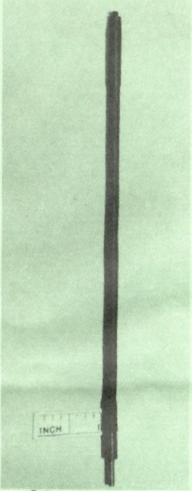
NEW PRODUCT

Antenna Static Discharger

It has been proven that Precipitation static and corona discharge noise can raise the noise level 20-30 dB above ambient. These static discharge devices bleed off excess electrons thereby reducing the undesired electrical noise that results in receiver desensitization. This is the same type device used on aircraft and ground stations to minimize electrostatic interference. The only difference is this model (AS-1) has been optimized for antennas to prevent any de-tuning of the antenna even if element mounted.



U.S. Patent 3,617,805
and others

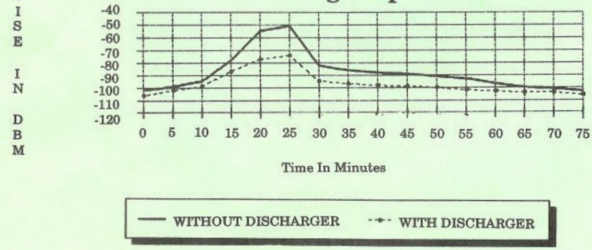
BENEFITS •

- Reduce or eliminate Precipitation Static.
- Reduce or eliminate Corona Discharge Noise.
- Increased range during noisy conditions.
- Minimize receiver desensitization.
- Lower antenna noise.
- Will provide results on long wires, dipoles, yagis for HF thru UHF, verticals, TV & TVRO.

FEATURES •

- Mounts easily to any antenna, boom or tower.
- No de-tuning of antenna.
- Maintenance free.
- Small size (1/4" x 6 1/2").
- Weighs only 1 oz.
- Inexpensive.

