"This Old Dipole"
or
Dipole 101

An antenna construction workshop conducted at Marshall N1FN's QTH on Sunday, 8/2/98

Mission:

> Replace an old co-ax fed 40M dipole with a new one, fed with 300 Ohm ladder line and in doing so provide a "workshop" for the necessary techniques, and document the process for "posterity."

It may take awhile for the thumbnail images to load... please be patient!

Click on the pictures to view in full size.

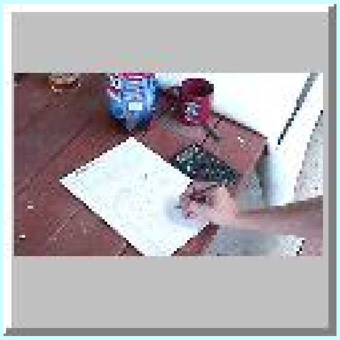
Here's the center connection of the old dipole. It shows a little wear and tear, but really not too bad after three years in the air. It was wrapped in electrical tape, which did a pretty good job of keeping out the elements.

The main reason for rebuilding (or replacing) it was that the old wire was full of splices after having been adjusted for various positions over the house, and repairs where it broke once, and neede further adjustment after its last move about 6 feet east. Since it had to be taken down, it seemed sensible to rebuild it. Marshall also decided to replace the original 50 Ohm coax with 300 Ohm ladder line for the feed. 300 Ohm is a little harder to find than 450 Ohm, but has lower wind resistance and is generally easier to handle. It presents all of the advantages of balanced transmission line (the main ones we were looking for were very low loss and the ability to tune the antenna for other bands), and at the design frequency is a closer match to the impedance of the dipole. Still another advantage of ladder line as compared with coax is that on "awkward" bands you have some options. You can connect both legs of the ladder line to your antenna tuner and feet it as if it were a random wire antenna, or connect either of the two legs and let the other one float.

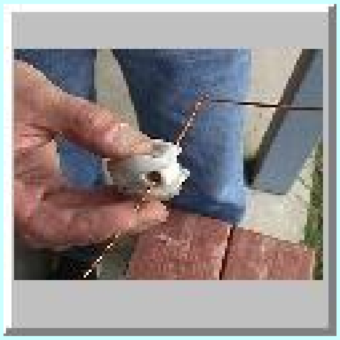
Marshall decided to use the existing ropes to attach the antenna to the trees, but he described how to put the ropes into place in a "new" system. The perfect installation, he said, would be to attach the ends of the antenna to two structures which won't move. If you can't do that, then one fixed and one moveable (e.g. a chimney and a tree) is still better than two trees, because trees move a lot. One end of this dipole is a youngish pine tree, which really isn't as tall as would be desired, but it does have the advantage that is is fairly "whippy" and the other tree can "pull" the dipole (and the attached pine tree) without breaking the wire. If the tree had been bigger, it would have been advisable to put the rope through a pulley and counterbalance the antenna with a bucket full of rocks.

Marshall (N1FN) uses one of his XYL's prized crystal wineglasses to demonstrate the basic principles of resonance. When a wet fingertip is rubbed around the rim of the glass, the glass vibrates at its characteristic (or resonant) frequency, with a very noticeable ring. At resonance, a very large percentage of the applied power is converted to sound, and little power is required to sustain the oscillation. Alter any of the physical parameters even slightly, as Marshall showed by touching the body of the glass with another finger, and the glass stops ringing. The same principles apply to radio frequency oscillations in a wire. Thus a dipole operated at its resonant frequency is very efficient in that most of the power fed into it is radiated as electromagnetic waves. Off the resonant frequency efficiency drops noticeably. It will still be useful as an antenna, but it will not be as effective. A resonant antenna offers 3dBi gain (compared to a theoretical isotropic radiator). An important point to remember is that adjusting the impedance match at the transmitter end of an antenna system has absolutely no effect on the efficiency or resonance of the antenna itself. The term resonance is often used inappropriately, for example "adjust your antenna tuner for resonance..." which is one reason the usefulness of a resonant dipole is often overlooked. Often operators will use a tuner to adjust the impedance of a wrongly cut antenna, with no idea of how much better it would work at that narrow area of resonance.

The new dipole was made from all new materials. Mighty Samson, the QRP dog offered the use of a "dogbone" insulator for the center connection, but we went with a standard plastic one, with small ceramic insulators for the ends, as you'll see in the illustrations below. For the wire we chose CQ 14awg Solid ccs (copper-clad-steel) wire from the Wireman, also the source for the 300 Ohm 18awg 19-strand copper transmission line. Choice of wire depends on several variables, but the main ones that were taken into account here were ease of working, dimensional stability (stranded wire tends to stretch), and low noise induction (stranded wire offers more wind resistance; movement of the strands, and corrosion build up all contribute to noise).



Hams often think the first step in building a dipole is to do the calculations, but as discussed above there is some pre-requisite homework! At any rate, the math is pretty simple, using the standard formula of 468/f where f is the frequency in MHz, and the answer is in feet. An easy way to remember the formula, as demonstrated by Marshall, is the cheer "Two, four, six, eight! Which antenna will we make? Dipole! Dipole! Yay!" Corny, but effective. This dipole was intended for 7.040MHz, so we divide 468 by 7.040 and get 66.48 feet total length. Divide by 2 to get the length of each side, or the length of the two pieces of wire we need to cut. In this case, each side of the dipole is 33.24 feet long, or 33 feet 2-7/8 inches. The calculations were done twice to confirm the result.



There seems to be some confusion over exactly where you take the measurements of a dipole. On the ends you measure to the farthest point of the loop of wire that goes through the insulator. The picture shows the insulator, and a bend in the wire which will be the measuring point. You bend the wire like this at both ends to mark the necessary length, and allow about 10 inches or so beyond the bend to allow for attaching it to the insulator and also so that the antenna can be lengthened a bit if necessary to adjust the resonant frequency. Marshall said it is sensible to make this allowance because it is very easy to cut it shorter if you need to, but a real pain to cut it longer. When the wire is attached to the insulator, the bend is positioned in the center of the hole through the insulator.

