MOONBOUNCE cont'd

factors as Faraday rotation can cause signals to return out of polarization and nothing will be received for long periods. Faraday rotation usually changes, so some reception will be possible during a one-hour test on 2 meters.

When you have checked your system and completed some receiving tests, it's time to contact an experienced EME operator and attempt a QSO. You can usually find someone who will attempt a QSO if you check into the EME net (see sidebar). If you can't operate HF, look in The World Above 50 MHz column in *QST*, check the results of the ARRL EME Contest, or obtain a copy of one of the EME newsletters for an idea of who is active with a big signal, and write a letter asking for a schedule. These sources are explained elsewhere in this article.

Operating times and procedure must be agreed upon in advance and a frequency selected. The usual procedure on 144 MHz is for each station to transmit for two minutes and listen for the next two minutes; the easternmost station begins by transmitting the first two minutes of the hour. This sequence continues for one hour or until the QSO is completed. Clocks must be calibrated carefully with WWV or at least with each other.

Two-meter EME QSOs follow a set procedure. See Tables 3 and 4. Call signs of the stations are repeated during the first minute and a half of each two-minute sequence. Once an operator hears his call sign, he will send a signal report during the last half minute. If he hears nothing, then nothing is sent during the last half minute.

If complete call signs are copied, an O is sent as the report; if portions of calls are heard, an M is sent. Experienced operators sometimes use the RST system if signals are very strong. Once you hear your report from the other station, discontinue sending call signs (except as required by FCC for identification) and begin filling the first 1½ minutes of your 2-minute transmit periods with RO RO RO RO. This indicates "Roger my report. Your report is O." Send O until you hear an RRR from the other station. Many finish a QSO by sending 73 73 73 $\overline{SK}$ $\overline{SK}$ $\overline{SK}$. Discussion with the other operator prior to beginning the test should help clarify QSO procedure.

That's the end of our overview of EME operation. If you think you would enjoy putting together a station, read the referenced articles and books for more information. Most important, contact active EME operators and ask for help. Don't be bashful! Most would jump at the chance to help you get on the air "off the moon." With some work, you can join that exclusive club of operators who have QSOed via the ultimate long path!

Table 3
Signal Reports Used on 144 MHz

T—Signal just detectable.
M—Portions of call copied.
O—Complete call set has been received.
R—Both "O" report and call sets have been received.
SK—End of contact.

Table 4
144-MHz Procedure—2-Minute Sequence

Period	*1½ Minutes*	*30 Seconds*
1	Calls (W6XXX DE W1XXX)	
2	W1XXX DE W6XXX	M M M M
3	W6XXX DE W1XXX	O O O O
4	RO RO RO RO	DE W1XXX K
5	R R R R R	DE W6XXX K
6	QRZ? EME	DE W1XXX K

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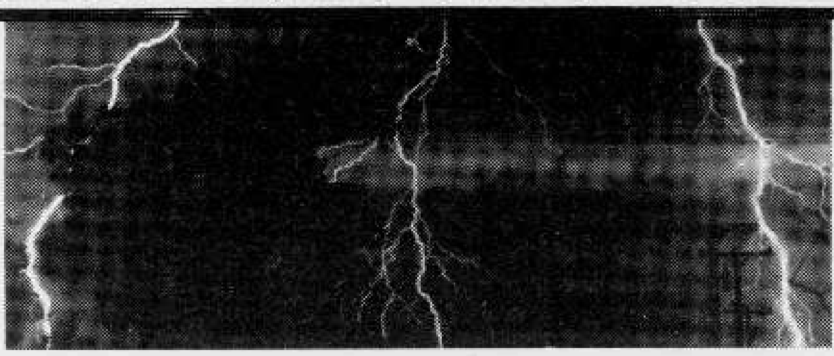

Lightning Protection for Your Equipment

Don't Blow It!

by W. Clem Small, KR6A

In the August 1985 issue of Monitoring Times, reader Kal White suggested that an article on lightning protection, both for electronic items and for antennas, would be of interest to our readers. And from quite another source, the Radio Communication Handbook(1), the same concern is voiced: "In order to achieve the most efficient radiation from an aerial, it should in general be erected in the clear and as high as possible. In such conditions it then becomes a potential hazard since it represents a very good lightning conductor.

