topics

New Prevention and Monitoring System for Lightning

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OVERVIEW: Use of conventional lightning protection systems based on lightning rods may result in damage to vulnerable electronic and IT equipment when a lightning strike occurs due to induced currents that result from the surge current passing through the building. This article describes a new lightning prevention system that minimizes the possibility of lightning strikes on the building being protected. It also describes a new lightning monitoring system that detects the three dimensional coordinates of lightning discharges. The information obtained by this system indicates the direction of travel of the thunder storm, thereby enabling advance predictions of which areas are at risk of lightning strike. This can prevent lightning damage by allowing preventive actions to be taken in advance.

NEW LIGHTNING PREVENTION SYSTEM

THUNDER storms have become more frequent in Japan in recent years, and this is having a serious impact on social infrastructure, such as disruption to transportation networks or power outages. This has created a strong demand for ways of preventing this lightning damage.

Conventional lightning protection systems protect buildings, equipment, and people from lightning strikes by using lightning rods to attract the lightning and conduct the resulting surge current to ground via a grounding wire or the building's steel frame. However, the associated electromagnetic pulse (EMP) can cause a surge current to flow through electronic devices in the building, resulting in damage to equipment.

In contrast, the new Dissipation Array*1 lightning protection system prevents lightning damage by inhibiting the lightning strikes themselves (see Fig. 1).

The new lightning prevention system consists of a hemispherical ionizer formed from wires to which a large number of protruding rods have been welded. It is installed at the highest point on the building being protected and connected electrically to a ground current collector buried in the ground. The electric field that forms between the bottom of the thunder cloud and ground causes a corona discharge at the tips of the ionizer rods, positively ionizing the surrounding atmosphere. In the case when the bottom of the thunder cloud is negatively charged, the ionizer rods positively ionize the surrounding atmosphere, weakening the electric field in the direction of the earth. This prevents lightning strikes by inhibiting the creation of upward leaders from the ionizer, thereby minimize the risk of connection with downward leaders from the thunder cloud.

The new lightning prevention system has been installed at more than 4,000 sites in 57 different countries around the world (as of December 2010,

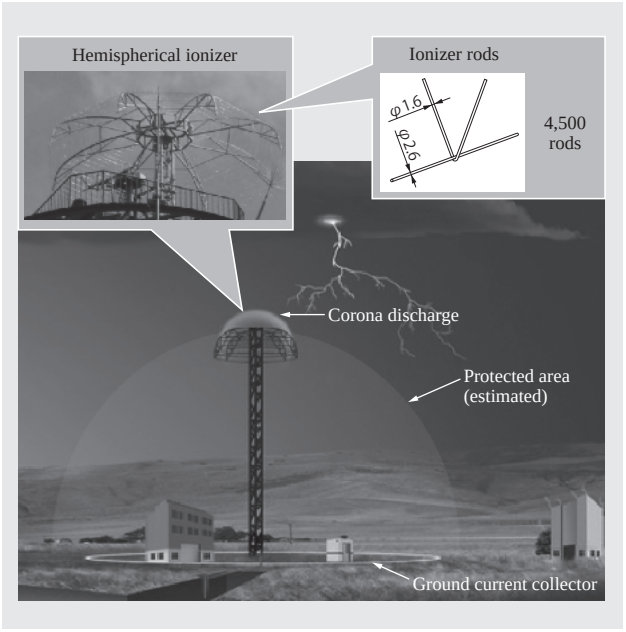

Fig. 1—New Lightning Prevention System.
A feature of the system is the hemispherical ionizer with large numbers of protruding rods located at the top of the protected building.

*1 Dissipation Array is a registered trademark of Lightning Eliminators & Consultants, Inc. of the USA in Japan and is used by Hitachi, Ltd. with permission.

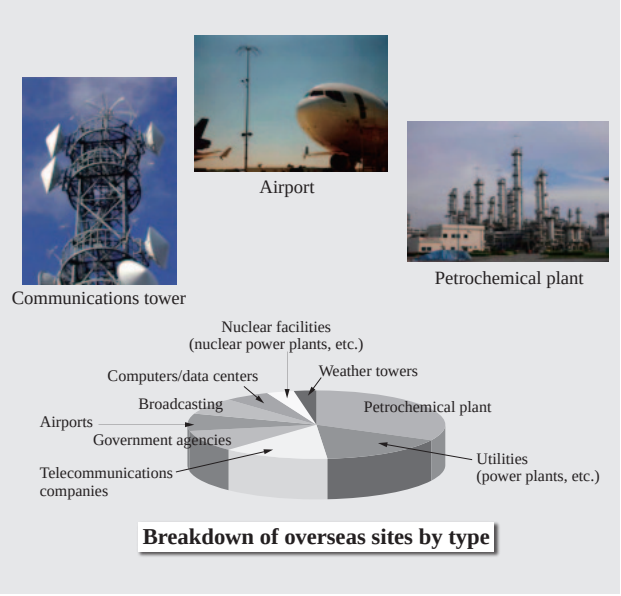

Fig. 2—New Lightning Prevention System around the World. The system is installed at a variety of sites subject to significant damage from lightning strikes, including chemical plants, power plants, telecommunications and broadcast facilities, and information technology centers.