At the center connection, the measurement is technically to the point at which the transmission wires are no longer balanced, in the case of ladder line, or open out in the case of coax. Generally it makes so little difference at HF frequencies that Marshall just measures to the inside of the loop, as with the ends.

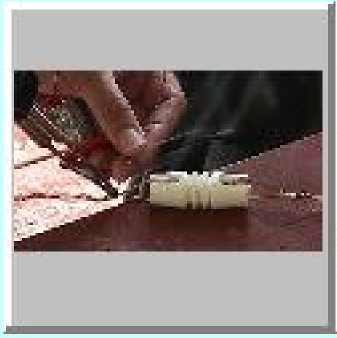
Here (L-R) Wayne (N0POH), Dennis (W0GD), and Michael (KB0ZTN) measured the first wire, using a 25' measuring tape. 25' is measured off from the 0" end of the measuring tape with the wire stock behind the tape and the bend in the end of the wire going to the 25' position. At that point the near end of the wire is picked up and moved to the 8' 2-7/8" mark, and the wire is bent back at the 0" end of the tape, giving a piece of wire with a bend ten inches from one end and another bend 33' 2-7/8" away. Then the wire can be cut a further ten inches or so beyond the measured point. Wait! Measure it again before you cut it! Or, as carpenters say, "measure twice, cut once."

The second wire is not measured with the measuring tape, but by holding it out alongside the first piece. That way, even if you are slightly out in your original measurement, the two pieces will be the same length. It is better to have two pieces that are identical in length but slightly long or short, than one leg which is the correct length and one which is not.

Nate, KD0UE, casts a calibrated eye over the two wires as Wayne holds them.

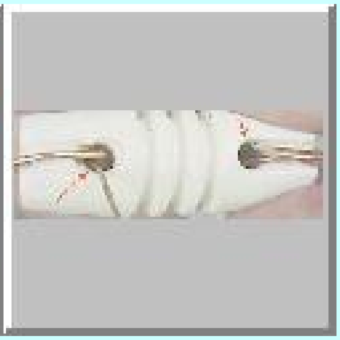
Once the two wires are cut to length, one end of each is attached to the center insulator of the antenna as shown. The bend (marking the measured length of the wire) is centered in the hole in the insulator. The free end is crossed over the running wire so that the two meet at about a 45 degree angle. A sharper angle increases stress on the connection and a broader angle induces extra capacitance. More particularly, 45 degrees is the narrowest angle at which the wires can meet without degrading the strength of the loop.

The free end of the wire is twisted around the running wire, and will usually follow its own path. That is, you don't have to worry about whether the twists are too close together or too far apart, although you do want the loose end to wrap pretty tightly around the running wire.. Since this is the center of the antenna, additional wire length is not necessary and five or six turns around the running wire would be adequate. If the antenna needs to be lengthened later, it will be done at the tree ends, not the center, but we just went with the whole ten inches. It makes no electrical or radio difference.

The two horizontal legs of the dipole are soldered at the center insulator. We used a 230W soldering iron, and ordinary rosin core solder. This was brand new wire, so it took the solder well. Older wire should be cleaned before soldering.

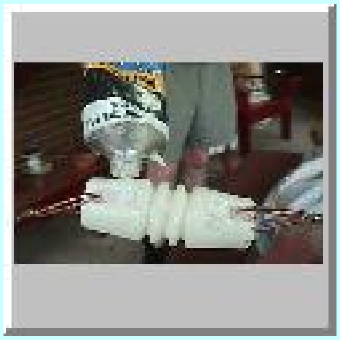
This is a closeup of the center insulator with both legs attached, but before the feed line is connected.

The ends of the two conductors in the feed line are separated over a distance of about six inches from the ends, and four inches stripped, as shown at left above. Use scissors to remove the dielectric material from the middle to the point where you want the separation to finish, leaving two wires with insulation which can be stripped easily. This particular wire is made up of 19 strands which tend to "unwind" so we tinned the very tips of them before inserting them into the center connector as shown above. The two wires are extended through the holes in the insulator until the insulated wire is flush with the surface of the insulator. If you view the full size image at the right, above, you will just be able to see the ends of the insulated line.

The stripped ends of the feed line are wrapped tightly around the antenna wire on each side of the insulator, following the groove made by the twisted wire. The connection is then soldered, making sure that solder has flowed evenly over the entire surface of feedline and twisted antenna wire. The completed center connector is shown at right. If the transmission line is particularly heavy you might want to take a loop of it over the top of the insulator and tape over the entire insulator with electrical tape. With co-ax this approach also helps to keep water out of the line.

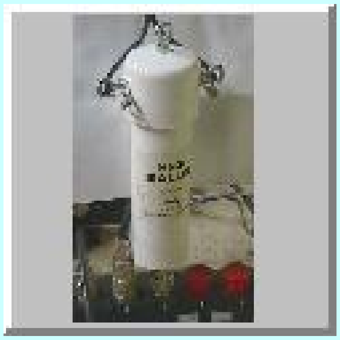


As an optional final touch, the holes are filled with flexible silicone sealant. With most good quality ladder line it is not necessary to seal the end to keep water out of the wire (which IS necessary with co-ax). This was done mostly to keep the little spiders from nesting there. And before somebody starts yelling at us, the use of an acetic acid cured sealant doesn't matter here either-- this is heavy-duty wire and the small amount of vinegar in the glue is not going to cause any problems.

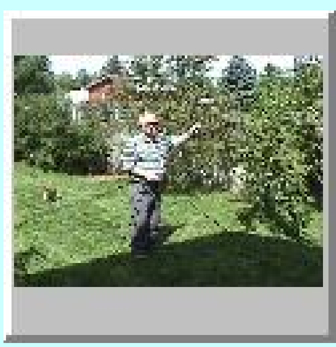
We had to carefully "pre-position" the antenna with parts of it laid over two of the guy lines for a GAP vertical, so we did it BEFORE attaching the ends of the dipole to the end insulators and ropes.

