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Making Generator Field Coils

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Have you ever found yourself in need of a set of generator field coils that are no longer available? There are manufacturers out there that will still custom make a brand new set for you. It is not a low price solution, but it is always available if the customer is willing to pay. There is another choice you may never have thought of—make a set yourself!

We should note here that it is best to exhaust all resources before deciding to make your own set of coils. To search for replacement coils, first measure the length and the width of the pole shoes. Then, look for a similar set in either the Ace or IPM field coil catalogs. While neither company is no longer in business, their part numbers are alive and well and can be cross referenced easily to Wilson or Dixie part numbers. Both Wilson and Dixie still manufacture generator field coils. The Ace and IPM field coil catalogs are available for download on the ERA website if you do not already have them. You will find a full list of field coil resources at the end of this article.

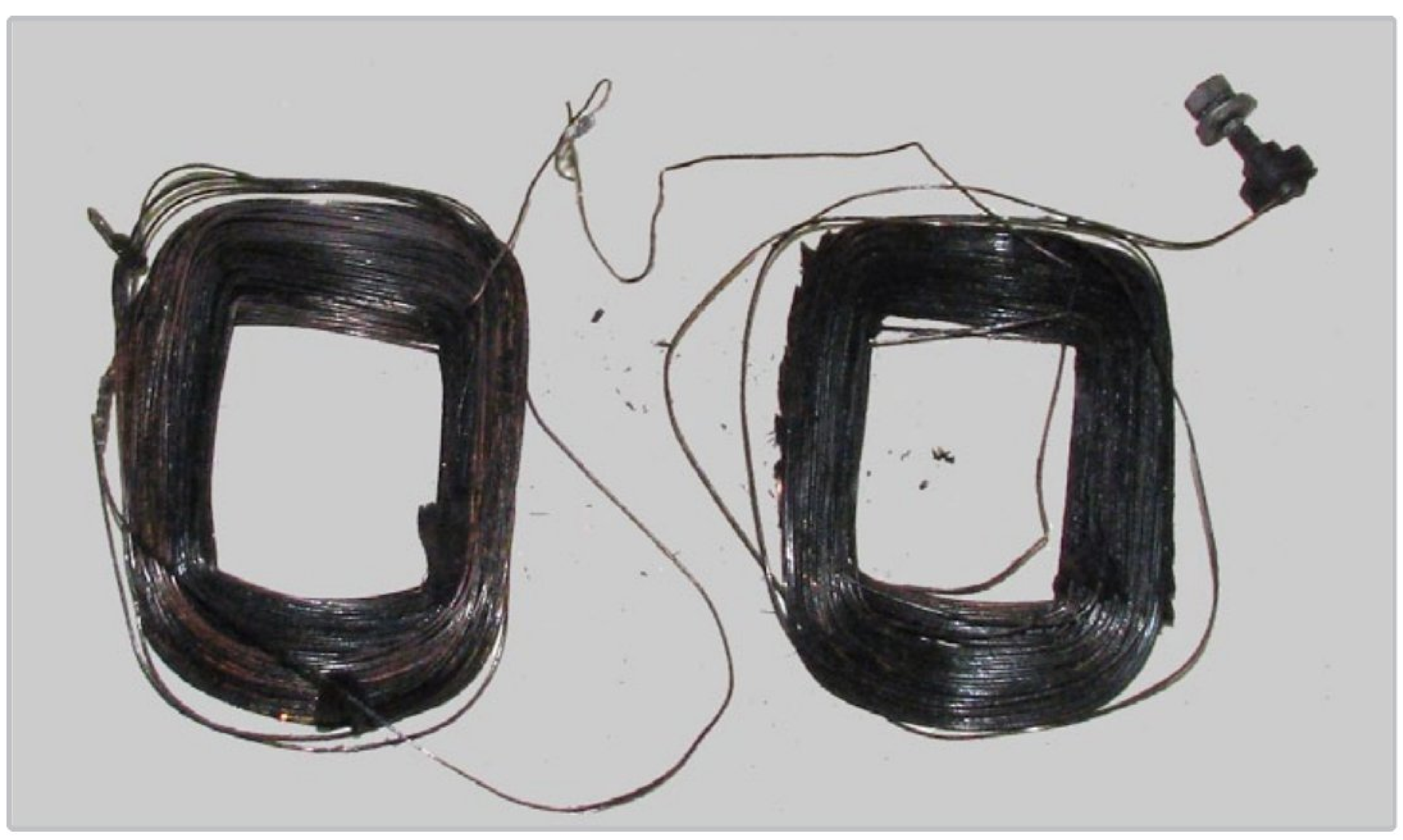

Figure 1—Burned Generator Field Coils

The set of field coils shown in *Figure 1* is from a Delco 036J three-brush generator, the original unit from a 1936 Buick. The pole shoe size did not match anything in either the Ace or the IPM catalog. As you can see in the photo, they are badly burned, even though the rest of the generator is in very good condition. At the end of this article we will explain the most likely reason why the coils ended up like this and the best way to prevent it from happening again. First, we will go step-by-step through the process of winding a new set of coils by hand.