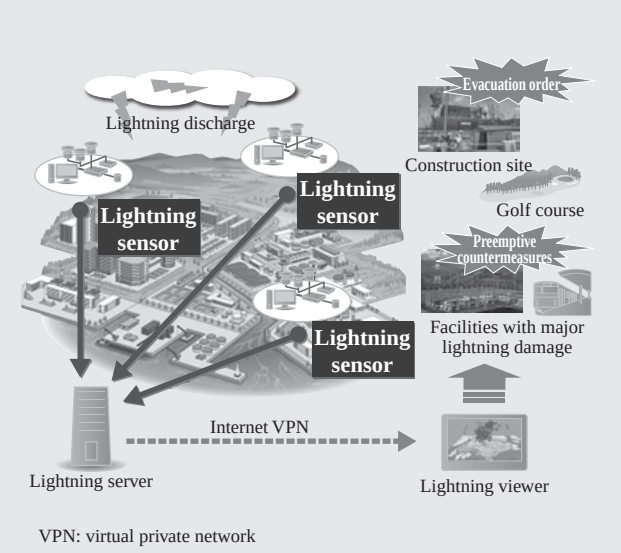

Fig. 3—Configuration of 3D Lightning Monitoring System. The lightning server uses position data from separately located lightning sensors to resolve discharges three-dimensionally and present the results in a lightning viewer.

including 229 sites in Japan as of September 2012)*2. To date, no reports of direct damage due to lightning strike occurring after installation have been received (see Fig. 2).

3D LIGHTNING MONITORING SYSTEM

The three-dimensional (3D) lightning monitoring system uses three sets of antennas to detect radio waves emitted by the progression of lightning discharges, and uses the phase difference between them to determine the direction of the discharges. By monitoring from a number of locations, the system can also determine the 3D coordinates of discharges (see Fig. 3).

The system uses a very high frequency (VHF) broadband digital interferometer developed by a group led by Professor Emeritus Zen-ichiro Kawasaki of Osaka University(1).

Whereas the lightning monitoring systems currently in general use only detect lightning strike points and display them on a two-dimensional map, the 3D lightning monitoring system can detect the detailed progress of a lightning discharge from cloud to ground and present a realtime display of lightning activity in three dimensions.

This 3D lightning monitoring system is expected to be more accurate than conventional systems at using trajectory monitoring to predict thunder cloud behavior.

The benefits of higher accuracy and faster prediction of thunder cloud position include sounding the alert at construction sites or golf courses and other outdoor facilities, or allowing infrastructure such as railways to take preventive actions to avoid significant damage.

The 3D lightning monitoring system is currently in use in the Republic of Singapore, where four sensors have been installed to cover the entire city. These are monitored continuously from both Singapore and Japan. One of the sensors in Singapore is installed at a junior high school where science classes also use it to perform their own lightning monitoring.

FUTURE DEVELOPMENTS

This article has described a new lightning protection system that inhibits direct lightning strikes and provides a solution for reducing lightning damage, and also a 3D lightning monitoring system that helps with preemptive measures for preventing lightning damage. In the future, Hitachi intends to continue responding to the need for lightning damage prevention by improving both performance and functions.

*2 The new lightning prevention system was developed by Lightning Eliminators & Consultants, Inc. of the USA. Hitachi, Ltd. undertakes design, manufacturing, and sales under a licensing agreement.

REFERENCE

(1) Y. Nakamura et al., "An Error Estimate of the VHF Broadband Digital Interferometer," IEEJ Transactions on Fundamentals and Materials **129**, No. 8, pp. 525–530 (Aug. 2009) in Japanese.

ABOUT THE AUTHORS

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Andrew Mui

Appointed President of Lightning Eliminators & Consultants Pte. Ltd. in 1997 and President of Lightning Eliminators & Consultants (Asia) Pte. Ltd. in 2003. He took up his current position as CEO of Hitachi Critical Facilities Protection Pte. Ltd. in 2011. He has held an additional post at the infrastructure group management headquarters of Hitachi, Ltd. since 2013. He is currently engaged in the management of the Lightning Eliminators & Consultants.

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Zen-ichiro Kawasaki

Professor Emeritus, Osaka University. He is currently engaged in research on remote sensing using electromagnetic waves, and on the use of field observations to study the mechanisms of lightning discharge. Professor Kawasaki is the chairman of International Conference on Atmospheric Electricity (ICAE).