Identical Yagis Up 30 feet

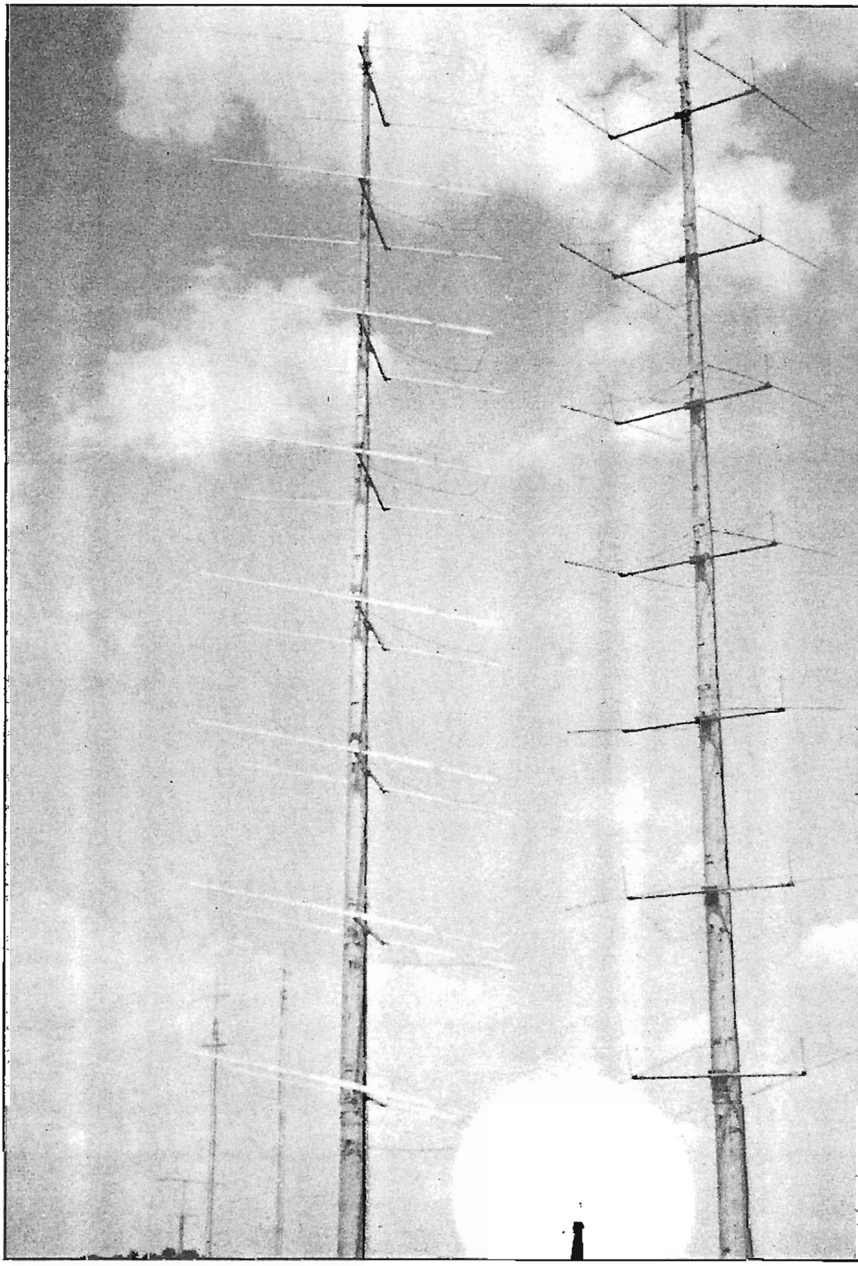


Available Exclusively From

Static Buster
% REPEATER BUILDER
1143 COLEMAN STATION ROAD
FRIEDENS, PA 15541 USA

Static discharger wicks cut precipitation static noise

Adapted from aircraft applications, static discharger wicks for towers and antennas are designed to reduce radio noise caused by corona discharge and precipitation static. Improvements as great as 40dB have been noted.



By Michael E. Norton

Have you ever wondered why a receiver's noise floor elevates above the ambient noise level and, more importantly, what can be done to reduce or eliminate the problem?

Modern receivers have high sensitivity and extend radio communications range under normal conditions. But electrostatic discharge (ESD) produces broadband noise that can degrade system performance by raising the noise floor.

In 1988, I began monitoring radio signals used for nationwide communications via meteor-burst propagation. The signals are slightly stronger than galactic noise. Daily monitoring revealed the true importance of noise. Noise level increases of only a few decibels can entirely mask weak signals. As noise increases, a high receiver signal-to-noise ratio can be swamped easily.

Noise "crashes" propagated from distant thunderstorms and noise from man-made electromagnetic interference must be tolerated. At least they usually come in the form of impulses. Such noise may be bothersome, but at least it is not normally sustained.

ESD noise, on the other hand, may continue for long periods.

Earth-ionosphere capacitor

Air, a mixture of gases, largely is composed of nitrogen and oxygen. Air generally is considered to be an insulator. It would be an excellent insulator if all its oxygen and nitrogen molecules were in a neutral state. But air is composed of varying quantities of neutral molecules and positive and negative ions—charged molecules.

As the number of ions in the air increases, air becomes a progressively better conductor. Generally, the higher the altitude, the more ions air contains. At an altitude of 40 miles to 50 miles, in a layer of the atmosphere called the ionosphere, ions are so plentiful they refract radio waves.

Although the ionosphere is electrically conductive, as a whole it is considered to be "uncharged" because the layer's number of positive ions equals the number of negative ions and electrons. The ions and electrons are distributed within the ionosphere in layers of various altitudes and degrees of charge.

In contrast, the earth has surplus electrons. Its charge approximates 300,000V to 400,000V negative compared to the ionosphere.[1] This potential difference, together with the atmosphere's total conductive qualities, is sufficient to cause the earth to lose electrons to the ionosphere continually.

