Surviving the Unthinkable: Part III

WA8YKN outlines simple precautions that will allow your radio equipment to survive an electromagnetic pulse.

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One of the primary justifications for the very existence of amateur radio is emergency communications. Indeed, amateurs all over the world have volunteered their skills in times of need, and we can look with pride on our record to date.

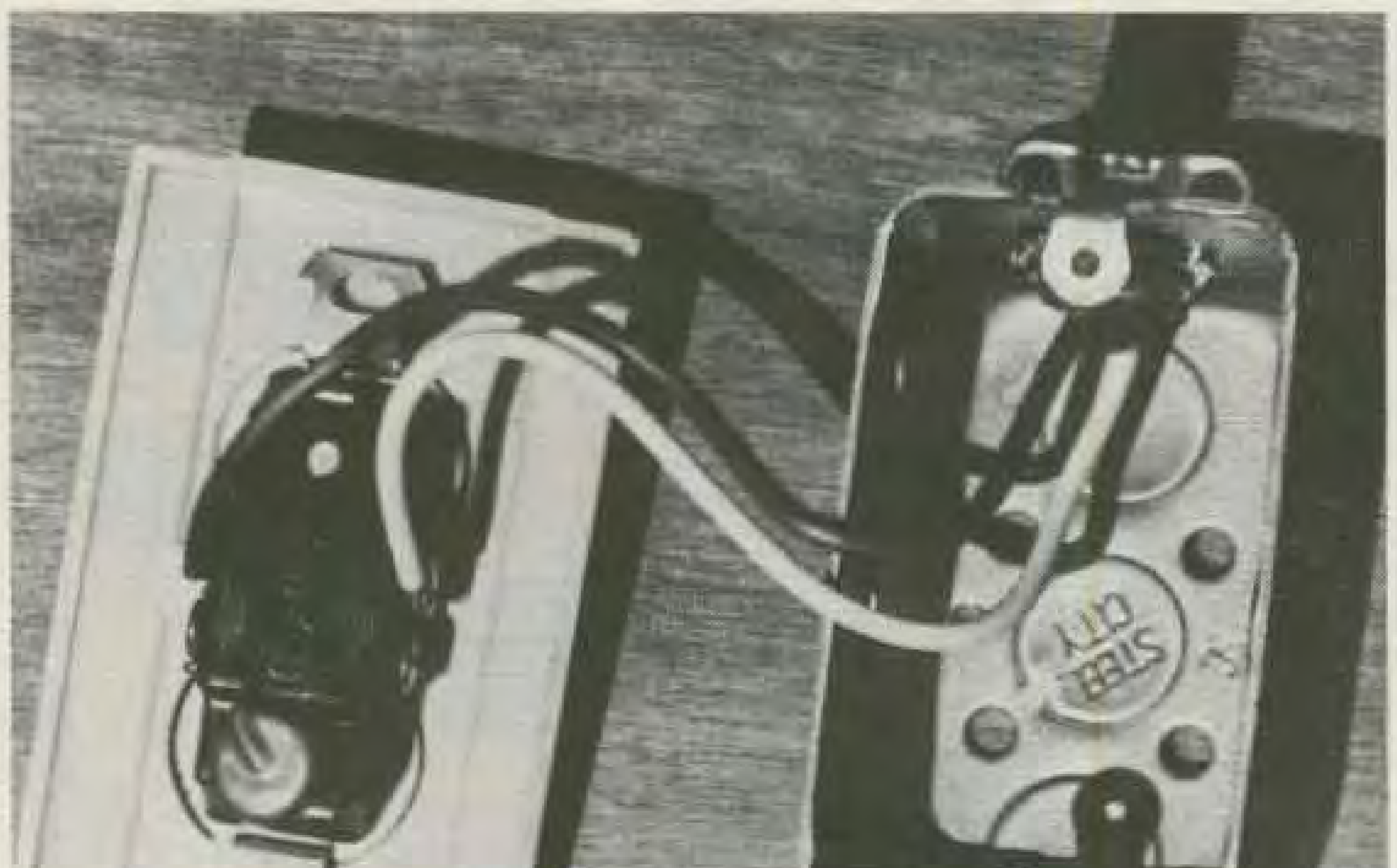

Photo A. Electric outlet with MOV spike suppressor properly installed. Below, two MOVs are connected in series for installation on a 220-volt line.

However, with today's ever-present nuclear threat, there exists a potential for the greatest communications disaster ever imagined, and there is a very great possibility that this time amateur radio might not be able to do the job. The danger to commercial, military, and amateur communications is EMP, electromagnetic pulse.

When a nuclear bomb is detonated, electromagnetic energy is released across the entire spectrum, from extremely low frequency up through radio frequency, infrared (heat), and right on through visible light to gamma rays. This massive release of broad-spectrum energy can cause large-scale disruption of radio propagation.