Start by sketching a diagram showing the position of the CW and CCW coils (*see Figure 2*). Lay them out with the curved inside surfaces facing up. Also note which coil leads are joined together and where each of the other leads go. In this case, one lead goes to the third brush, and the other lead goes to a field terminal.

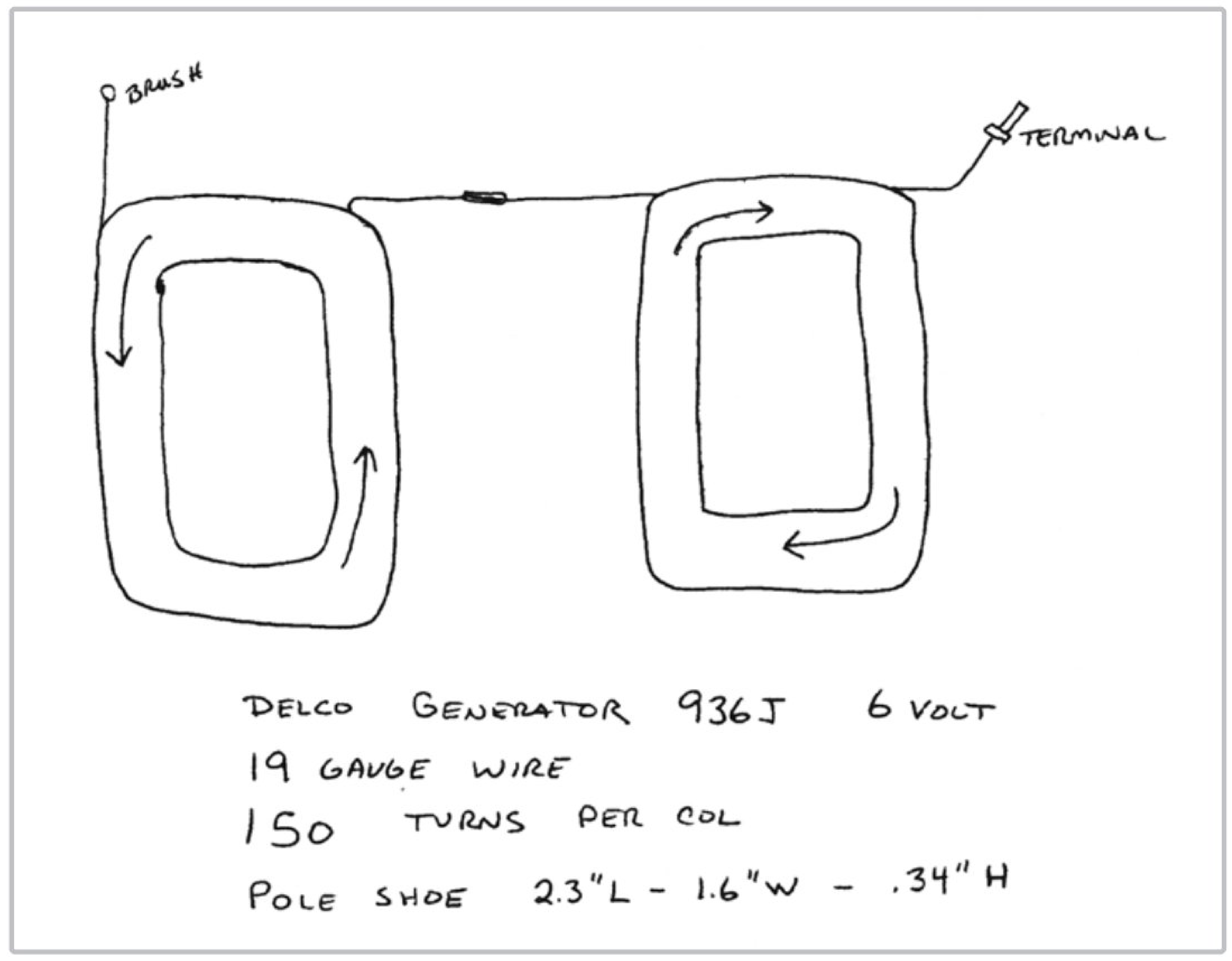

Figure 2—Hand-Drawn Sketch

One thing you need to know is the exact wire gauge size. It is very important that you measure the copper only, without any insulation. In this case, it was easy, because the insulating enamel was already burned away. Removal of the insulation by burning is better than by trying to scrape it off, because you need all of the copper to get an accurate measurement. Scraping might remove some of the copper. A torch will do this job quickly. Measure the thickness of the bare wire in several different places to be absolutely sure that you get the right gauge size (*see Figure 3*). Use a wire gauge

Figure 3—Measuring the Wire O.D.