The entire earth's surface and the ionosphere may be considered to be oppositely charged plates of a vast capacitor with a leaky air dielectric. Along with ions that make the air slightly conductive, meteorological processes contribute to the earth-ionosphere "capacitor's" leakage. The hydrologic cycle—precipitation—falling rain, for example—tends to drop larger, less mobile ions toward the earth as electrons rise in moisture-laden updrafts.

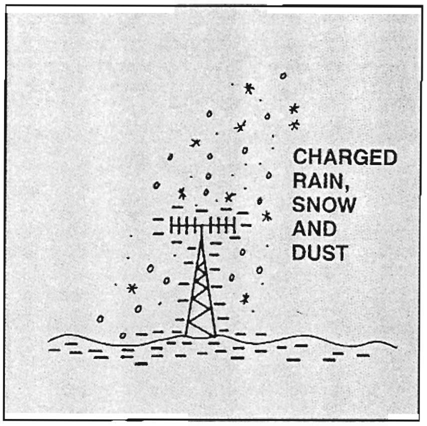


Figure 1. Electrically charged particles, such as raindrops, snow and dust, strike an antenna's tower, boom or elements and induce a current impulse that produces broadband noise. The noise is called *precipitation static*.

The earth's steady loss of electrons is called *ionic current*. Infinitesimal as it is, it has been measured and it amounts to about $9\mu A$ for every square mile on the earth's surface.[1] Ionic current flows via the most convenient conductive path—the path of least resistance. Thus, most of the electrons are discharged at natural and man-made *points*, such as peaks, trees, buildings, towers and antennas that project into the air.

When electrically charged particles, such as raindrops, snow and dust, strike an antenna's tower, boom or elements, they induce a current impulse that produces broadband noise. (See Figure 1 to the left.) The noise is called *precipitation static*. It generally is defined to include all external atmospheric electrical effects that produce electromagnetic interference.

Corona discharge noise

Another type of noise, *corona discharge noise*, happens when electrons flow through the antenna's tower, boom or elements and into the atmosphere when a charged cloud is near. (See Figure 2 below.)

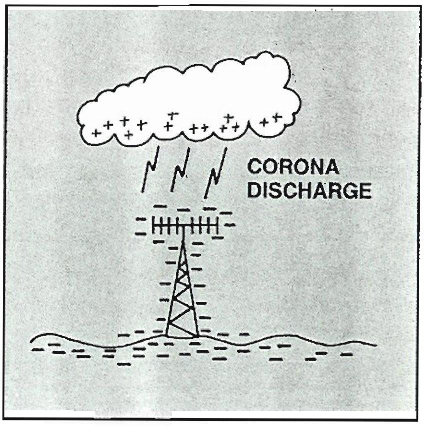


Figure 2. Another type of noise, *corona discharge noise*, happens when electrons flow through the antenna's tower, boom or elements and into the atmosphere when a charged cloud is near.

Corona or brush discharge occurs when a charge builds up and electrostatic lines of force develop. More lines of force per square inch appear at the sharpest points where it is more likely a strong field will pull free electrons from the point.

Electrons pulled from a sharp point form a corona or brush discharge that causes radio noise.

This type of noise can be caused when a mobile antenna is in motion. To reduce the noise, most mobile antennas are fitted with a ball at the tip. (The ball offers protection against puncture wounds, too.) Because the mobile whip lacks a sharp point, corona discharge is reduced.

If enough electrons leave the tip, they heat and ionize air near the tip. The air takes the form of a visible spark, known as St. Elmo's fire.

Corona is a major source of noise in the discharge category, but there are others, such as streamer currents that may precede lightning strikes and electrical arcs between objects with high voltage differences. When a charge builds up on an antenna, tower or other supporting structure, an arc may occur. The arc may leap between any insulated parts or poorly connected parts if the charge potential rises high enough—and it happens frequently.

Hardware noise

Another noise source is the antenna and tower hardware. Without proper grounding and bonding, the hardware may create multiple noise sources. Pay particular attention to any point where two conductors are in poor contact. Two conductors rubbing against each other can cause several types of noise, including rectification of strong radio signals from any nearby source.