"A strike to an unguarded aerial can have disastrous results in the radio room, causing damage which may be serious or even fatal. It is therefore prudent to give some thought to the question of lightning protection when erecting an antenna system."

I agree with both reader White and the handbook just quoted, so let's be "prudent" and "give some thought" to various points of interest in respect to lightning and protection from its effects.

If you live in an area such as the San Francisco Bay Area where I live, you might choose to forget about lightning protection. Lightning damage is so infrequent here that most radio enthusiasts I know do not include lightning protection at their stations.

That doesn't mean there are no strikes by lightning around here--there are occasional reports of lightning damage. Usually, they are to tall tower-mounted antennas and the associated equipment, located on high hilltops. Still, most of the people that I know in this area do not utilize lightning protection and are generally none the worse for it.

Back in the midwest as a kid, however, it was a different story! Thunderstorms were frequent and severe. I recall an antenna one of my friends had which was not grounded and, luckily, was not connected to his receiver at the moment that lightning struck it. He was in his house at the time, and was startled to behold "electrical fire" shoot off the end of the antenna lead-in and bounce around the room like a ball!

My friend's experience was not unique and there are many radio enthusiasts like reader White who are not so lucky as to have only harmless "balls of fire" result from the lightning strike. There are many areas of the U.S.A., and of the world in general, where these "bolts from the blue" are not too uncommon. So, for many MT readers, lightning protection is a factor to consider.

Past studies have shown that, in the U.S. alone, lightning may cause up to 400 deaths, 1000 injuries and millions of dollars in damage annually.(2) Danger to persons is minimal, however, when they are indoors in a substantial building such as the average home.

Danger is maximum in outdoor exposed areas on high places such as hills or tall buildings. Taking cover under a single isolated tree is not safe, either, as the tree may attract a lightning strike and the current thus passes down its trunk to the area beneath, perhaps exploding the tree trunk and sending chunks of wood flying as this happens.

And don't believe that old adage that "lightning never strikes twice in the same place." It does strike repeatedly in the same place in some locations. Tall towers on high hills in areas where lightning is common are hit repeatedly by lightning bolts.

Underground caves, low ground and dense woods are safer areas. Much useful information on protecting buildings, towers and even trees from lightning damage is contained in reference (2).

BEN FRANKLIN FOUND THE "KEY"

Let's take a look at the history of the problem. Most MT readers are probably familiar with Benjamin Franklin's famous key experiment in which he showed that lightning was electrical in nature. Not so well known is Franklin's "sentry box" experiment(3) which actually preceded the kite experiment.

In the sentry box experiment a tall metal rod with sharpened end was extended over a small enclosure. The rod extended through the box to an insulated platform on which a man could stand to test whether there was electrification, via the rod, of the platform.

Several experimenters were actually killed by lightning while trying Franklin's experiments!

The rod of the sentry box was the first lightning rod for which Franklin is now famous. Lightning rods help protect against lightning by draining atmospheric electricity off to ground slowly through their sharp point, or by attracting and conducting to ground some lightning bolts which might otherwise cause damage to a structure. Lightning rods are currently found on houses, barns and other tall buildings the world over.

To begin your lightning protection program, you might consider installing lightning rods on high exposed buildings or trees. A lightning rod must extend at least 10 inches above the building or tree it protects and be connected to the ground by a heavy electrical conductor. Wire size recommendations vary from 10 gauge to 17 gauge, with one source suggesting that 13 gauge should be adequate for the largest discharge one might expect.(2)

The grounding wire should run from the lightning rod to the ground with as little bending as possible: sharp bends in the wire may make it ineffective. Rods used for the ground connection are usually at least eight feet long, driven vertically down into the earth. The use of water pipes, especially newer ones which may utilize plastic-pipe sections, is discouraged. Gas pipes are never utilized for ground connections for obvious reasons.

As explained below, adding lightning protection to tall buildings and trees

LIGHTNING PROTECTION cont'd

surrounding your station can be an important part of the overall lightning-damage prevention-and-minimization program for your station.

PROTECTING THE ANTENNA AND FEEDLINE

OK now, so much for the general protection, what about the protection of antennas and communication gear? Metal antenna towers are fine lightning rods if they are grounded at the lower end, but ungrounded, they can lead to problems. For instance, a lightning strike on an ungrounded tower can follow the tower into its base and explode the base as it seeks the ground beneath.