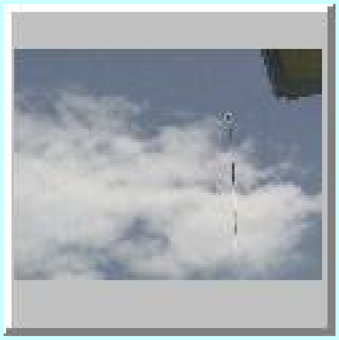
As shown above, the rope and the wire OVERLAP each other in the body of the insulator. Picture it as if the insulator weren't even there-- a loop of rope goes THROUGH a loop of wire. We used nylon sash cord for the ropes-- it has proven to be pretty reliable and has a degree of "give" which helps keep the antenna from breaking when the wind blows. The knot shown is not the same as the double-half-hitch used on the other end. We don't think this knot has a name.

To get to the shack, the feedline is run perpendicular to (90 degrees, or straight away from) the antenna, down to ground level with changes of direction kept as gentle as possible (should be no more than 45 degrees). It's twisted once per foot along its length, so it has a kind of spiral appearance. This lessens wind loading, and also helps to maintain balance between the two sides where there are objects or structures in the near field. In this case, it comes into the house along an opening for a PVC drain pipe, then straight down about four feet to a 4:1 balun which is mounted directly on the shack's main antenna switch with a double-male coax connector. The ends of the feedline are soldered to the lugs on the balun, as shown. The balun is necessary because the antenna tuner, an LDG automatic AT-11, does not include one. If there are severe problems with RF in the shack, the balun can be relocated outside, i.e. under the eaves, and fed with coax from the tuner or switch, but this generally seems to cause more problems than it solves.

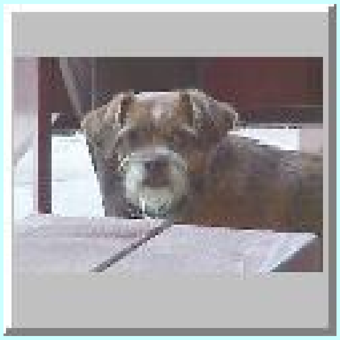
  

At last it's time to hoist away. We used five men and a dog for what is essentially a three man job-- one in the center to guide the wires and feed line over the guy lines and other low-level obstacles, and one on each end to pull on the ropes. The trick was to hold one end secure while raising the other end into position, then raise the held end, then stand back at a distance to judge how much more tension (or less) either end might need so that the antenna is almost but not quite flat. A little bit of droop in the middle is not only acceptable, but indeed gives a much greater capacity to withstand wind stress.



An antenna in the air is a thing of beauty and a joy forever. Well, until it needs "improvement," anyhow!

Nate seems to have some sort of corner on the market for old ski poles and inventive uses for them. This is the "snow basket" from an ordinary ski pole, and as you can see it would make an excellent center insulator for a dipole. The holes are perfectly placed two wires, a center support, and feed line, with a couple of spares for guying or extra elements.



Mighty Samson, the QRP Dog, says "Nice job, guys!"