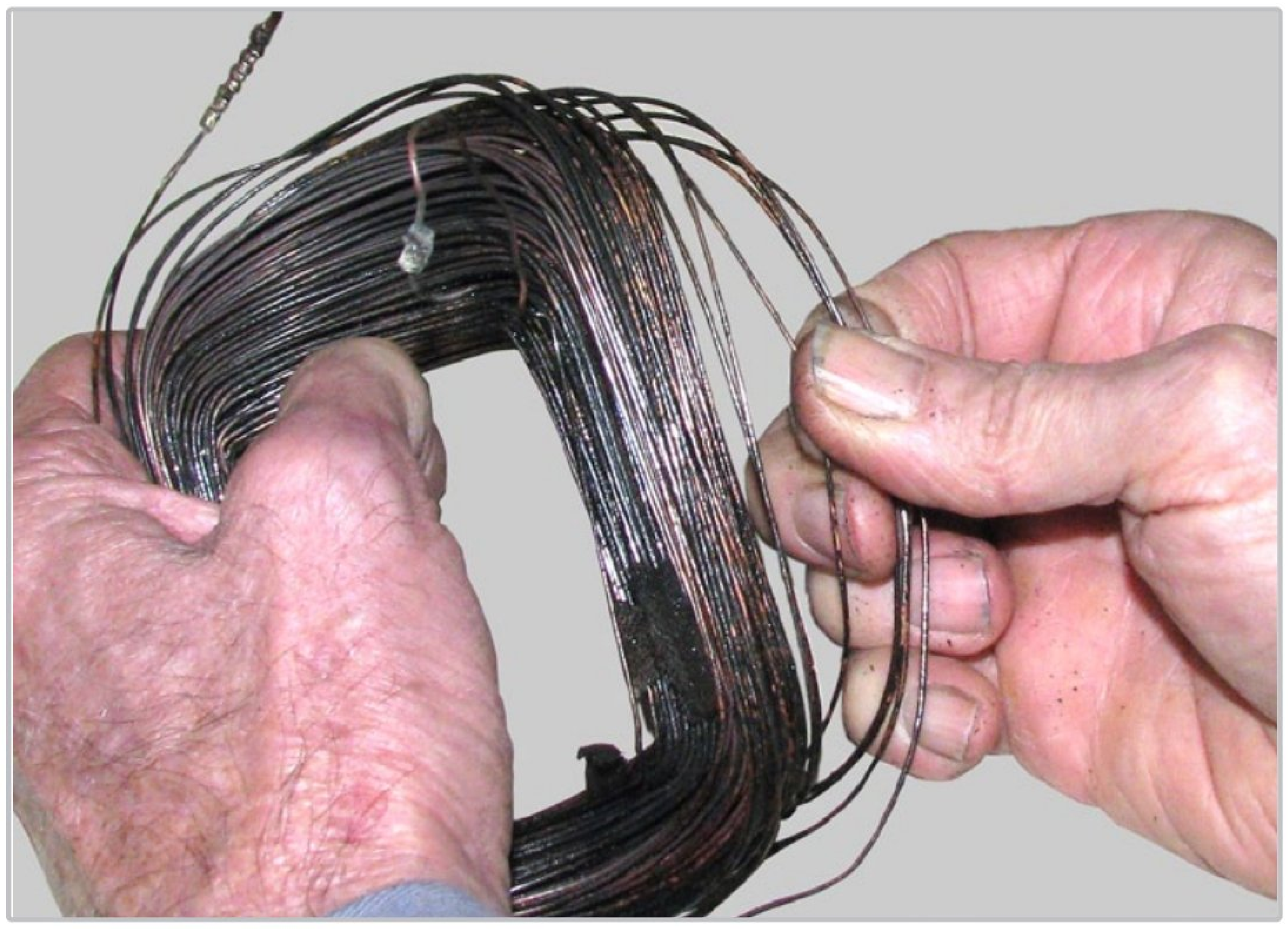

Figure 4—Counting The Coils

Figure 5—Measuring Pole-Shoe Height

Figure 6—Measuring Pole-Shoe Lip

chart to determine the AWG size of the wire. Such a chart is available in the online ERA Technical Library, or you can find one on the Internet by searching on "wire gauge chart". Be sure to write it down. You must document everything that you can about the set of coils you want to make. *Figure 8* has been included for you to use as a worksheet.

After you have a good diagram, and you know the wire gauge size, you must count the number of turns in one of the coils. The coils will be the same, so there is no need to count them both. To make this job a little easier, separate the two coils where they are spliced together. Remove any wrapping material left on the coils. Do not be tempted to completely unwind the coils as you count. It makes a big mess of loose wire, and it is impossible to start over if you lose count. Hold the unwrapped coil in your hand as shown in *Figure 4* and slowly pull each turn away as you count it. Write the number of turns on your diagram. (Our subject coil had exactly 150 turns.)