If your tower is such that it must be left ungrounded in order to function as a base-fed antenna, you might want to consider using a lightning arrestor of some sort at the base of the antenna. One type of arrestor which is used on vertical antennas is shown in figure one.

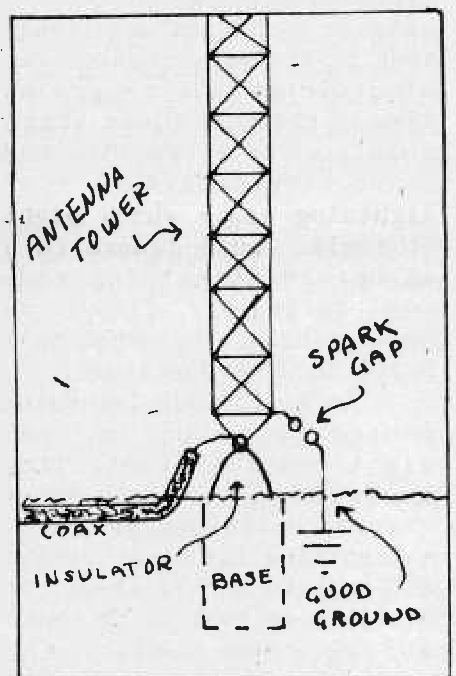

FIGURE 1. SPARK-GAP TYPE LIGHTNING ARRESTOR USED ON UNGROUNDED TOWER. COAXIAL CABLE BRAID CONNECTS TO BURIED RADIALS (NOT SHOWN)

A switch which grounds the antenna at the base when the antenna is not used is also a protection, but must not be accidentally left shorted during antenna use, especially during transmission.

The shield or outer braid of coaxial cable feedlines which leave the tower should be grounded as they enter the house. Running them underground for their outside length is a good idea also. Antenna rotor cables and transmission lines would have some protection if threaded down through the center of the tower rather than coming down alongside it.

These sorts of precautions are valuable for protection against near-miss strikes. If you sustain a direct hit from a sizable lightning bolt, it is likely you will sustain equipment damage and possibly tower damage, even with the precautions suggested. That's one argument for using lightning rods of various nearby buildings and tall trees. If you get the lightning bolt to leap to ground through these rods before it gets near to your antenna or tower, then your equipment won't get the direct strike, and you have won half the battle. The other precautions suggested in this article will help with the other half.

INSIDE THE STATION

What can you do to minimize damage to equipment once the strike has gotten past the defenses you have provided outside? First, for your own safety as well as for the welfare of your equipment, you should never operate your equipment during weather likely to

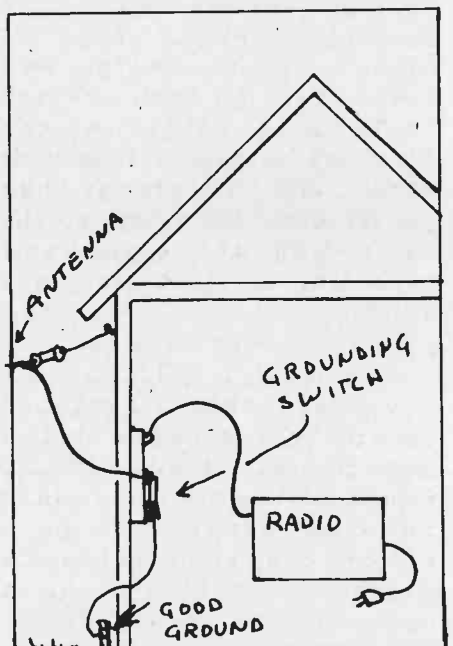

FIGURE 2. ANTENNA GROUNDING CIRCUIT.

produce lightning. Secondly, there is only one sure way to protect your equipment from lightning: Disconnect it from the antenna and power line after you use it. The disconnected antenna should be grounded (see fig. 2).

These precautions are admittedly a nuisance, but one that I have lived with during the thunderstorm season. After seeing the "well-fried front end" of a friend's rig, I became a believer. This approach admittedly takes a few extra seconds each time you operate, but it is fool proof.

