WAR OF THE LIGHTNING RODS

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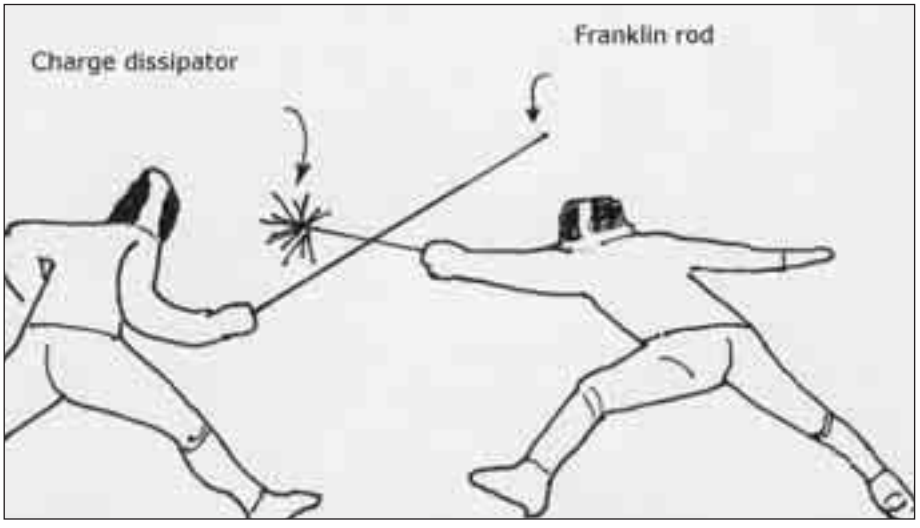
Since the dawn of civilization, lightning has inflicted a great deal of damage on the structures built by mankind. About 250 years ago, an effective method of protection became available when Benjamin Franklin invented the lightning rod. Its application to power lines took the form of shield wires. A great deal of the research done since then was regarding how to best place the lightning rods and shield wires so as to provide effective protection at a reasonable cost.

In recent years, the marketplace has been flooded with products for alternative protection methods. These include gadgets that claims to eliminate lightning [also called Charge Transfer Systems (CTS)], and rods that claim to emit giant early streamers that vastly extend their protective range (ESE devices). This article explains the requirements for effective lightning protection, and presents the position of the scientific community regarding the claims behind the above devices.



THE CONVENTIONAL LIGHTNING PROTECTION SYSTEM

The science of lightning protection was born when Franklin discovered that lightning was a form of electricity. The conventional protection method consists of the following:

a) Deploying "air terminals" at suitable points above the structure to act as sacrificial termination points for the lightning strokes.
b) Dissipating the collected lightning 2 charges safely into the ground via ground rods that are connected to the air terminals via "down conductors".
c) Bonding the down conductors to any nearby conducting objects in the building to prevent side flashes.
d) Installing suitable surge protection devices on the electric and electronic systems of the building.

In the beginning, it was thought that the protected zone was described by a cone around the lightning rod. In the early 1940s, C.F. Wagner applied lightning impulses to a scale model in an attempt to define the protected zones of shield wires and masts/lightning rods. The great R.H. Golde theorized that such scale models produce invalid results. Field observations on the double circuit 345 kV lines of the early 1950s proved Golde's theory. The ensuing research led to the development of the electrogeomteric model (EGM). The Rolling Sphere Method (RSM), which is widely used in standards, is a method of visualizing the application of the EGM, and it was developed by R.H. Lee. The RSM involves an approximation as it assumes the "striking distances" to all objects (air terminals, the ground, and the protected structure) to be equal to one another. The conventional lightning protection method adopted in national and international standards rests on using Franklin rods that are placed using the RSM.

THE DRIVER BEHIND THE ALTERNATIVE AIR TERMINALS

In recent years, some vendors of alternative air terminals have been waging a war based on claims that have been rejected by the scientific community at large. In the process, they lowered the debate to the point of denying the existence of the extensive research behind the EGM/RSM. They then attempted to force their point of view by using threats of legal action against the participants in the debate, both individuals and organizations. This escalated to actual court action against NFPA (National Fire Protection Association) and others, and some scientists were humiliated by being forced to submit to interrogations.