However, the situation could be much worse. If the device were detonated above the atmosphere, say 300 miles or more, the high-energy gamma rays released in the first split second of the explosion would crash into the molecules of the upper atmosphere, knocking electrons loose. These electrons would be gathered up by the earth's magnetic field, where they would be deflected to the planet's surface. The result is a discharge of extremely high voltage which finds its way to ground through any conductor available, much like a bolt of lightning does.

Just as lightning striking an antenna will destroy a radio on its way to ground, the high currents generated in cables, overhead wires, antennas, and other conductors can destroy electrical equipment connected to them. This can cause loss of electrical power, telephone service, and other serious problems. But the EMP isn't through yet. The large current flowing through all these conductors to ground generates a huge electromagnetic field, and that's the real problem for solid-state electronics, amateur radio included.

When an electromagnetic field collapses, it will generate *induced* current in any conductor which happens to "cut" its lines of magnetic force. The magnitude of the induced current is proportional to the intensity of the field that created it.

The field intensity of an EMP caused by a nuclear device of moderate size exploded above the atmosphere can reach 50,000 volts/meter in the first ten billionths of a second.

The problem to radio amateurs is clear. The initial voltage pulse from either the ac power line or from the antenna and feedline can destroy an amateur-radio station. And even if the antenna and power are disconnected, the currents induced by the collapsing magnetic field into the very circuits of the radio gear can destroy transistors and integrated circuits with ease.

The similarity between the effects of EMP and lightning are striking (pun intended). However, while a lightning strike might damage some equipment in the general area, the EMP from a nuclear blast would cover a much larger area. In fact, if the device were detonated around 400 miles above the central US, the resultant EMP could damage equipment over most of the country! Imagine lightning striking every power line, radio tower, and telephone pole in the country *simultaneously* and you can begin to realize the extent of the EMP threat.

In 1962, during a series of high-altitude weapon tests, a 1.5-megaton bomb called "Starfish" was detonated 250 miles above Johnston Island in the Pacific Ocean. Instantly, lights winked out and burglar alarms rang all over Hawaii, over 600 miles away! Such an effect from so small a device was unexpected and began the first real look into the EMP problem.

No one is more concerned about EMP than the military. Since the Nuclear Test Ban Treaty prohibits atmospheric tests, a way had to be found to simulate the effects so that various protective measures could be evaluated. One such EMP simulator is "Trestle," located at Kirtland AFB in New Mexico. Trestle has a platform twelve stories high which can support a B-52 bomber. In order to simulate a free-space condition, the entire structure is made of wood! 250,000 wooden nuts and bolts hold the structure together. Trestle can generate five million volts which is discharged through antennas surrounding the structure.

The results of tests at Trestle and other simulators seem to indicate that the actual effect of EMP is pretty hard to predict. In fact, in a study by the National Research Council Committee, it was found that the effects of EMP often varied from predicted results by as much as 100:1 in either direction!

Even though test results have often been unpredictable, enough data has been gathered to suggest that there is much that we, as amateurs, can do to protect our equipment from the effects of EMP. It is important that we take these steps if amateur radio is going to be of any value in the event of an EMP emergency. Let's take a look at the typical amateur station and see what can be done.

Power lines: The best bet for ac power is to supply everything from a single fused disconnect located at a convenient spot in the room, to be used as a "master switch." This way the station, when not in use, would not be vulnerable to large spikes propagating down the ac line.

To offer some protection while in use, a transient suppressor such as a GE-MOV (General Electric metal-oxide varistor) should be installed from each ac line to ground at the disconnect. An additional MOV should be installed across each outlet into which the equipment is plugged. (See Photo A.)

Another source of trouble here is the three-wire cord. These things are fine to prevent your toaster from electrocuting you if it should develop a short, but on radio equipment they are an invitation to ground loops, and in the event of an EMP or lightning strike, currents can be induced from the ac line to the third "ground" wire, causing large circulating currents in the chassis itself. That brings us to the next point.