You will also need to estimate how much wire you will need. Measure one of the outer turns with a ruler. It is important that you measure an outer turn because the inner turns require slightly less wire. Multiply the length of one turn by the total number of turns, and you will have a rough estimate of the length of magnet wire you will need to make each coil. You would rather have too much wire than not enough, so err on the high side. Magnet wire comes in many different lengths and insulation ratings. Small spools of wire suitable for winding one set of generator coils can easily be found by searching the Internet for "magnet wire". You will find the name of the vendor that we used for our wire at the end of this article.

Now, you need to make a wooden blank around which to wind the wire. Before you begin you need to determine several important dimensions as shown in *Figure 8*.

- The length and width of the pole shoe.
- The height of the pole shoe under the lip,

It is important that the finished coils fit under this lip. First, measure the pole shoe thickness as shown in *Figure 5*. Then, measure the thickness of the lip as shown in Figure 6. Subtract the lip thickness from the pole-shoe thickness to calculate the height of the area into which the new coil must fit. Keep in mind that you'll have to leave room for the wrapping material too, so subtract enough from your measurement to account for the thickness of six layers of wrapping material (see *Figure 7*). You can use *Figure 8* as a worksheet. The inside corners of your new coils are where the fit will be tightest. That is where your wrapping will be the thickest.

Figure 7—Measuring Six Layers of Coil Wrap

Using the length, width and under lip height, make a rectangular wooden blank to serve as substitute for the pole shoe during the winding process. Getting the dimension of the wooden blank exactly right is essential to make a properly fitting field coil. Too small and the pole show will not fit into the finished coil—too large and the coil will be loose and vibrate, causing shorts.

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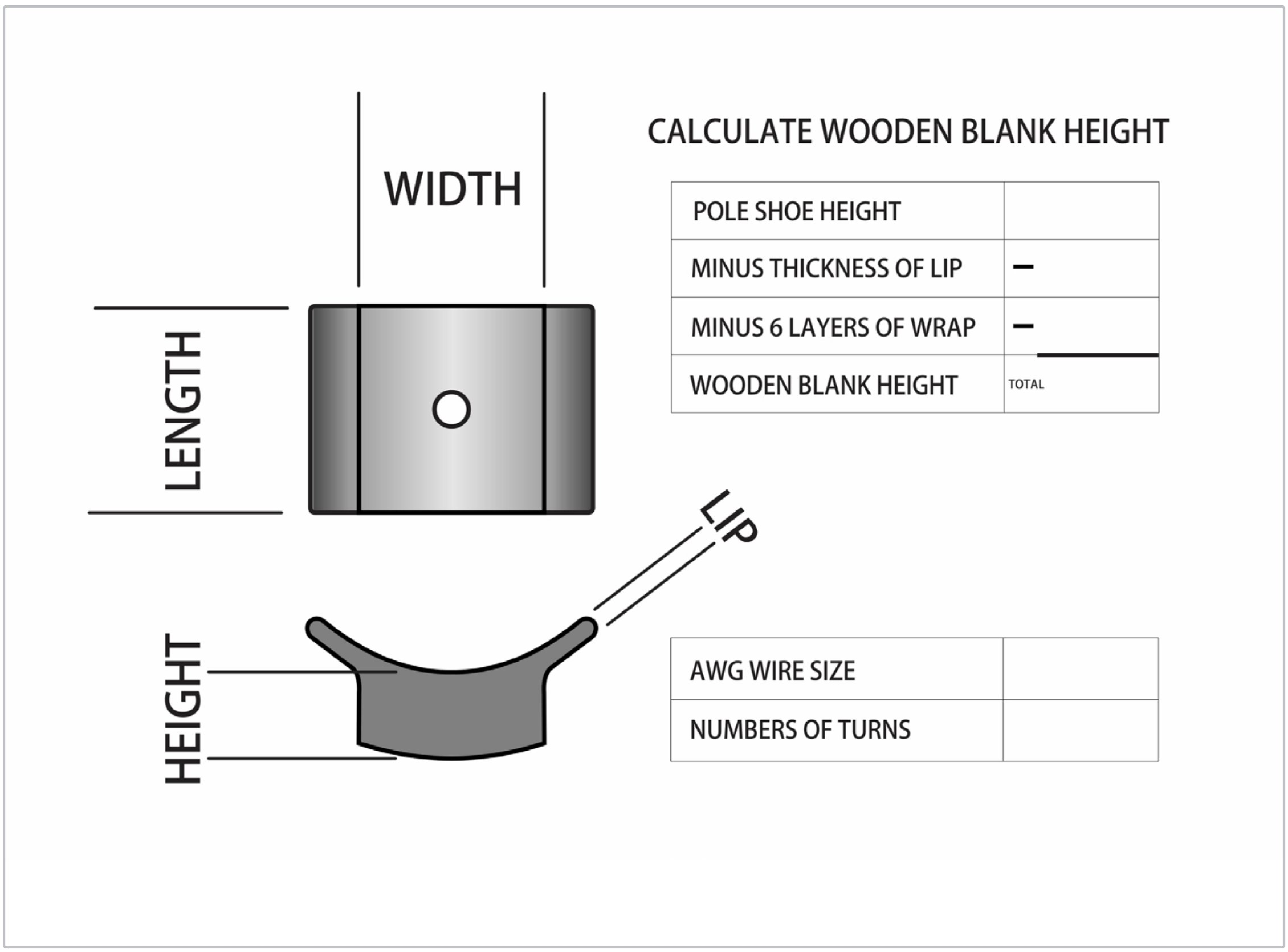

