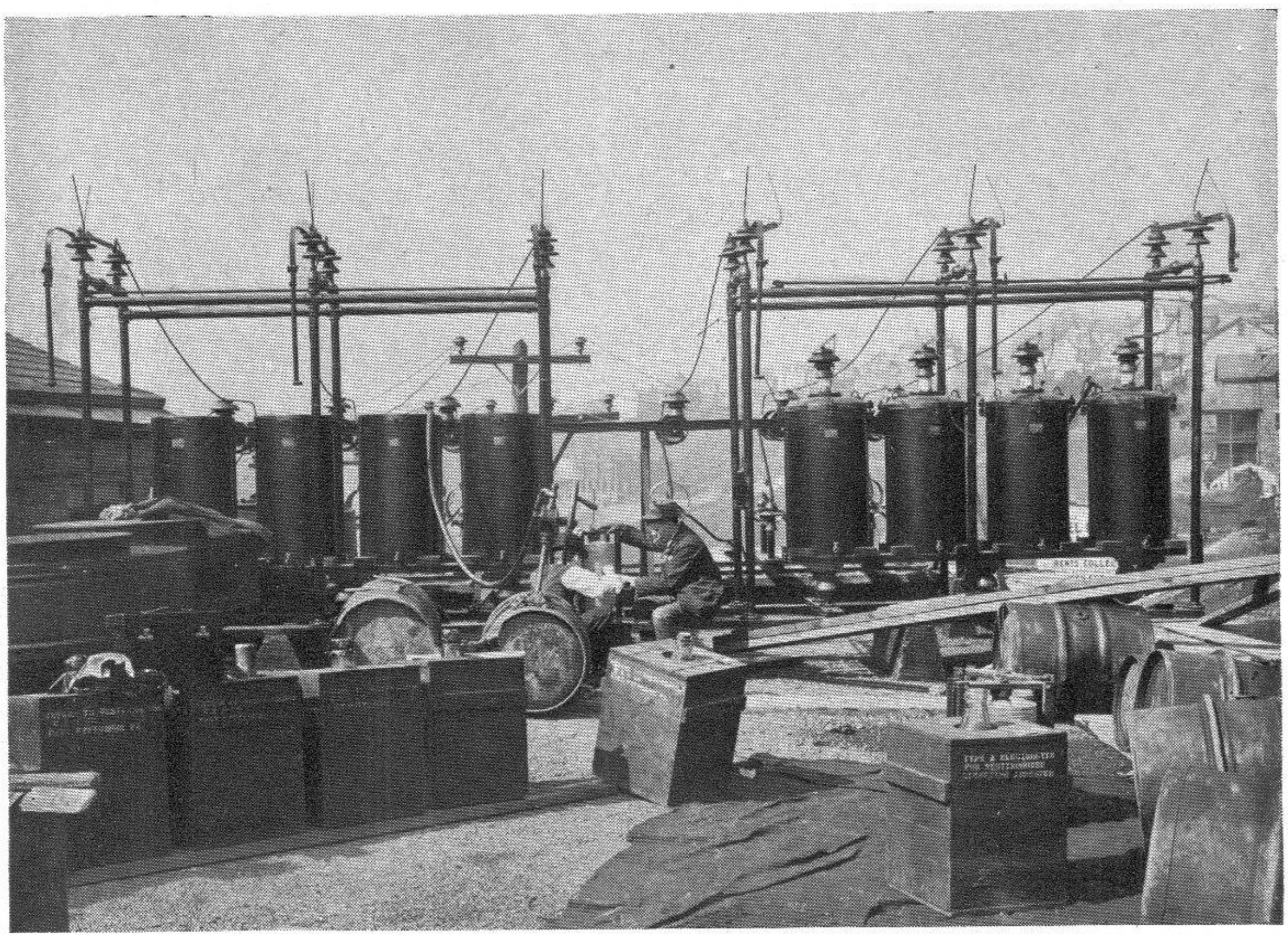


Figure 7: Electrolyte arresters under construction on the roof of the switch house of the north side substation of a Pittsburg Railroad building. Circa 1910