If a feedline is not secured at short intervals, wind may cause enough movement to wear through the cable jacket, exposing the shield to intermittent contact with the tower and creating another noise source.

Joints formed of dissimilar metals, such as copper wire-to-galvanized steel tower connections for grounding, may corrode and oxidize quickly because of galvanic action. The best way to bond such joints is with exothermic welding, known by the trademark Cadweld.[2] Exothermic welding provides a mechanically rigid, electrically superior, low-maintenance connection that does not corrode or loosen.

Both corona and precipitation static, are well known and easy to recognize. (The abbreviation p-static often is used to refer to either or both.) P-static can raise the actual noise level 40dB to 50dB above the ambient noise level for sustained periods. The phenomenon long has been known to affect the HF radio spectrum, and it was not believed to have much effect above 50MHz. Recent, well documented reports indicate that sustained VHF and UHF p-static noise can and does occur.[4]

On HF, the elevated noise floor is readily apparent because of the nature of single-sideband (SSB) signals and the action in which rising background noise masks weak signals. This reduces the receiver's signal-to-noise ratio, preventing otherwise usable reception.

Because FM is the most popular mode on VHF and UHF, the effects of p-static noise in those bands is not as readily apparent when it happens. Receiver desensitization as great as 20dB to 30dB may occur without unsquelching the receiver. The noise decreases system range, makes received signals noisy and causes calls to be missed. The deficiency may be attributed to "poor conditions."

Sometimes the noise rises high enough to unsquelch the receiver. When it does, a repeater may transmit white noise "for no apparent reason."

P-static's frequency spectrum may lead to the conclusion that a given receiver range is immune to the noise. But frequency discrimination applies only to linear circuitry. Large transients that drive a receiver into non-linear operation represent another desensitization mechanism.

Typical characteristics of individual electron avalanches that make up a corona discharge include an amplitude of 10mA, a rise time of 10 nsec (nanoseconds, which are one-billionth of a second) and a decay time of 100 nsec.[5]

For a typical 50Ω antenna, this characteristic results in an impulse voltage that peaks at 0.5V. Compared to normal receiver sensitivities in the range of 0.5μV, a 0.5V signal is huge.

The electron avalanche causes the broadband noise, which in turn is modulated at the avalanche repetition rate. The repetition rate ranges from a low audio signal of a few pops per second, through the audio range and up to at least 1MHz. Through the receiver, you hear a high-pitched, screaming noise that comes in cycles two to 20 minutes long.

The pitch changes constantly. At times, it sounds like ignition or alternator noise. The noise slowly goes away as the static charge discharges through the receiver front end. Then the noise repeats as the antenna system recharges. The pattern occurs with mobile and fixed stations alike.

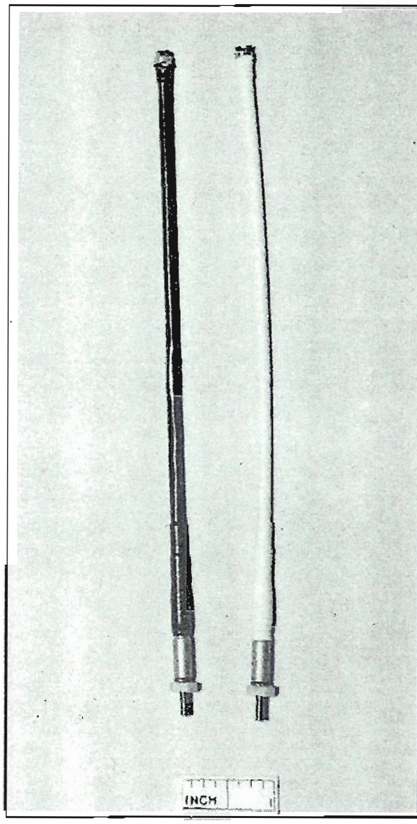


Photo 1. P-static and corona noise can be reduced or eliminated with wick dischargers. These static discharge devices bleed off the excess electrons, reducing undesired electrical noise and receiver desensitization.