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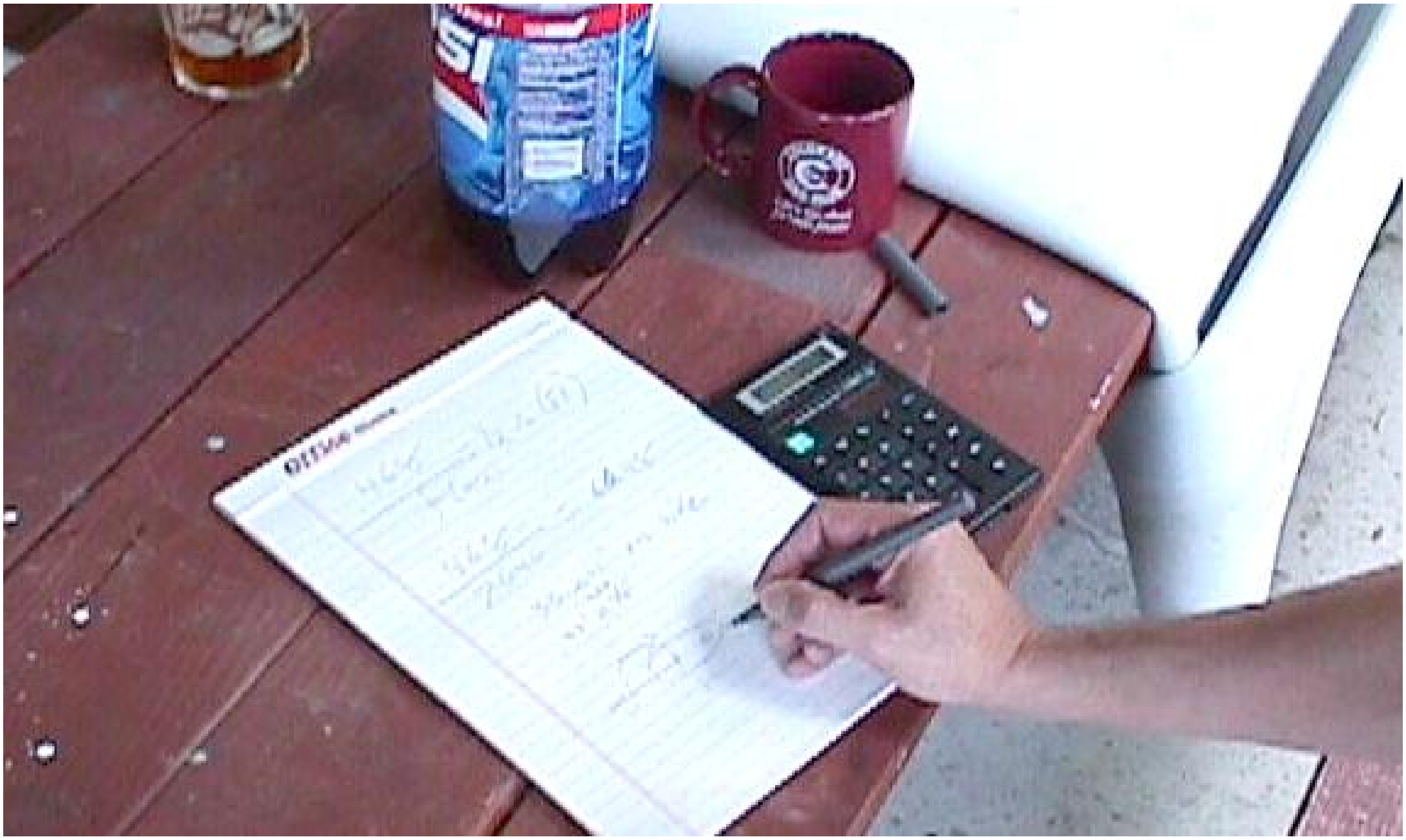