The proponents of CTS and ESE devices claim to be seeking to introduce superior lightning protection systems that better serve the customer. On the other hand, their real objective appears to be to make more profits from the sale of such systems. One tactic is to get the customer to pay more on the grounds that the offered air terminals can eliminate lightning. As an example of the price hike associated with such a claim, the cost of the CTS device called "Spline Ball" (US $105) is more than 10 times the cost of a Franklin rod ($6-$10 depending on length). It should be noted here that the Spline Ball acts as a one-to-one replacement for the Franklin rod. Hence, the customer in effect pays much more for a degree of protection which, at best, is similar to that of a conventional system.

Another tactic is to offer the alternative system at a cost which is comparable to that of a conventional system, but provide only one or a few air terminals. Also, the number of down wires is reduced to one or two. In contrast, a conventional system for the same building may require 20 Franklin rods and many

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down wires. This is the practice of the vendors of ESE devices, and it rests on the claim of having a protective range that is much larger than that of the Franklin rod. On the other hand, the protective range of an ESE device is practically equal to that of a Franklin rod. The result is that the customer pays "the full price" for a fraction of the protection. This could have serious consequences to life and property, especially if the building houses hazardous materials.

As implied by the above, the price of an ESE device is also much higher than that of a Franklin rod. For example, one manufacturer which offers both systems charges US $1250 for the ESE device and $10 for a Franklin rod.

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LIGHTNING ELIMINATION DEVICES

While the concept itself is much older, the commercialization of CTS started in the early 1970s. Shortly thereafter, studies were commissioned by several departments of the US government to evaluate their effectiveness, and the results were presented in a report edited by J. Hughes [1]. The conclusion was that lightning cannot be eliminated and that the subject gadgets did not work. This was confirmed by several subsequent studies. Recently, a comprehensive review of CTS was conducted by Professors Uman and Rakov [2]. Again, the conclusion was that the lightning elimination claim was unfounded. The above work is of special significance as it was widely endorsed by the scientific community, including ICLP (International Conference on Lightning Protection), the American Geophysical Union and the American Meteorological Society.

Equally important, Russian scientists hired by the CTS people themselves agreed with the scientific community regarding the invalidity of many of the claims that the CTS industry aggressively pushed in the past. For example, the main claim of the CTS folks has been that their gadgets produce copious amounts of charge that will neutralize the cloud or at least form a cloud of space charge that will neutralize the downward leader. On the other hand, the Russian scientists found the emitted charge to be not much larger than that produced by a single electrode. Further, they found the subject charge to be incapable of neither discharging the cloud nor neutralizing the downward leader.

Another important finding of the Russian scientists is that lightning strokes will continue to strike the CTS or the protected object. However, they suggest that if the stroke arrives beyond a certain distance from the structure, designated "D" in Fig. 1, then the opposing field of the cloud of space charge may be able to cancel it out, thus inhibiting the formation of an upward counter leader. Hence the stroke would terminate elsewhere. Let "X" be the effective collection radius of the structure in the absence of the CTS. The "failure ratio" of the CTS would then be:

$$F = (D/X)2 \quad ...(1)$$

Based on the assumption that X = 3H, "H" being the height of the structure, and that the downward leader will have a constant charge density of 0.001 C/m, the Russian scientists suggest that the failure ratio will be small.

Contrary to the above, Ref. [3] shows that the failure ratio will be almost 100% even if the idealized condition upon which the Russian model is based materializes. For one thing, distance X is actually much smaller than 3H. Second, proper modeling of the charge distribution in the downward leader may make distance "D" larger than "X".

Regardless of the value of the failure ratio, the admission of the Russian scientists that at least some strokes, especially the ones having larger amplitudes, will terminate on the structure renders the CTS not feasible on economic grounds. Further measures will still be necessary to enable the structure to cope with direct lightning strokes. Those same measures will also enable it to cope with the rest of the strokes. Hence, there is no justification for incurring the additional high cost of a CTS.

ESE LIGHTNING RODS

ESE devices were invented when their predecessors — radioactive rods — were banned on the grounds that their claimed benefit did not justify the resulting nuclear pollution. An ESE device releases a charge at its tip earlier than done by a Franklin rod. The charge is claimed to form a giant upward streamer which acts as an extension to the rod. The downward leader would then connect to the tip of the streamer, thus vastly extending the protective range of the rod. If such giant streamers existed, it would be possible to photograph them with a streak camera or a Boys' camera. The vendors failed to produce such photographs, yet continued to insist that their theory was valid.