Data presented here indicate that p-static and corona noise can be reduced or eliminated with wick dischargers. (See Photo 1 above.) These static discharge devices bleed off the excess electrons, reducing undesired electrical noise and receiver desensitization. The wicks reduce a structure's discharge threshold by draining the charge before it reaches a level at which severe broadband noise is caused.

The wick is the type of device used by the aircraft industry to reduce electrostatic interference to airborne and ground station equipment. The difference is that this model has been optimized for antennas instead of airframes to ensure the antenna is not detuned, even when the wick is mounted on the antenna element.

Few aircraft manufacturers do not offer, at least as an option, a high-quality static discharger installation. These static discharge devices are just as effective in eliminating the same problems from antennas and towers. They deliver results on long wires, dipoles, yagis for HF through UHF, verticals, TV antennas and satellite dishes during corona and p-static charging conditions. In many cases, the discharge wicks reduce the noise level several decibels under normal weather conditions.

In the aircraft industry, the standard procedure for discharger wick ground testing is to insulate the wick from the airframe and monitor the discharge current. The aircraft is insulated from ground and exposed to an ion flooding fixture. The current discharge levels then are used to determine how many wicks are needed and in which areas they should be placed. Aircraft are subject to the influence of more variables than antennas and towers are.

To test the dischargers, two identical 7-element 50MHz yagis were assembled and mounted 30 feet high (1.5 wavelength). One wavelength separated the yagis. Both were fed with equal-length feedlines. (See Figure 3 below). Both yagis were swept with a spectrum analyzer-tracking generator combination to verify their resonance at the same frequency.

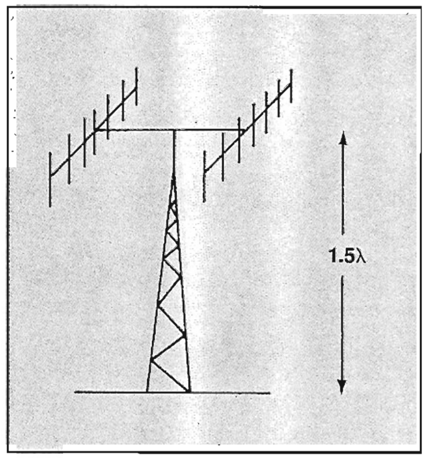


Figure 3. To test the dischargers, two identical 7-element 50MHz yagis were assembled and mounted 30 feet high (1.5 wavelength).

The antennas were lowered, and a static discharger was attached to each end of the boom on one yagi. (See Figure 4 below.) The yagis were raised back to 30 feet. The yagi without the discharger was used as a control antenna.

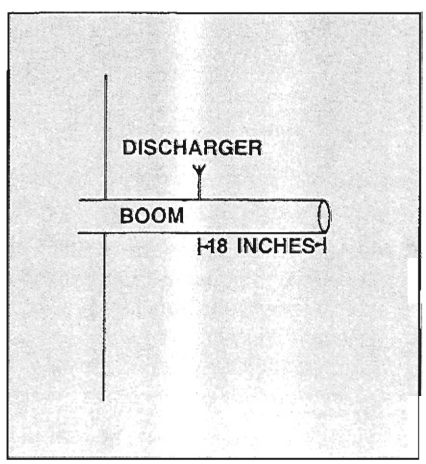


Figure 4. A static discharger was attached to each end of the boom on one yagi. The yagi without the discharger was used as a control antenna.

The results are shown in Figure 6 on page 36. The reduction in corona discharge and p-static attributed to the dischargers is not trivial.

The noise measurements were made as an approaching weather front caused a few sprinkles of rain to fall as the noise level peaked. It does not have to be raining for corona and p-static discharge to take place. A weather front with embedded charged clouds moving in the antenna's vicinity causes electrons to build up.