Figure 8—Dimension Worksheet

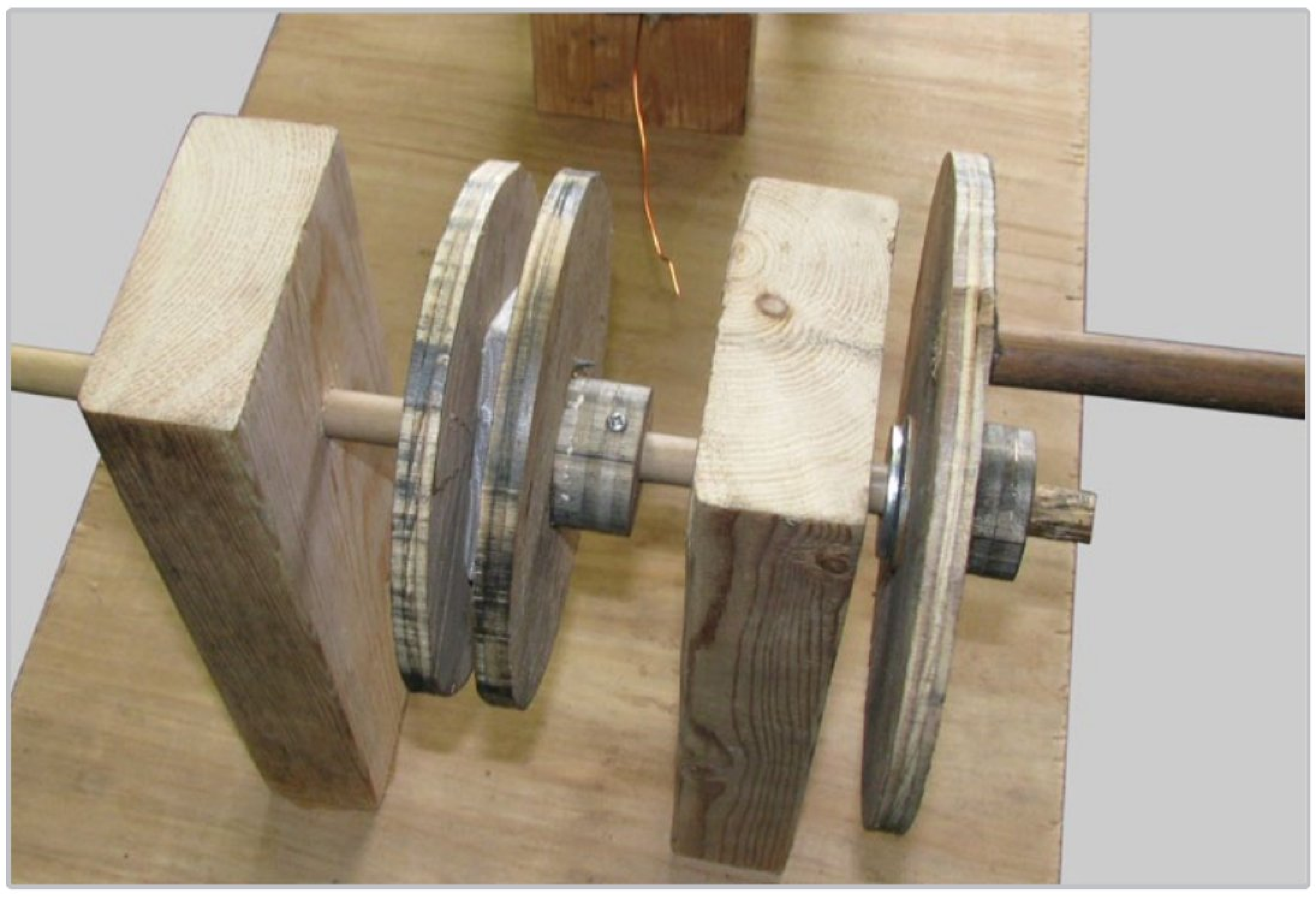

Figure 9—Spool With Crank