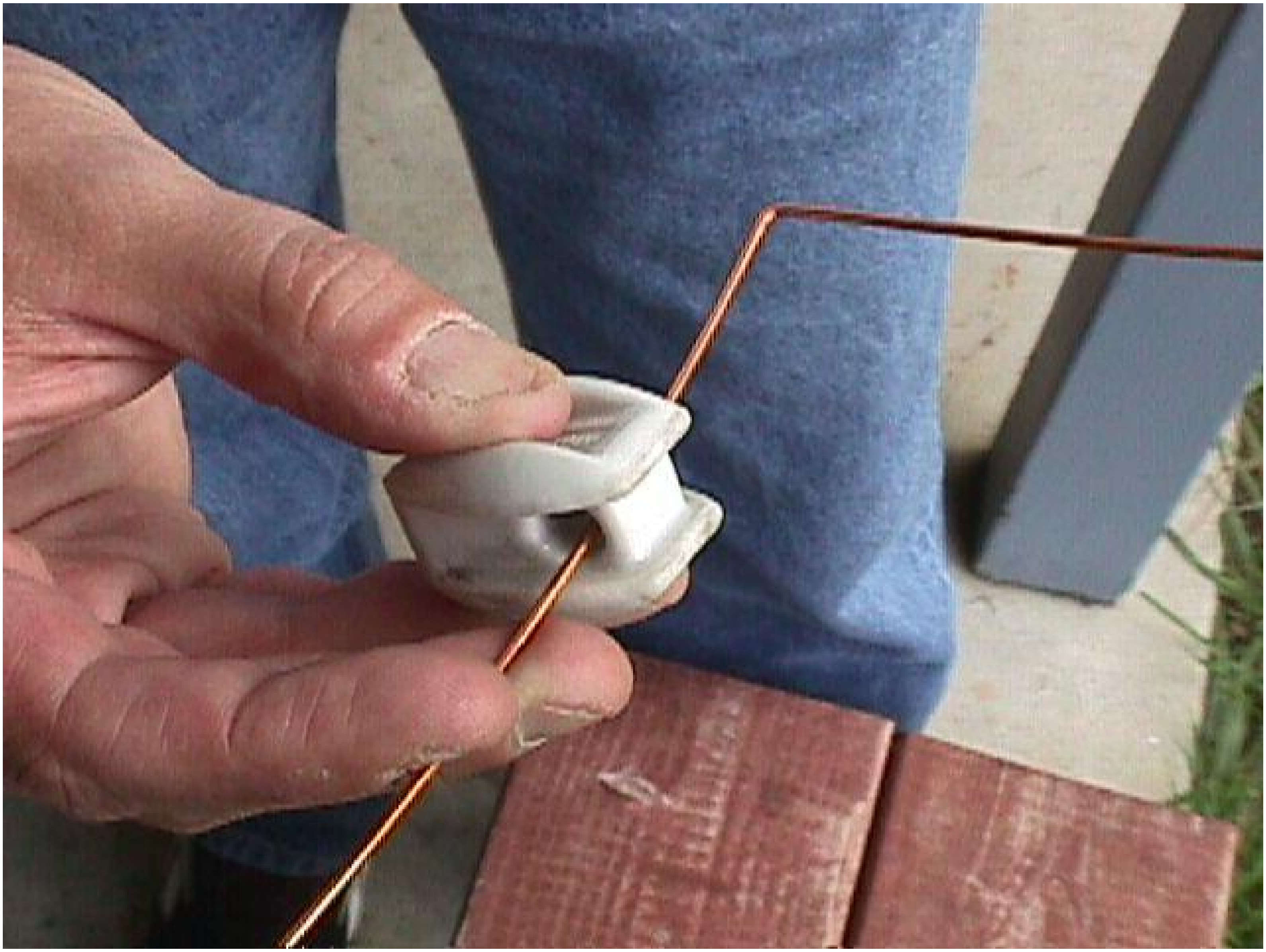
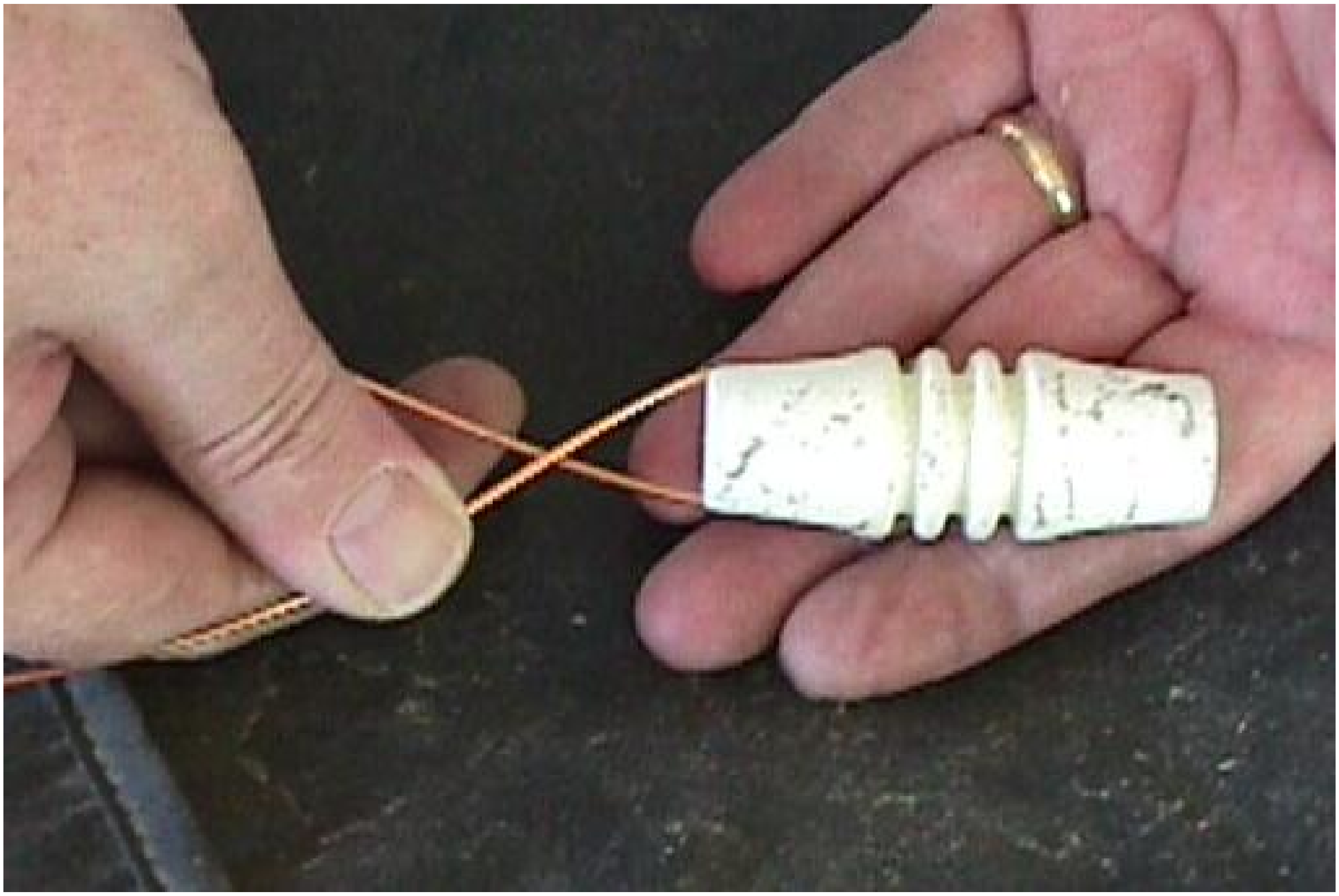
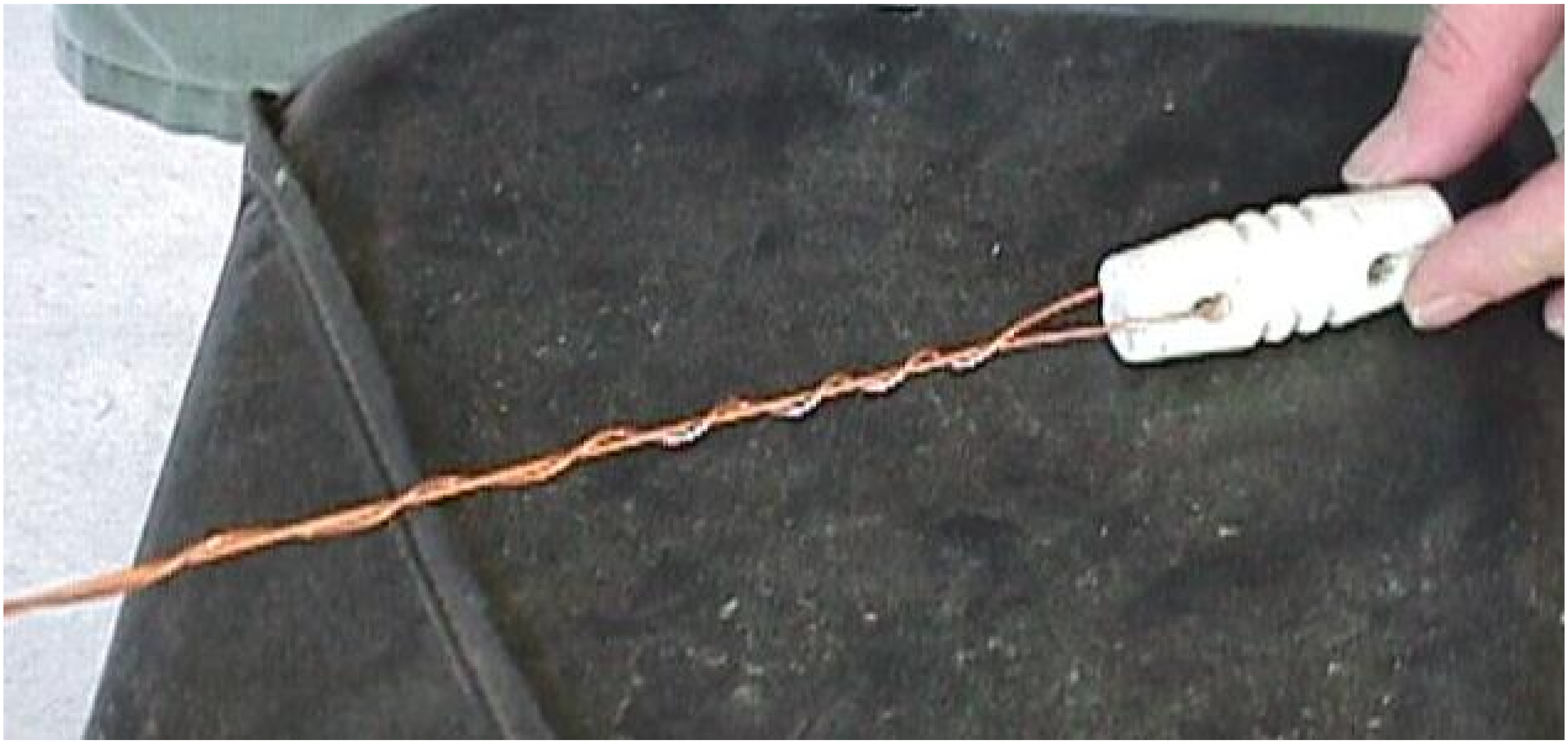