When the discharge threshold is reached and discharging begins, the noise starts. The object of using the wicks is to reduce the discharge threshold. With a lower threshold, electrons drain at a lower potential that does not cause noise or that causes less noise. If the charging intensity is high enough, some noise will be heard. But the noise level is likely to be 20dB to 30dB less than it would be without the wicks.

Efforts were made to find the wicks' optimum mounting location. The first noise graph (Figure 6) was made with the dischargers mounted vertically, 18 inches from the ends of the 40-foot boom. Noise reduction was significant.

Next, the wicks were positioned on the ends of the boom and in the plane of the boom. (See Figure 5 below). Figure 7 on page 38 shows noise results of the Figure 5 wick position. The performance improvement probably results from the discharger being in a more prominent dc field area of the antenna.

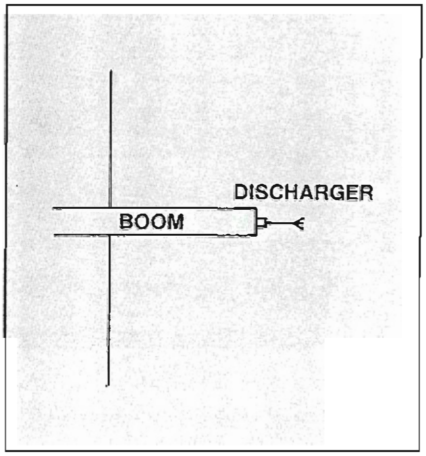


Figure 5. A second test was made with the wicks positioned on the ends of the boom and in the plane of the boom.

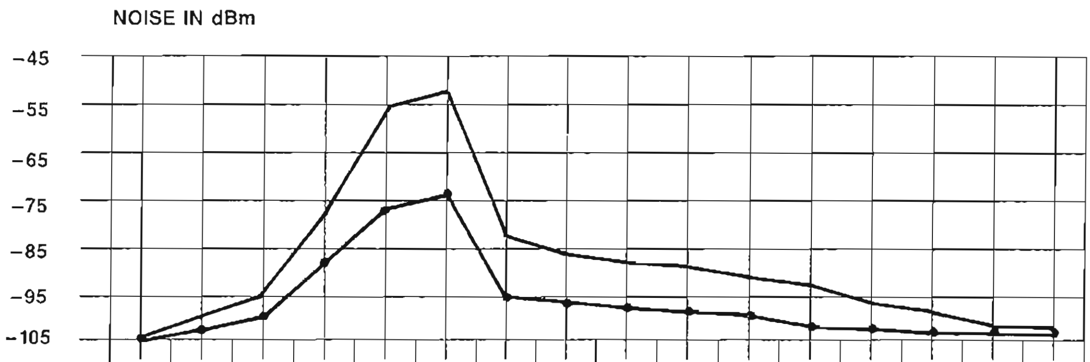
Dischargers can be mounted vertically at the end of the boom if they are within three inches of the end.

Data are being collected with the dischargers mounted on the driven element of a seven-element yagi to compare the effectiveness of boom, driven element and parasitic element mounting positions.

Various methods were used to record the antenna and discharger performance. Noise graphs were prepared from data collected by an eight-channel analog-to-digital converter connected to an IBM PC-AT-compatible computer.

A three-range ammeter was built to measure individual discharger currents during various weather conditions. The ammeter read in 100-picoamp, 100-nanoamp and 100-microamp scales.