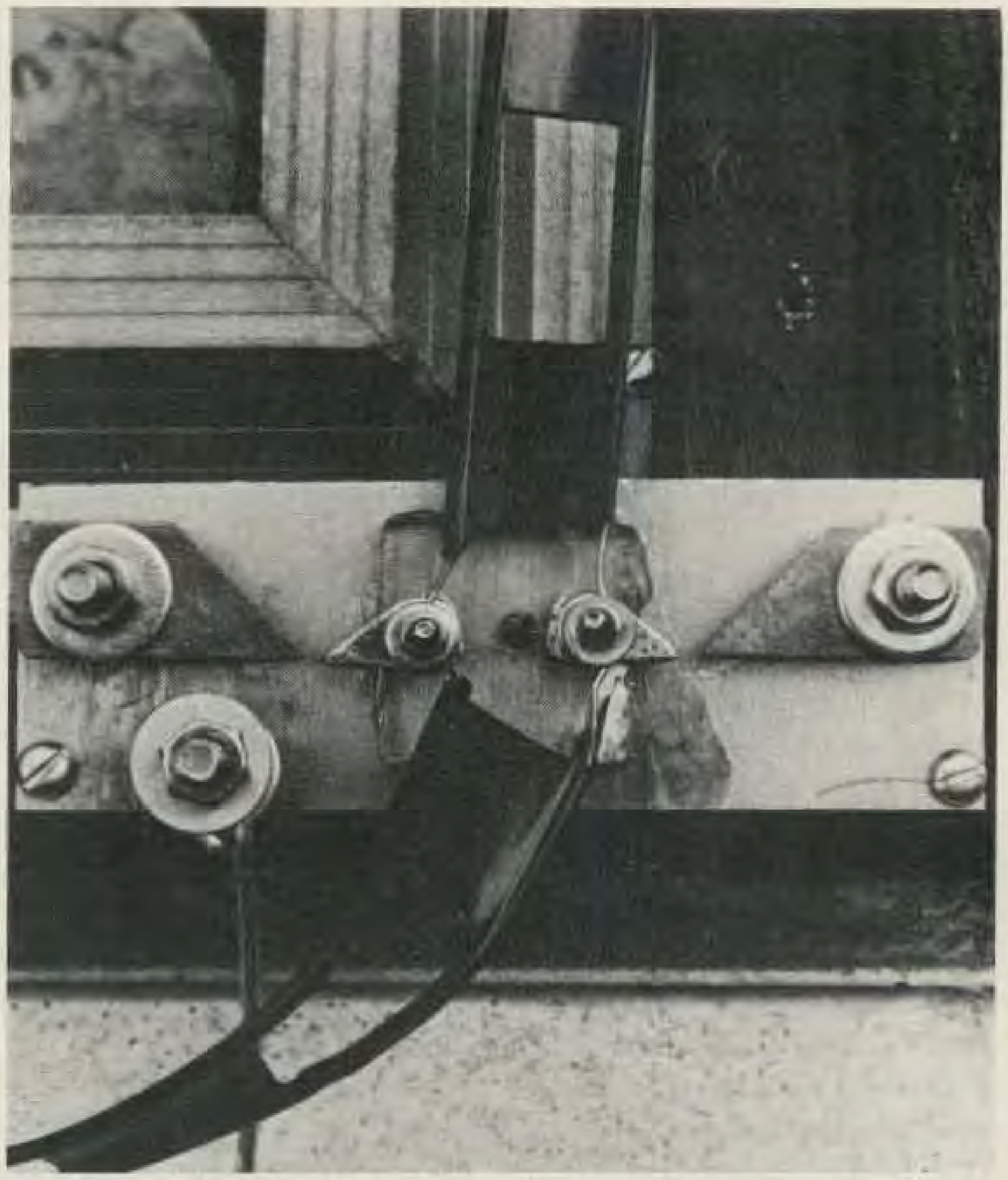

Photo B. A simple home-brew high-voltage discharge gap for open-wire feedlines.

Grounding: If we are going to spare our equipment from EMP, we have to offer it something more attractive. We need the *best* ground we can possibly get. The standard eight-foot copper ground rod is a good starting point. Even better is several ground rods several feet apart joined together by a heavy (#8 or larger) wire just below the surface. The ground should be located near the equipment so that the connecting wire is as short and straight as possible.

Many amateur stations are located near a window to provide easy ingress of feedlines, and this is an ideal place for the "station ground." Mount a plate of 1/4-inch aluminum to the windowsill and connect it directly to ground. Now *all* equipment in the shack is connected *individually* and *directly* to the ground plate using #8 aluminum wire. The cold water pipes, the tower base, the neighbor's chain-link fence, in short all the various large metal objects that hams are known to hook into the ground system, should all be connected to the common ground plate. Everything connects to *one point!* This is why we cut off all the grounded plugs in the previous step. Does your house have aluminum siding? Ground it! Not only will it provide lightning protection, but it will also provide a degree of shielding.

