

Lightning Protection of Power Systems - Then and Now - Part 1

By Jonathan Woodworth ArresterWorks

First Electrical Product Mass Produced

When I teach Overvoltage Protection Classes, I break up the sections with electric history questions. This always gets everyone thinking and presents a good segue for learning about surge protection. So today I will start the same way:

What was the first mass produced electrical product?

Who invented it?

What year was it invented?

In my classes invariably the answer I get is the light bulb. I usually respond with a comment like “Much before the light bulb” and that gets everyone thinking. A second response is often “A lightning Arrester”, however that is wrong too, but not so far off. Generally after a few moments, the correct answer pops out ... the lightning rod. This protection device was invented by Ben Franklin around the year 1750.



Figure 3 - Lightning Terminal in Substation

As it turns out, Ben Franklin was an inventor long before he was the famous statesman who signed the Declaration of Independence. I like to call him the first Electrical

Engineer in the United States.

Of course there were electrical

products made hundreds of years before the lightning conductor as it was called, but they were not mass produced and never used by common folks.

The lightning rod was not only mass produced, but it was the first electrical product ever used by the masses.

Since this product is still in use by the masses today, it must also qualify as the longest running mass produced electrical product. One does not have to look very far to see a lightning rod when you are in a high lightning region. They are used on nearly every substation, on nearly every tall building in the high lightning regions, and are certainly on the top of every tall antenna. They have changed very little in the last 260 years. Ben Franklin surely was one of the early pioneers in lightning protection. Figure 4 from an 1868 patent that shows how lightning rods were used to protect the poles and lines from lightning in that era.

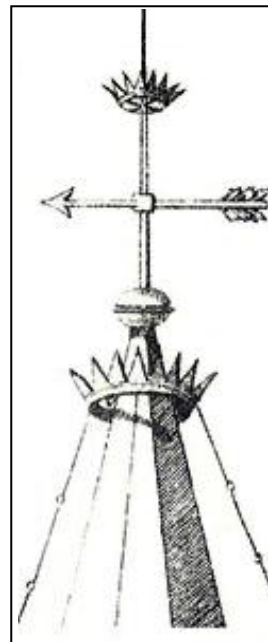


Figure 1 - 1750-60
Lightning Rod by Franklin



Figure 2 - 2011
Lightning Rod



Where Lightning Rods and Power Systems Meet

In substations, lightning terminals, as they are called today are a major part of protecting power systems from direct strikes. They serve as the first line of defense for transformers and the bus work. The terminals are generally mounted near the outer edges of the stations and provide an umbrella like protection. The height of the rod determines the breadth of protection. A rolling sphere method is used to determine the height of the terminals. This rolling sphere method and all considerations regarding the protection of substations from direct strokes of lightning is described in detail in IEEE Standard 998.

Lightning Arresters (First Cousins to the Lightning Rod) and Joseph Henry

Another question I like to ask my students regarding the history of electricity is: When did the first protection of electric lines occur? Invariably my students from the power industry say 1880ish because they know that is when power systems began to evolve, so arresters had to start at the same time. However they are wrong, because the telegraph companies, not the