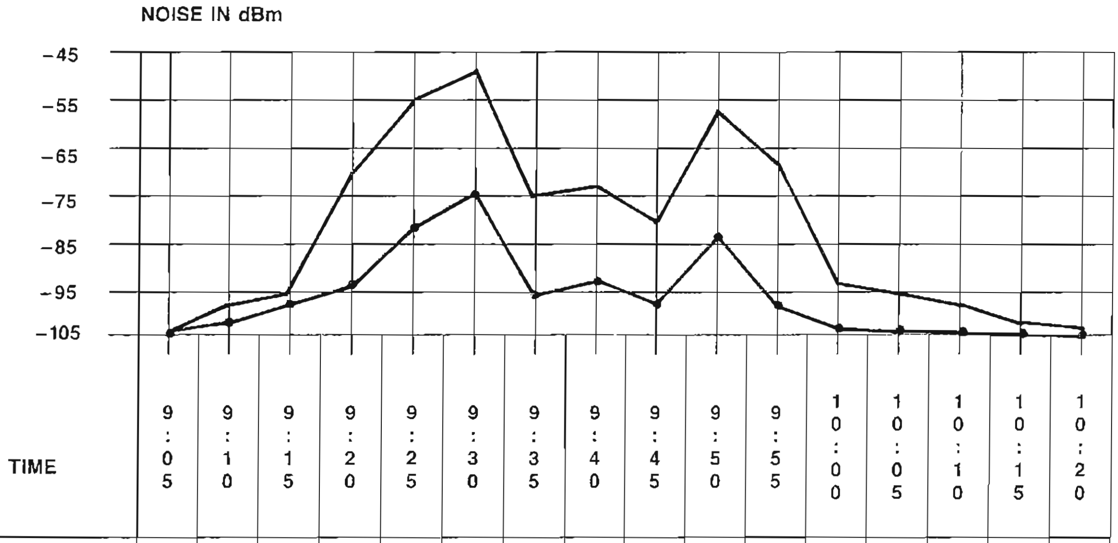
Once a normal baseline is established



TIME	1:25	1:30	1:35	1:40	1:45	1:50	1:55	2:00	2:05	2:10	2:15	2:20	2:25	2:30	2:35	2:40
W/O WICKS	−104	−99	−95	−78	−55	−51	−82	−86	−88	−89	−91	−93	−97	−99	−103	−103
WITH WICKS	−104	−102	−99	−87	−77	−74	−95	−97	−98	−99	−100	−102	−103	−104	−104	−104

Freq. = 50MHz —— W/O WICKS —•— WITH WICKS AS-1 mounted 18 inches from end of boom

Figure 6. Noise measurements were made on the yagi test setup shown in Figure 3 as an approaching weather front caused a few sprinkles of rain to fall and the noise level peaked. It does not have to be raining for corona and p-static discharge to take place. The graph compares noise received on the yagi with dischargers with noise received on the yagi without dischargers.



TIME	9:05	9:10	9:15	9:20	9:25	9:30	9:35	9:40	9:45	9:50	9:55	10:00	10:05	10:10	10:15	10:20
W/O WICKS	−104	−98	−95	−70	−55	−50	−75	−73	−80	−57	−68	−93	−95	−99	−103	−104
WITH WICKS	−104	−102	−98	−92	−80	−76	−96	−93	−98	−82	−100	−102	−103	−104	−104	−104

Freq. = 50MHz ——— W/O WICKS —•— WITH WICKS AS-1 mounted on end of boom

Figure 7. A second set of noise measurements made with the wicks positioned at the ends of the boom shows improved performance that probably results from the discharger being in a more prominent dc field area of the antenna.