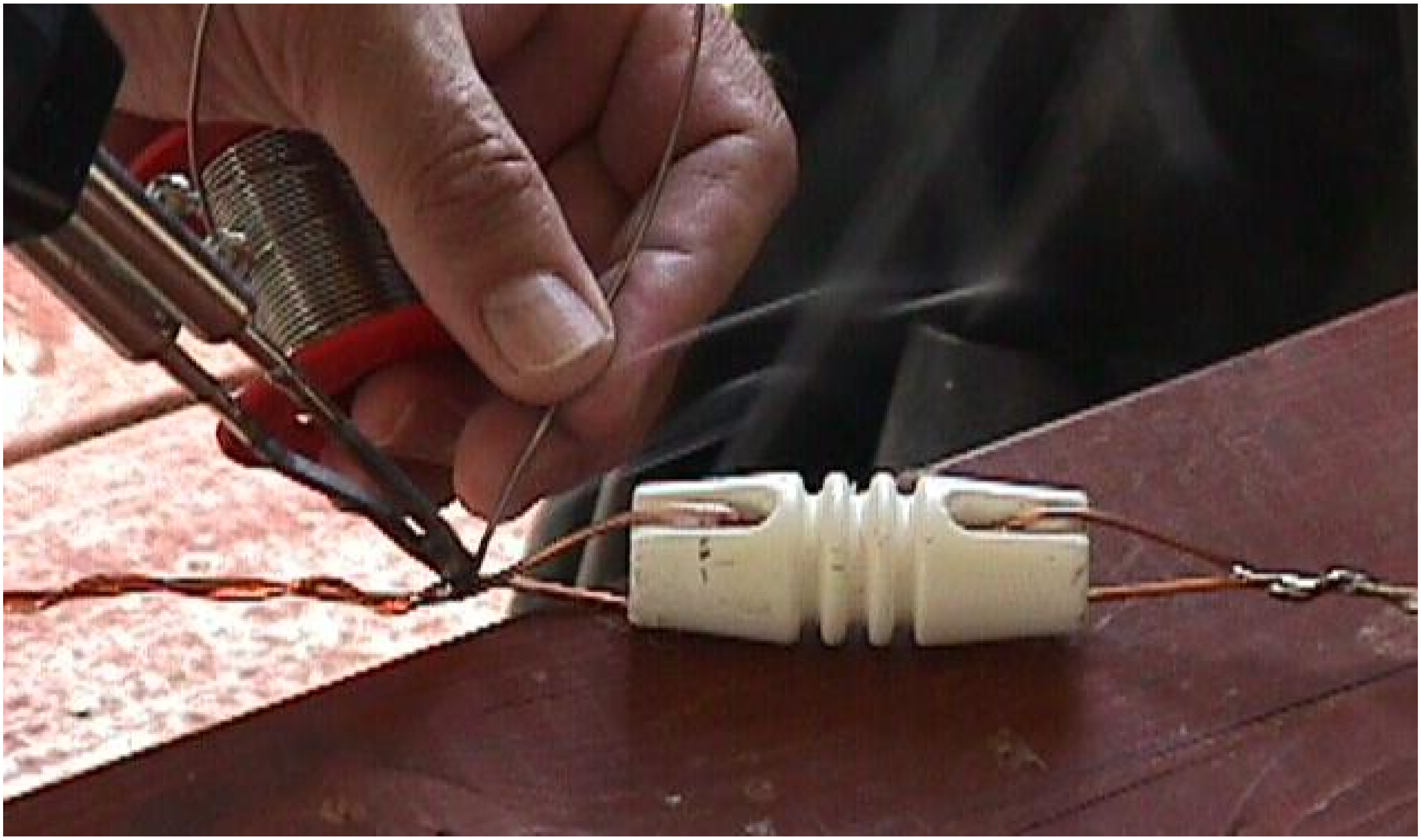
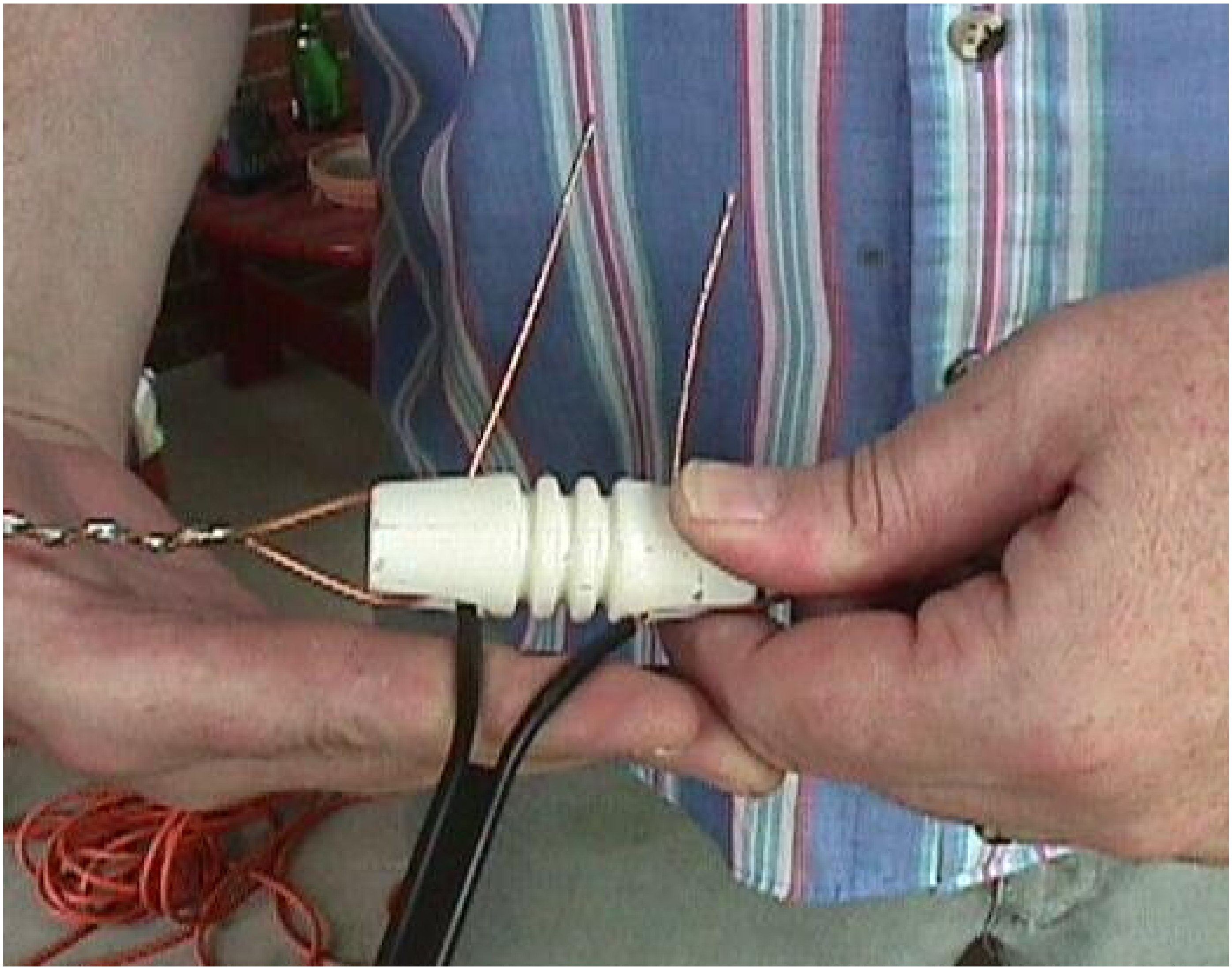