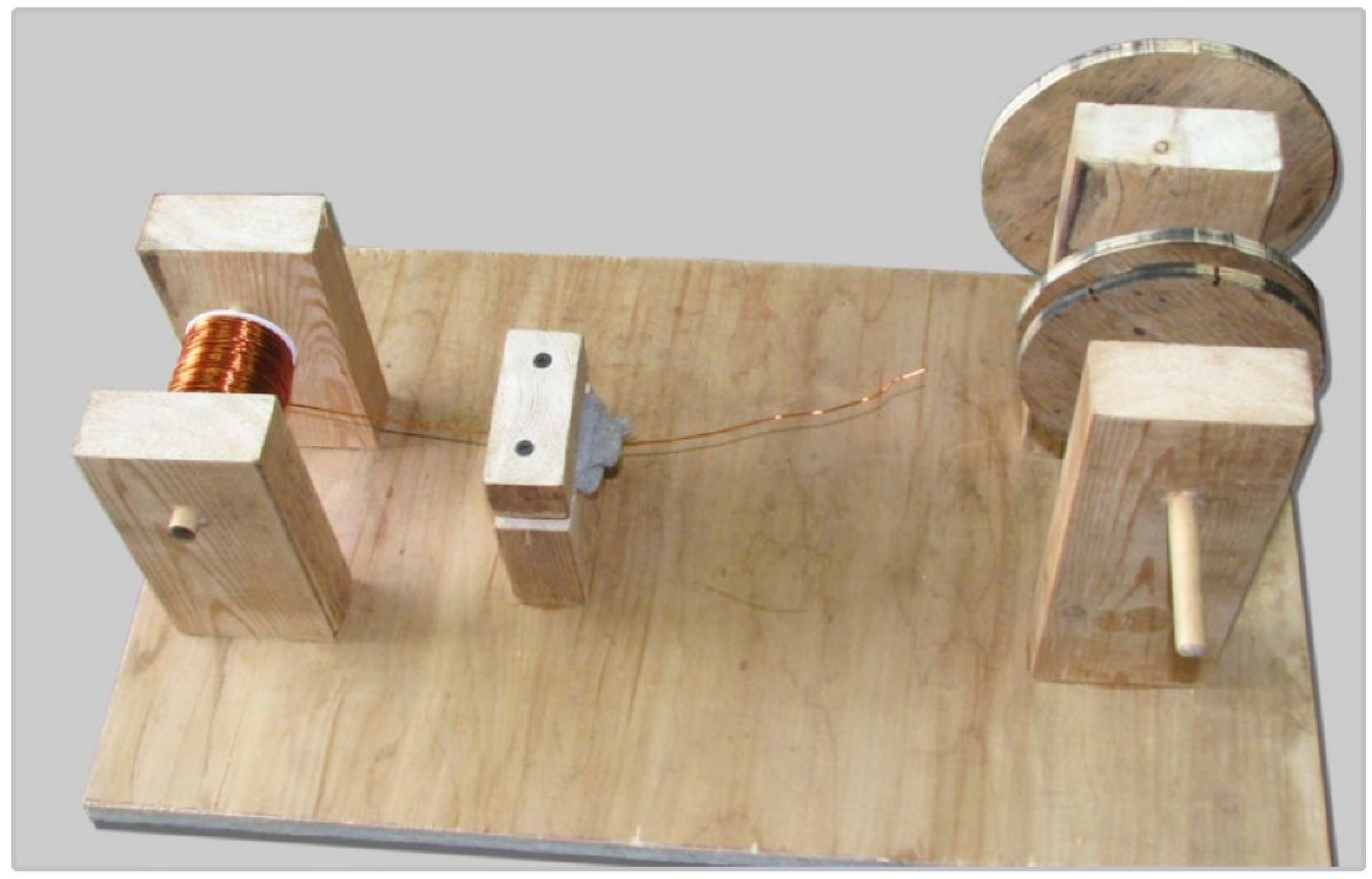

Figure 10—Completed Winding "Machine"