Feedlines should each be provided with a good lightning arrestor at the point where it enters the house. Coaxial feedlines can use the arc-gap type, such as the Cushcraft "Blitz-Bug" or something similar. For open-wire line or twinlead, a simple arc gap can be made

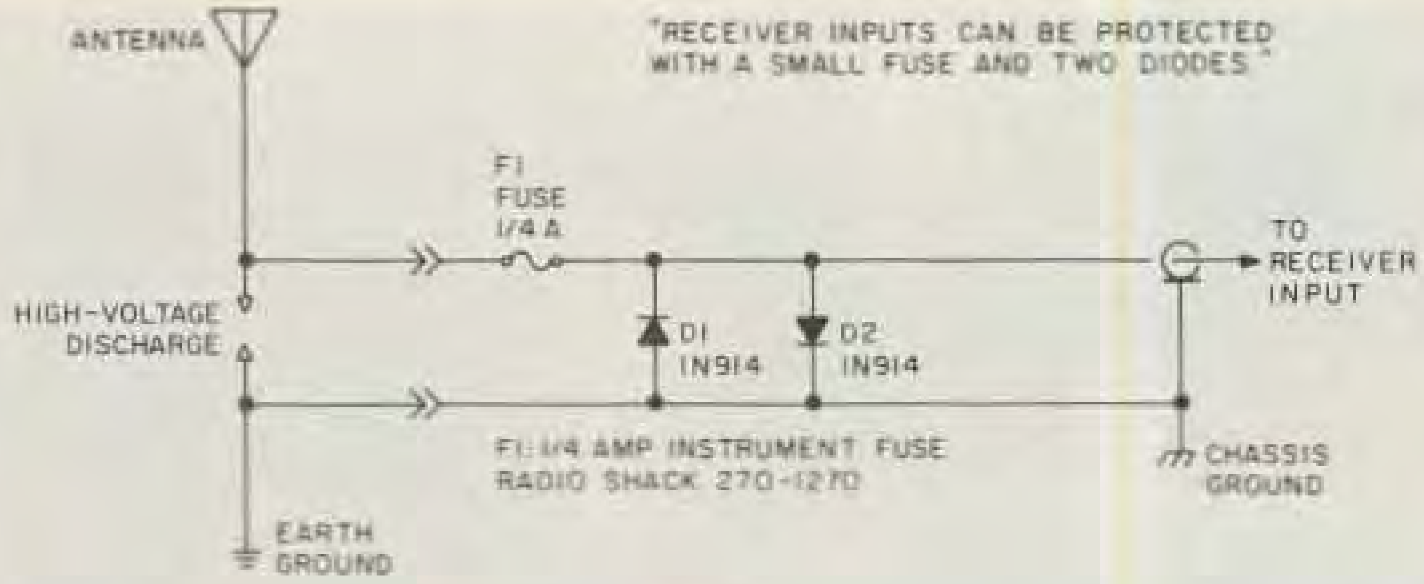

Fig. 1.

from copper or aluminum. (An example is shown in the *Radio Amateur's Handbook*. See Photo B.) Whatever type of suppressor is used, connect it directly to the station ground.

Even with the lightning arrestors, it's a good idea to ground all feedlines when not in use. The rotary switch commonly used to select coax-fed antennas usually will ground all inputs but the one in use. Open-wire feedlines can be grounded with a large knife switch.

Feedlines can also be fused with fast fuses such as the Buss ABC type. The input to a sensitive receiver can be protected with a 1/4-Amp fuse such as the kind used to protect the input of a delicate volt ohmmeter. Back-to-back diodes should be added across the antenna terminals to shunt the pulse to ground, blowing the fuse before the receiver is damaged. (See Fig. 1.)

If the equipment in your shack is tube-type, the above steps may be all that is needed to offer reasonable protection from EMP. Once we've provided a good ground and shunted off the primary surge, tubes are usually quite capable of withstanding the voltages induced in the circuits by the collapsing field of the EMP. However, if your equipment is solid state, you may have to look at the final category in our EMP protection plan.

Shielding: The field generated by the EMP will not cause current to flow in the circuits of our equipment if we prevent the magnetic lines of force from reaching those circuits. Many commercially produced transceivers on the market today are very well shielded. Some are not. This will have to be determined on a case-by-case basis. Things to watch are seams and cracks in cabinets, and jacks for connecting cables. The "Construction Practices" chapter of the *Radio Amateur's Handbook* gives practical information on making radio equipment truly rf-tight.

As we look back over all the above steps to protect our equipment from EMP, one fact stands out clearly: *All of the steps are extensions of normal amateur practice!* There is nothing secret or exotic here, not even anything difficult or expensive. In fact, if you read the building codes governing radio stations, you will probably find that most of these switching and grounding techniques are *required by law!* But even though we all know about proper grounding, lightning suppression, etc., how many amateurs have taken the time to do the job right?

By taking the steps outlined above, we can stand a much better chance of providing the service our neighbors expect of us should the electromagnetic pulse ever threaten our normal communication channels. At the same time we will be making our amateur-radio stations better organized, less likely to cause TVI, and above all, safer! ■