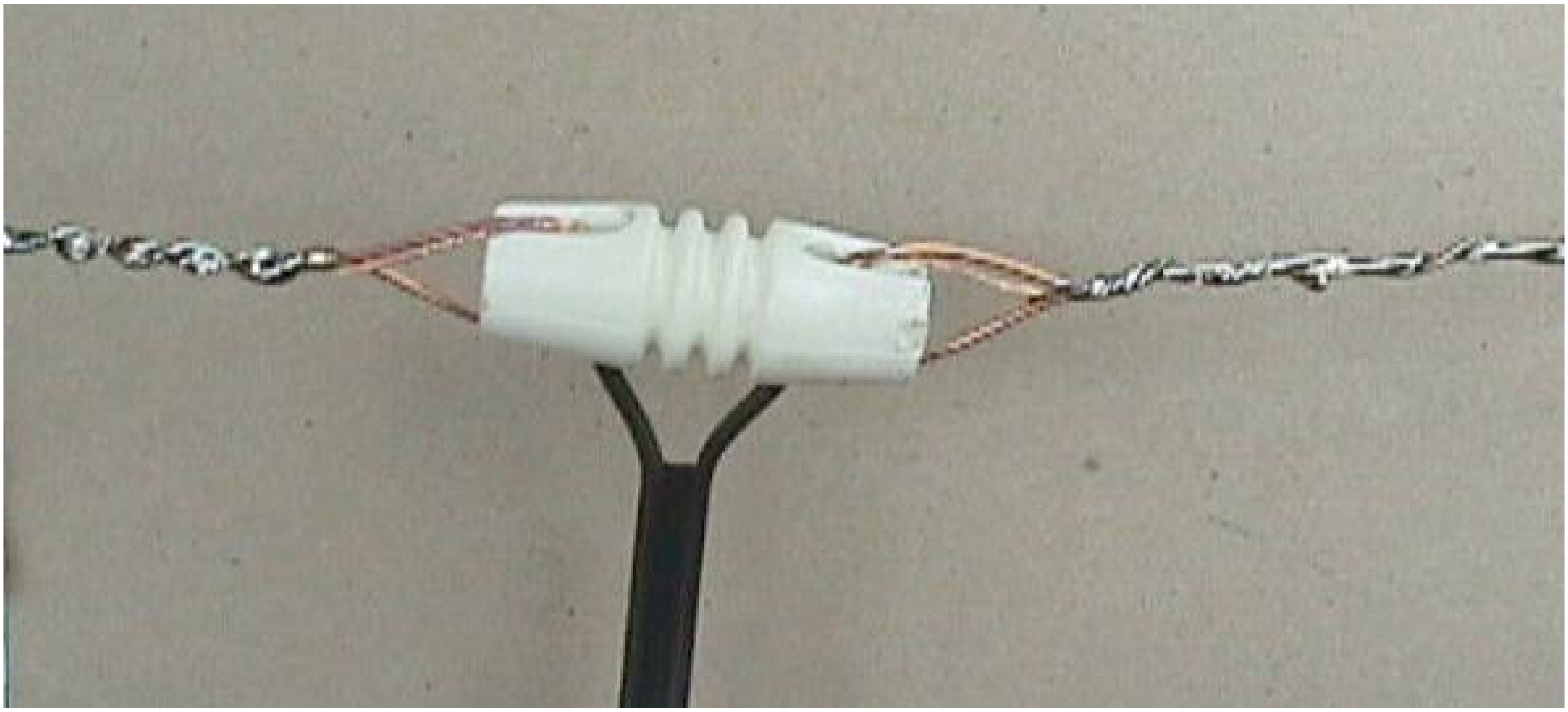




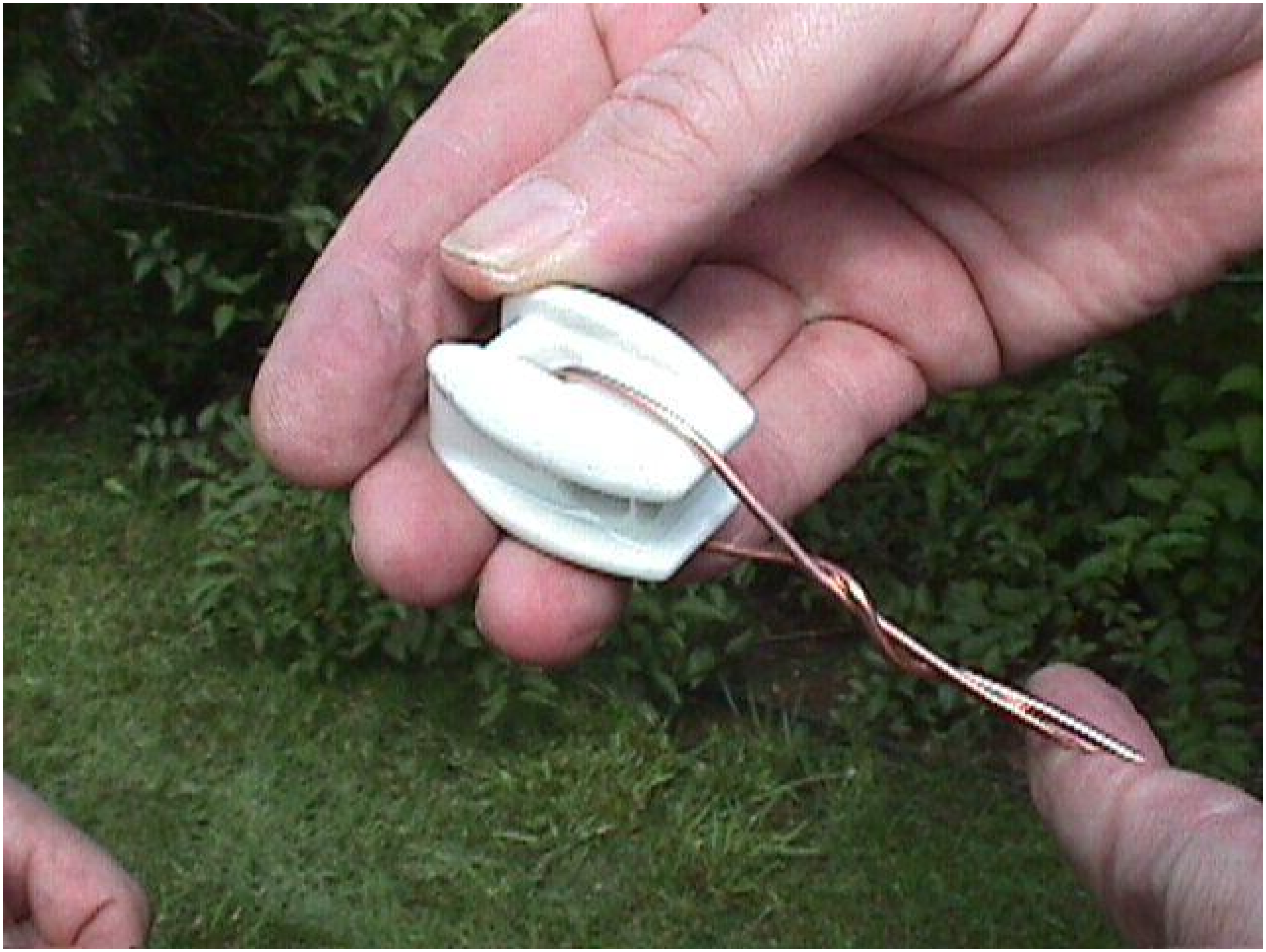