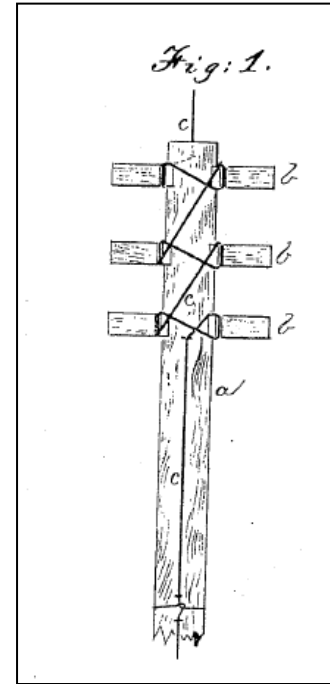


Figure 4 - Early Lightning Rod on Telegraph Pole

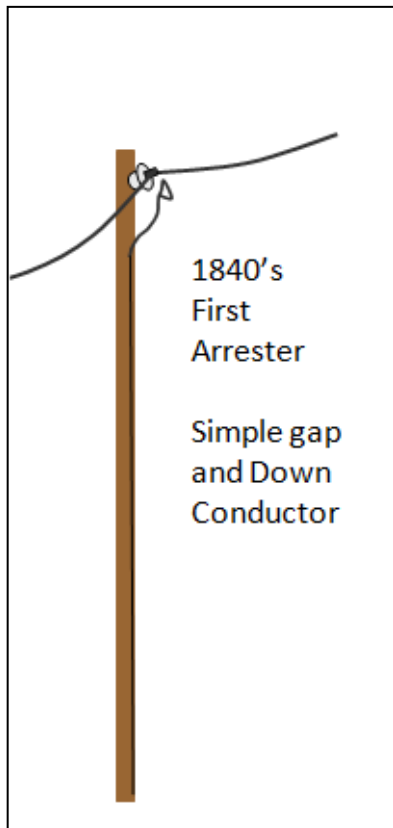
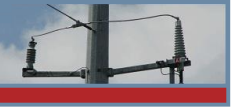


Figure 5 - Rendition of First Lightning Arrester 1850s

power companies, were the first to install electric lines across country that were subject to lightning or atmospheric discharges as it was called at that time. The first telegraph systems arrived on the electrical history timeline about 1837 and in the following years, a great deal of work was done in the area of lightning protection of telegraph lines. From my research, the first reference to a lightning arrester in the US came in a paper written by the famous Joseph Henry in 1847 while serving as a professor at Princeton. Yes, this is the Henry that the unit of inductance is named after. He made his famous discovery of induction while teaching at the Albany Boys School in 1837. Today he is credited for his contribution along with Michael Faraday who subsequently made the same discovery in England at approximately the same time.

Henry's article specifically details that a wire should be connected between earth at the bottom of a pole and carried up the telegraph pole to within 1/2 inch of the telegraph line as shown in figure 5. He explains that the air resistance will allow the standard telegraph signal to travel along the telegraph line without interference, but if an atmospheric discharge was to get on the telegraph line, it would jump the gap and most of the charge would be drained to ground down the pole. Although the term lightning arrester was not used



In his article, this is certainly an early description of the simple gapped arrester. The term arrester is first used a few years later in 1852 in a document written by Alexander Jones when discussing the history of the telegraph up to that date.

By 1860 when the first patent to use the term "Arrester" on telegraph lines was issued, the technology had changed dramatically. The basic component was still a gap, but the gap was remotely operated by the telegraph operator and the gap had become more sophisticated.

