Advancement of **Lightning Protection** and **Prevention** in the 20th Century

Donald Zipse, Guest Author

Part 1 of this two-part series covered the primitive observations in ancient history, the experiments by Benjamin Franklin, and the early technical work by Nikola Tesla. This part will continue to explore the history of lightning protection further into the 20th century and touch on some of the controversies that have erupted in the recent years.

Carpenter's Dissipation Array System

In 1930, J.M. Cage patented a multipoint discharge system to prevent lightning. The concept was to use a sharp-pointed conductive metal similar to a barbed wire wrapped around a beach umbrella, connected to earth and positioned above the structures to be protected [1], [2].

In 1971, Roy B. Carpenter, Jr., began marketing an application of this concept (1922–2007, IEEE Life Senior Member). It is believed that he came across the Cage patent during his work as a system reliability analyst on the Apollo Space Program, although he never confirmed or denied when asked about this. His multipoint discharge system is also known as the dissipation array system (DAS).

NASA's Space Center in Florida is located in a region known for high-lightning activity. Hence, the agency had a great deal of interest in finding ways to protect both its fixed facilities as well as movable launching structures and rockets against direct lightning strokes. Carpenter proposed applying his DAS to not only protect NASA's Space Center facilities but also prevent lightning strikes to the facilities. There is a big difference between protection from lighting and prevention of lightning, and so his proposal stimulated heated arguments across industry.

Two extensive investigations have been conducted on the performance of the DAS, which culminated in a report containing more than 250 pages of discussion. Advocates concluded that the multipoint discharge systems function like a Franklin rod system, and a major factor in the effectiveness of the system in dissipating lightning is a consequence of the extremely low-resistance connection to earth. Conversely, detractors argue that it has never been demonstrated that the presence of a DAS actually eliminates lightning.

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Hughes organized a symposium, "Review of Lightning Protection Technology for Tall Structures," at the Lyndon B. Johnson Space Flight Center in Clear Lake City, Houston, Texas, on 6 November 1976. The agenda had Carpenter presenting "170 System Years of Lightning Prevention." Twelve distinguished experts presented different views of the efficiency of the multipoint discharge system.

In essence, the debate came down to the fact that the advocates of the DAS could not explain why it worked, and they could not provide anything more than anecdotal stories that suggested that facilities with DAS installations were not experiencing lightning strokes. At that time, conventional wisdom suggested that the physics behind lightning discharge was beyond the scope of human intervention. However, the above has been resolved, and prevention has been accepted in Japan and Southeast Asia.

The Franklin Rod Controversy

The first part of this series mentioned that Franklin had initially advocated the use of pointed rods for lightning protection. Subsequently, Tesla observed that rods with rounded ends appeared to be more effective. Dichotomy also became the basis for controversy in the 20th century.

In the 1980s, Heary Brothers developed a modification of the Franklin rod. A metal globe was installed at the

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base of the Franklin rod, which held an ionizing material. The purpose was to increase the height of the ionized streamer rising from the rod, thus increasing the effective height of the Franklin rod. Initially, the fear of ionizing material dampened the sale of the device. It was subsequently redesigned to eliminate the ionizing element.

Heary Brothers approached the National Fire Protection Association (NFPA) requesting a new standard on the ionizing air terminal, also known as early streamer emission (ESE). At that time, the NFPA standard on lightning protection was Standard 78. This was renamed to Standard 780 to allow for the generation of an expected series of related standards dealing with lightning protection, and a working group developed Standard 781 on ionizing air terminals.

A draft of the proposed Standard 781 on ESE was completed but was subsequently rejected as a whole by NPFA in 1995. Heary Brothers then initiated legal action against NFPA.

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The suit was settled out of court, and, as part of the settlement, NFPA agreed to reopen consideration of a standard for ESE protection. This reconsideration led to a reaffirmation of the decision not to proceed with Standard 781. In addition, it also raised questions about the understanding of Franklin rods and suggested that Standard 780 should also be revisited.

Because the NFPA had declined to address the DAS technology, an effort to initiate a standards project on DAS was started within the IEEE. To avoid conflict with commercial trademarks, the proposed standard was titled, "Standard for Lightning Protection System Using the Charge Transfer System for Industrial and Commercial Installations."

The efforts of this working group had significant support from Carpenter, who had employed atmospheric scientists in Russia to simulate the performance of his lightning protection system. In addition, several firms in Japan were interested in the technology and did extensive testing. Although some draft conclusions were presented, the working group was unable to arrive at a final consensus standard within the time period allowed in the IEEE standards-making process.

Ralph Lee and the Rolling Ball

The traditional view of lightning protection was that a grounded rod would prevent a direct stroke to a structure that was completely contained within a cone surrounding that rod. It was generally believed that the angle of protection of the rod was 45°.

Ralph H. Lee (1911–1987), Life Fellow, an electrical engineer associated with DuPont in the United States, proposed a modification to the traditional angle of protection concept. He suggested that the region of protection could better be defined as the surface traced by a sphere as it rolls across the region containing the rod; structural elements within the shadow of this surface are presumed to be protected whereas elements that project through the surface are exposed to potential strikes. Subsequent research in Europe has led to the refinement contained in the latest revision of NFPA 780 that the radius of the sphere considered for this purpose should be 150 ft.

Lightning Research in Florida

Another contributor to our modern understanding of lightning is Martin A. Uman, distinguished professor and director of the Lightning Research Laboratory at the University of Florida. He was instrumental in developing the lightning locating system based on electromagnetic field theory. The results of this work can be readily seen during a thunderstorm by visiting the Weather Channel Web site and clicking on the screen that displays lightning strokes on a weather map.

In his field laboratory near Gainesville, Uman is experimenting with techniques to control the discharge of lightning containing clouds and direct that discharge to items under study. His particular focus is on protecting lightning strikes to airport runway lighting facilities. He is also working on directing lightning strikes into explosive compounds to correlate the resistance of the explosive with ignition. The latter effort has already produced important improvements in safety with regard to handling of explosives. Obviously, his work promises to offer a better understanding of the physics of lightning that may eventually lead to definitive answers to some of the ongoing debates about ESE.

There Is More to Learn

We've come a long way from the days when lightning was perceived to be the result of Zeus hurling thunderbolts at some random target. Our advancing knowledge has contributed to an evolution in the science of protecting structures from lightning. At the same time, conflicting theories continue to be there about how (or even whether) lightning can be controlled and prevented, and these theories are the subject of fascinating and energetic discussions. (The author believes lightning can be prevented.) Eventually, as our understanding matures, we will have answers. For now, having an open mind helps us enjoy the process of debate.

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