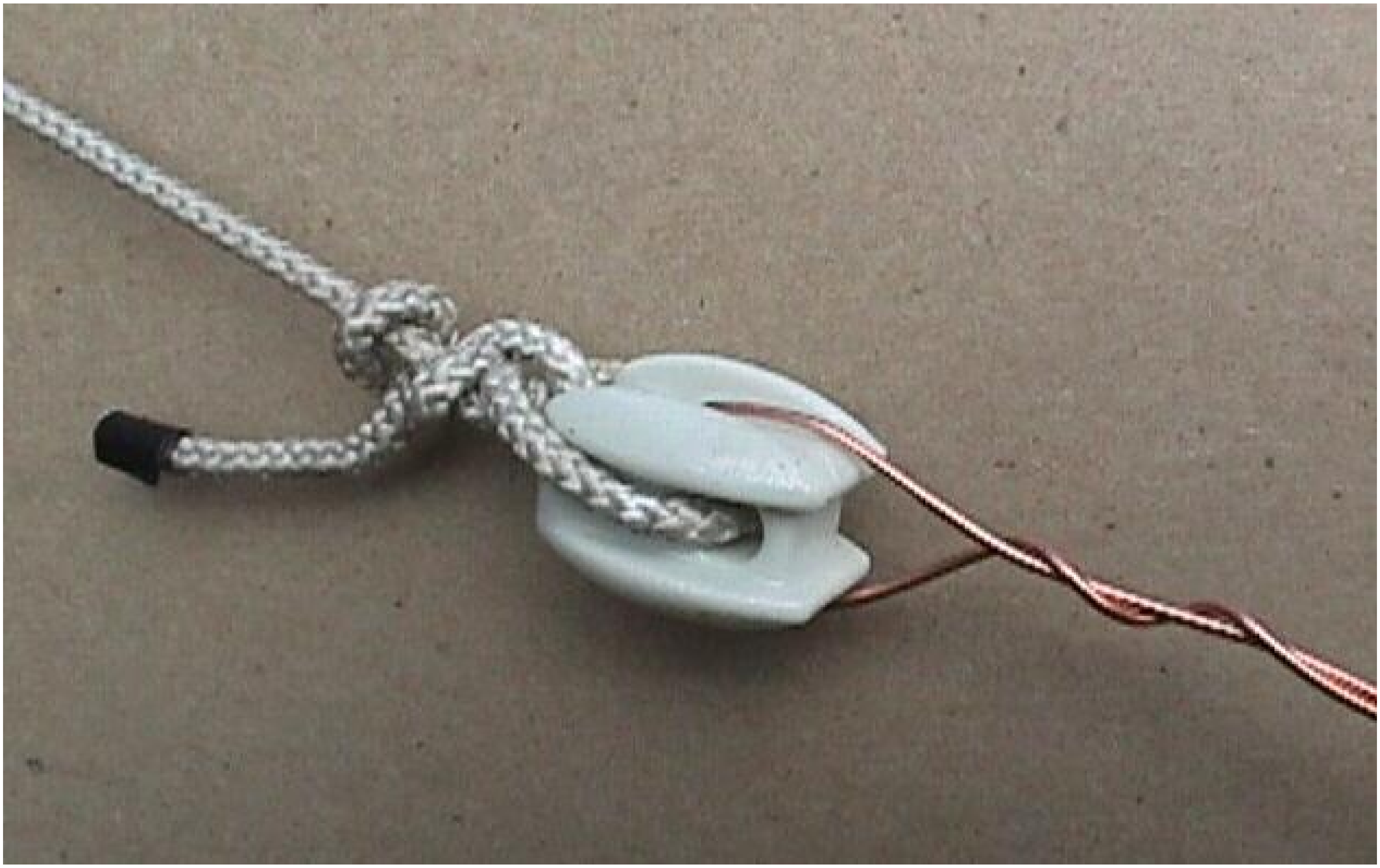







IRRITATES EYES



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