Figure 11—Adjusting Winding Tension

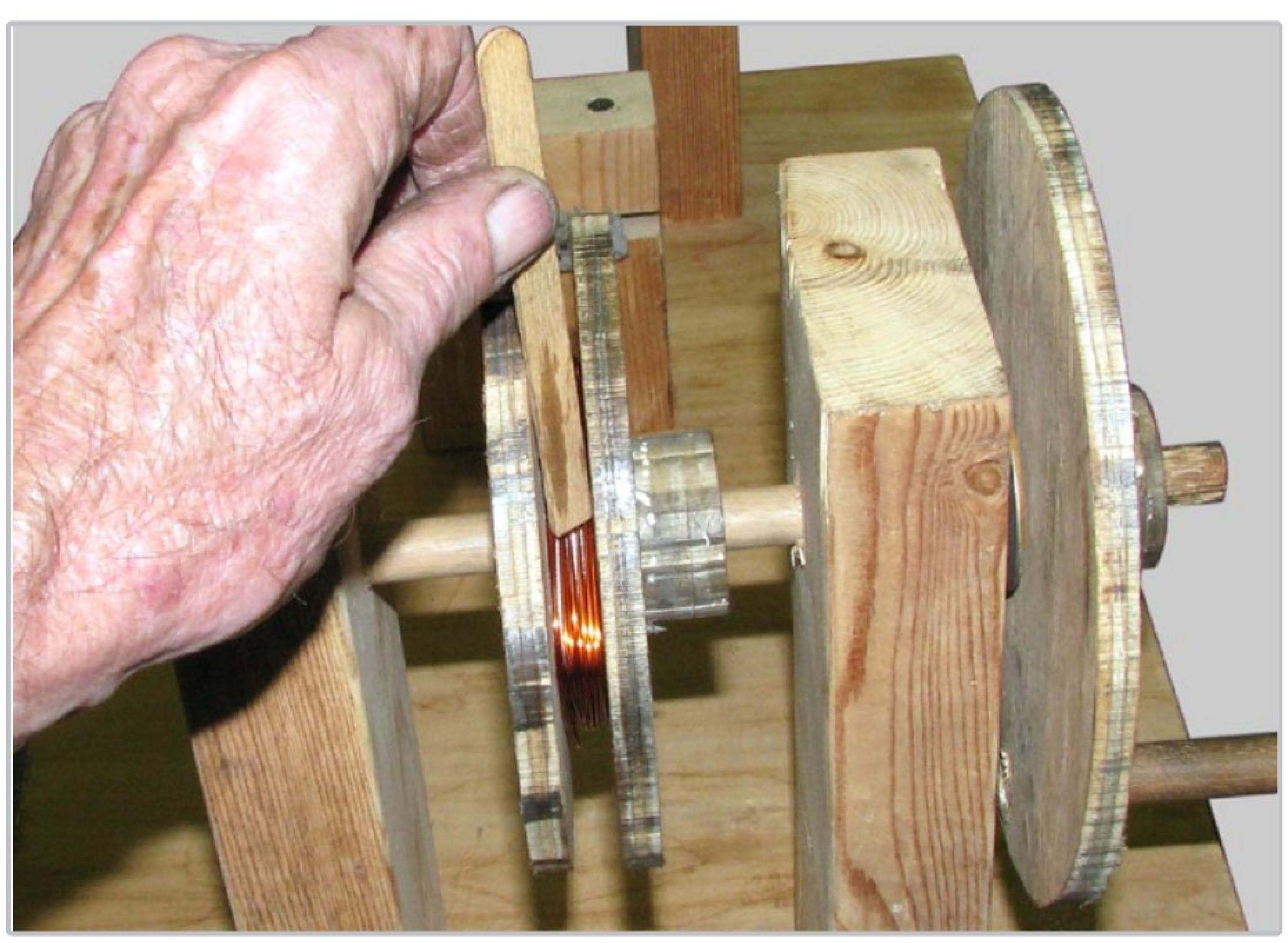

Figure 12—Shaping The First Turns

Create a winding spool by centering and sandwiching that blank between two circular pieces of wood. Use two small wood screws to hold the pieces together. Then, drill a hole through the center of the "spool". You could use this alone to wind your coils by hand, but we took it a step further. We added a crank handle and mounted our spool, along with a holder for the new wire, on a single board (see *Figures 9 and 10*). In addition, we added a padded press to keep tension on the wire as you turn the winding spool. This press tension is adjusted by turning two deck screws as shown in *Figure 11*. Each side of the wire is padded with multiple layers of cotton cloth. You want to keep the right amount of tension on the wire, but you do not want to scratch the wire's insulation. Keeping the right amount of tension on the wire is the key to creating a well-fitting coil. This setup enables a single person to efficiently wind any generator field coil given the correct gauge wire and wooden pole shoe blank.

Once you get all of your materials together and begin to actually wind the coil, remember to take your time and to leave more than enough wire to work with at each end of each coil. You should try to wind the wire in the same direction that it comes off the spool, to minimize twisting, which puts stress on the insulated coating. We cut a slot on the side of our spool to hold the end of the wire for the first few turns. We also wound two layers of field wrap around the blank first. This not only helps in removing the finished coil intact, but it ensures that there is room for the final wrap.

We used a squared off Popsicle stick to aid in keeping the first row of turns in alignment without being too tight (*see Figure 12*). If the first turns are too tight, you will not be able to remove the finished coil from the center block of the spool. Keep the remaining turns as compact as possible, to help eliminate airspace.