Some old timers use an automatic set-up such as that shown in figure three, although as you go higher in frequency into the UHF

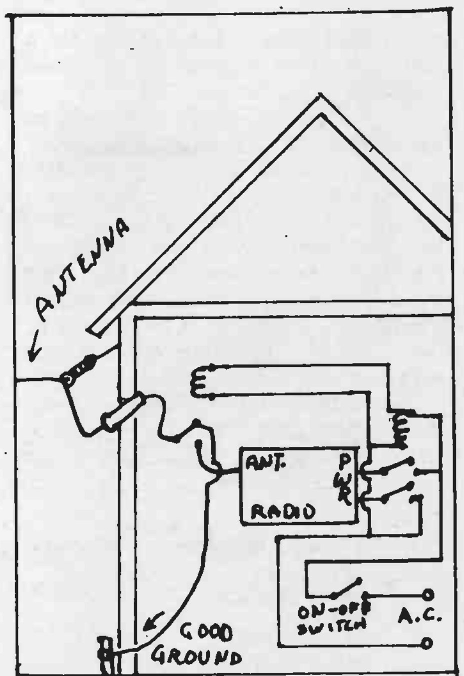

FIGURE 3. AUTOMATED ANTENNA GROUNDING CIRCUIT

region, the switching of the antenna by this system may cause some loss in signal strength. Good quality antenna relays will help here. For open wire lead-ins use an open frame type relay; for coaxial lead-in, there are coaxial relays available. A good source of information on lightning protection for antennas and towers is Radio Communication Handbook(1), referenced above.

There are also various types of lightning arrestors available from electronic parts houses which may be attached to your antenna as illustrated in figure four. Some radio enthusiasts even make their own spark-gap type arrestors from scratch using an automotive sparkplug. The gap is usually set as close as the situation will allow without shorting out the antenna to ground.

(Ed.Note: While spark gap lightning protection may be adequate for tube-type radios, the amount of voltage present jumping an air gap is enough to spell doom for most solid-state receivers and scanners.)

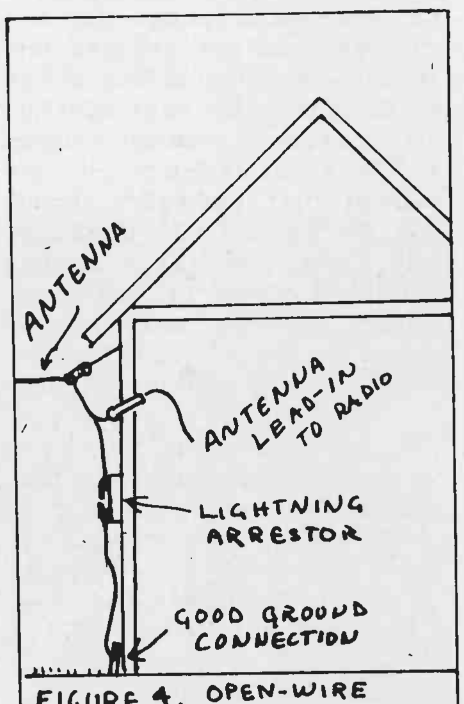

FIGURE 4. OPEN-WIRE ANTENNA LEAD-IN WITH SPARK-GAP TYPE LIGHTNING ARRESTOR.

When there is transmission involved as well as reception, be careful not to set the gaps so close that they arc during transmission. Also for transmitting antennas, if you have sizable SWR on your transmission line (who doesn't at times?) you would probably profit from finding a voltage node for the place of attachment for the lightning arrestor.

There are in-line lightning arrestors available for coaxial cable lead-ins, too. For receive-only antennas, a neon bulb or special gas tube protector connected between antenna and ground will afford a degree of protection by discharging some low level electrical pulses and static charges(4).

In planning for equipment protection, there is another lightning-conduction path to consider besides the antenna-ground system. This is the power line. Nearby or direct strikes to power lines may cause massive surges to propagate along the power lines and enter your equipment, destroying as they surge. Various surge protectors are available from electronic supply houses.

If you live in "thunderstorm country," give some consideration to a few precautions and protect your equipment. It's a small price to pay for a bit of insurance that your station will continue to serve you faithfully as you pursue your interests in the fascinating field of radio communications. ●

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