Some of the reasons for rejecting the ESE theory are as follows: a) a streamer cannot form before its natural time because the electric field within the gap will be too low to permit propagation.; b) even if the streamer started developing, its speed would be a small fraction of that assumed in the ESE theory;. c) according to the EGM, a huge increase in the effective length of a lightning rod does not significantly decrease the required number of air terminals.

It should be noted that the review by Uman and Rakov covered both CTS and ESE devices, and rejected both. The rejection of the ESE theory by independent scientists is also worldwide. Actually, the rejection of ESE theory goes back to February 1999. At that time, ICLP issued an opposing statement that was endorsed by 17 scientists from 15 countries [4]. Further, ESE technology was rejected by independent scientists in France, the birthplace of the ESE theory

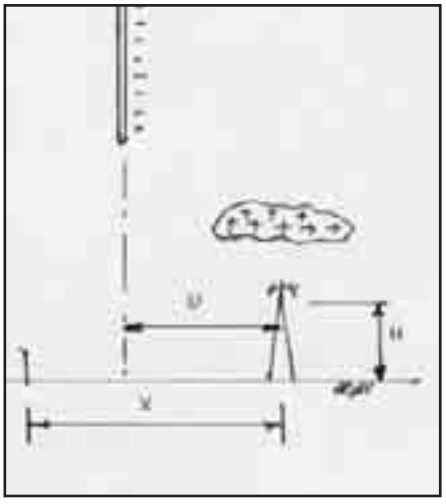

Fig. 1. Effect of CTS on downward lightning leader.

[5].

VALIDITY OF THE CONVENTIONAL LIGHTNING PROTECTION SYSTEM

The vendors of ESE rods and CTS devices often attempt to advance their claims by alleging that the basis of the conventional lightning protection system is also questionable. Those allegations have been rejected by the scientific community. Please see the related policy statement of the American Meteorological Society [6].

In addition to the above, a report by Tobias et al [7] proves the effectiveness of the conventional protection method. The Tobias report represents the collective position of 8 respected lightning experts.

CONCLUDING REMARKS

Like the rest of the marketplace, many false claims exist within the lightning protection field. Actually, it is easier to mislead the buyer in this case as complexity of the subject makes the junk science arguments of the vendors appear plausible to him/her. This fact, coupled with the power of well-financed commercial propaganda campaigns, enabled the vendors of CTS and ESE devices to get thousands of people to buy their products. In some cases, the damage is limited to overcharging the customer for non-existent lightning elimination capabilities. In other cases, the customer is given only a fraction of the required protection, thus exposing life and property to risks.

Potential buyers are advised to protect themselves by not entertaining any claim unless the vendor submits proof that it has been accepted by the scientific community at large.

Useful information in this respect can be obtained, free of charge, from the archives of the Lightning Protection group. To join, just send a blank e-mail message to: LightningProtection-subscribe@yahoogroups.com

REFERENCES

[1] Hughes, J. (Editor). (1977). Review of Lightning Protection Technology for Tall Structures, Office of Naval research, Arlington, Virginia, Report No. AD-A075 449, 275 pp. 6

[2] Uman, M.A. and Rakov, V.A. (2002). "A Critical Review of Nonconventional Approaches to Lightning Protection", Bulletin of the American Meteorological Society, Vol. 83, No. 12, pp. 1809-1820.

[3] Mousa, A.M. (July 2003). "Validity of the Lightning Elimination Claim", Proceedings of the IEEE-PES Annual Meeting, Toronto, Ontario, 6 pp.

[4] Mazzetti, C. and Flisowski, Z. (26 February 1999). "The ICLP Statement's to the NFPA Draft Standard 781", 2 pp. Included in section 5.4.3 on the web site of: www.lightningsafety.com

[5] Gruet, P. (October 2001). A Study on Early Streamer Emission Lightning Rods, INERIS (National Institute of Environment, Industry and Hazards), France, 64 pp. English highlights of the Report are given in message #1136 in the archives of www.Lightning Protection@yahoogroups.com.

[6] American Meteorological Society. (November 2002). "Lightning Protection Systems", policy statement, www.ametsoc.org/AMS/policy/lightningprot_statement.HTML-29k.

[7] Tobias, J. et al. (June 2001). The Basis of Conventional Lightning Protection Technology, Report of the Federal Interagency Lightning Protection User Group, DTIC (Military version of NTIS), Catalogue No. ADA396784, Report No. CECOMTR- 01-5, Source Code: 412503, 76 pp. Also available as section 5.1.9 on the website: www.LightningSafety.com

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