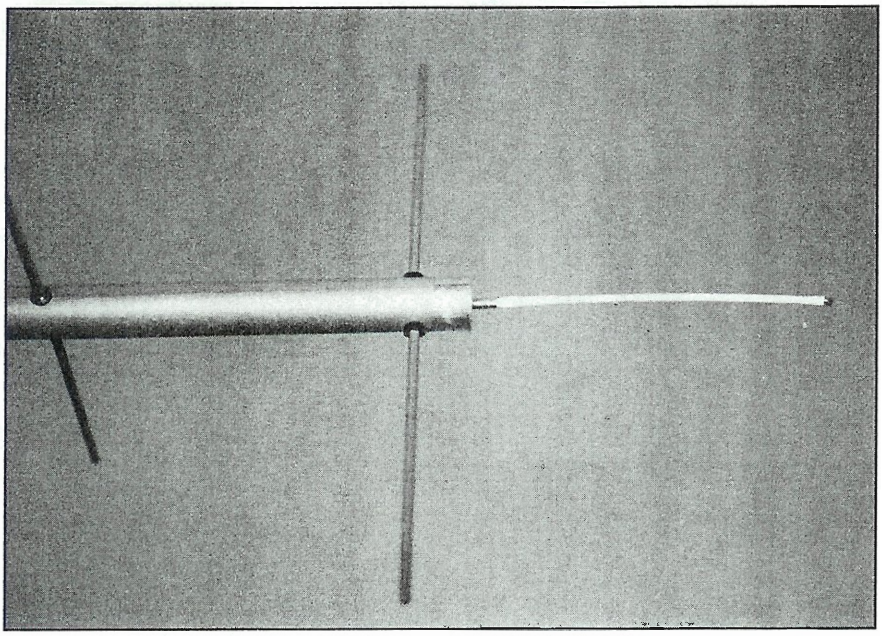


Photo 2. A discharger mounted on the boom of a 430MHz, circularly polarized satellite antenna.

for fair-weather discharger current, changes in readings can detect an approaching front when it is still 20 miles to 30 miles away. Using the ammeter in this way requires a resolution of at least 1.0 picoamp.

The onset of audible noise did not happen simultaneous with discharger increases above the normal baseline. Usually, the baseline current had to be exceeded by at least 10 times before detectable audio noise resulted. Nevertheless, the receiver front end can be desensitized by 10dB to 20dB before noise is heard.

Mounting

The dischargers are 0.187-inch (3/16″) × 6.75-inches long. Each discharger requires one tapped 4-40 mounting hole. Only the 0.25-inch base of the discharger is metal, so antennas are not significantly detuned even when a discharger is mounted on an active element at frequencies below 470MHz.

Most antennas are at dc ground potential. With such antennas, no modification is required when a discharger is mounted. A discharger mounted on an element that is not dc grounded should be bypassed to ground with a 100KΩ or 1MΩ resistor to provide the dc path.

Photo 2 above shows a discharger

mounted on the boom of a 430MHz, circularly polarized satellite antenna.

You can demonstrate how effective the discharger is by insulating it from the boom and connecting a single wire to a zero-center, 150μA meter to ground, as shown in Figure 8 to the right. The meter should be protected with back-to-back diodes.

As much as 100μA of discharger current will flow when the noise level rises to 40dB above the ambient level. The readings may differ at various installations, but the correlation will be evident.

A zero-centered meter is used because the discharge can be positive-point corona or negative-point corona.

These dischargers are not lightning "deterrent" devices. Although they are installed in the most prominent dc field area, they may become "sacrificial" if lightning strikes, possibly reducing damage to more expensive equipment.

Once installed, dischargers require no maintenance. They rarely need to be replaced.

As a precaution, check them to be sure they show continuity with whatever they are attached to. There must be an electrical path from the discharger to the structure. Other than checking for physical damage and a satisfactory mechanical connection while you perform other antenna and feedline inspections, you will find the dischargers are maintenance-free.

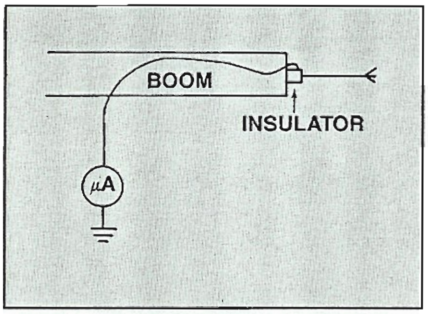


Figure 8. To demonstrate how effective the discharger is, insulate it from the boom and connect a single wire to a zero-center, 150μA meter to ground. Protect the meter with back-to-back diodes. As much as 100μA of discharger current will flow when the noise level rises to 40dB above the ambient level. The readings may differ at various installations, but the correlation will be evident.

A discharger's resistance is in excess of 20MΩ, so to measure its resistance, a driving potential of at least 100V may be required. Take care when making measurements at a voltage that high.

References

1. "Origin of Lightning," Lockheed Service Digest.

2. "Cadweld" is a registered trademark of EIRCO.

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