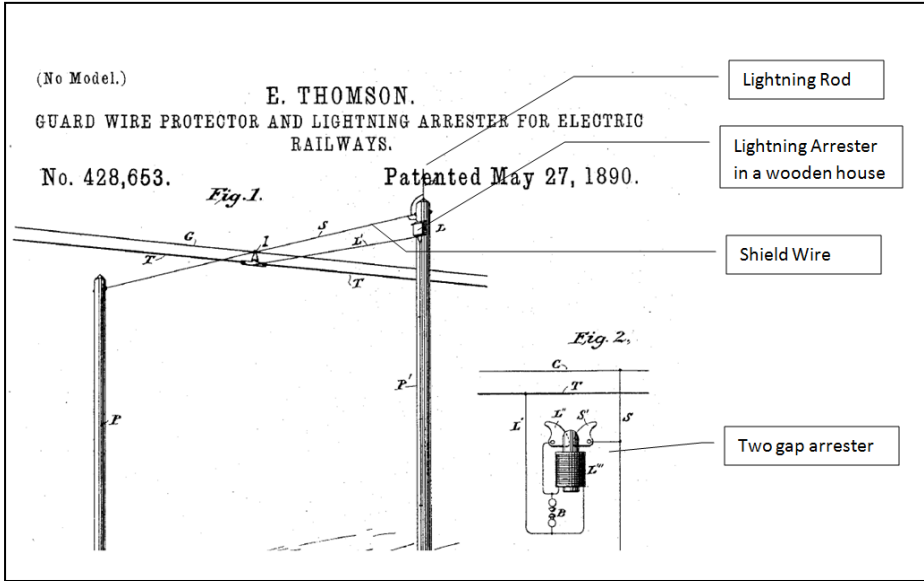


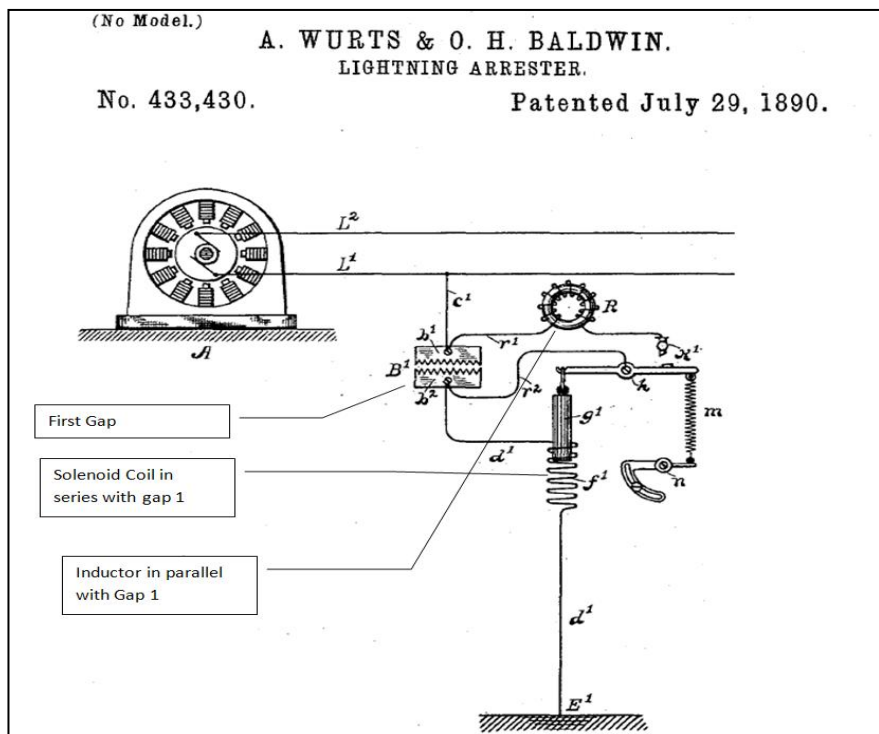
Figure 6 - First Power System Arrester

Power System Arresters Pioneers: Elihu Thomson and Alexander Wurts

With the introduction of the light bulb, by Thomas Edison, the need for overhead power lines was born. This coupled with the use of electric railways started the beginning of power systems in the 1880's.

By 1890, Elihu Thomson patented an arrester to be used to protect power lines for electric rails. His system also included a lightning rod on the pole, and a shield wire (another cousin of the lightning rod) across the line to the other pole as shown in Figure 6.

A few months later, another pioneer in power system arresters, Alexander Wurtz, was issued a patent for power systems. An interesting part of early arresters was the inductor, which we now know are a very negative aspect of surge protection.





Future Articles

1890 ends the first era of lightning protection. In the second issue of this article, the 1890 to 1980 era will be explored.

About the Author

Jonathan Woodworth is a surge protection consultant. He and his partner Deborah Limburg spun themselves out of Cooper Power Systems in 2007 and started ArresterWorks. Besides consulting in all aspects of Surge Protection, they have created ArresterWorks.com, the web's most comprehensive source of surge protection information.