Do not forget to keep an accurate count of the turns. There

Figure 13—A Mechanical Counter

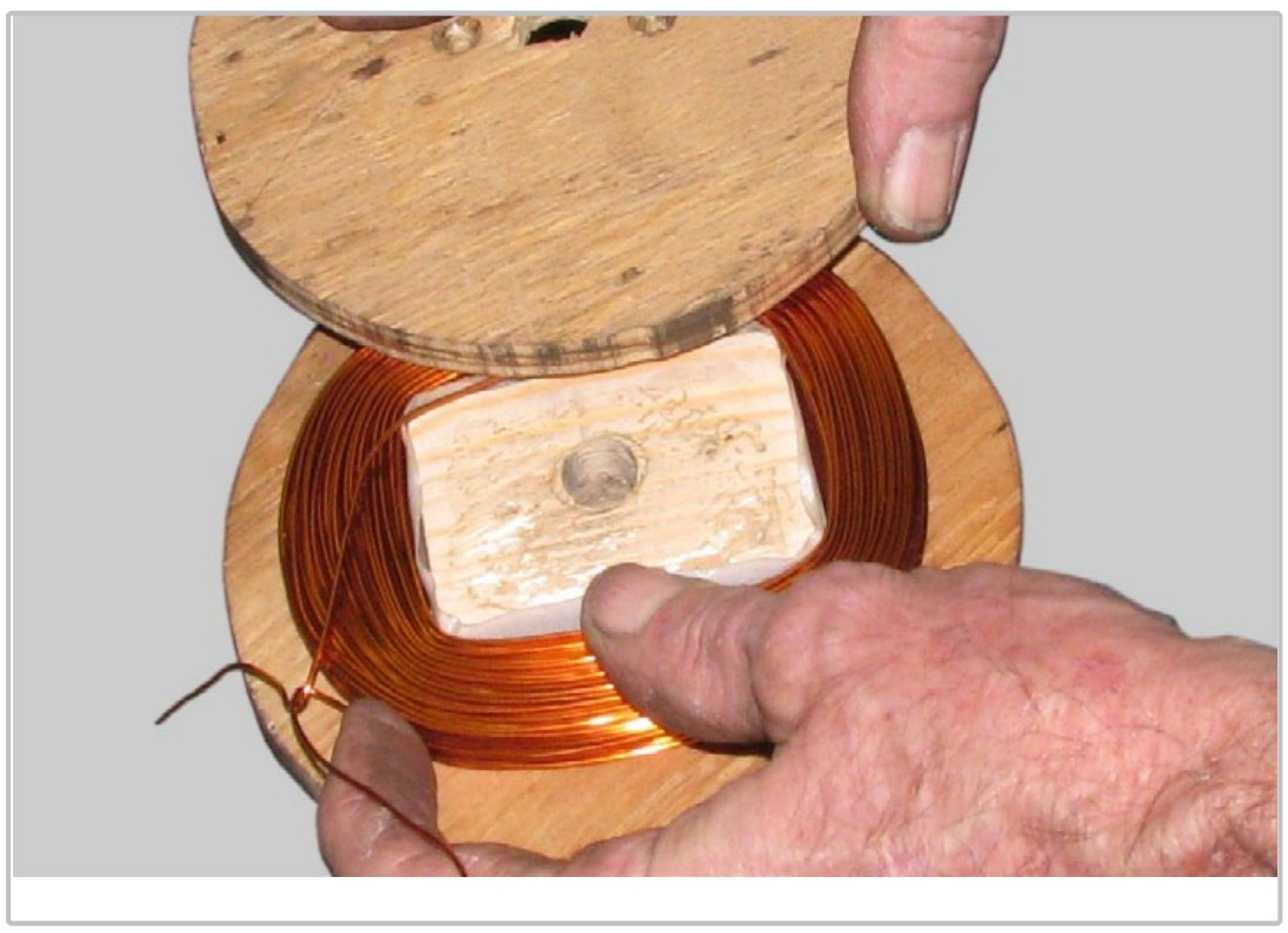

Figure 14—Opening The Spool

Figure 15—All Taped And Insulated

are a number of different counters available that could easily be adapted for use with this coil winder. (*see Figure 13*)

Once the first coil has been wound,, twist the wire ends together to keep the coil tight when you remove it from the blank. Then remove the two wood screws holding the winding spool together and slide the coil off the wooden blank (*see Figure 14*).

At this point you will want to have some adhesive-backed tape ready to secure your coil for wrapping as shown in Figure15. Next, you must add some extra insulation to the lead coming from the inside (first turn) of the coil. This extra insulation can be a glass sleeve, heavy paper or the adhesive-backed tape we used to secure each side. To keep this lead from being pinched, it must come out and lie across, what will be, the inside of the coil away from the field case. Once you have secured the first coil, wind the second one. Remember, it must be wound in the opposite direction of the first coil. If you forget this and wind them in the same direction, you can fix it if you leave the leads long enough

There are several different options available for wrapping the coils, including wax impregnated paper, cloth or glass re-enforced cloth with adhesive backing. We chose to use paper, because it is inexpensive and simple to work with. Cloth is easy to work with, too, but it can rot away quickly if exposed to moisture. Using a tape with adhesive backing is more difficult, but it is also more durable. While it may seem like a good choice, we do not recommend using electrical tape to wrap or repair field coils. It does not stand up well to the heat, and if oil gets into the generator (as it often does) the glue on the tape dissolves away quickly. The vinyl then becomes slippery enough to move around.

It is important to keep the wrap as tight as possible and to overlap each turn by at least 50% (*see Figure 16*). Pay special attention to the inside corners, where it will fit tightly against the pole shoes. Do not skimp on the wrapping. After the coil is completely covered, finish by tucking the last wrap under the previous one and pulling it tight on the back side of the coil (which will be against the field case). You can now form a curve in the coil so that it will fit better in the field case. Do this by slightly pressing and bending the coil length-wise against any hard smooth straight edge The curved edge of a counter top serves nicely (*see Figure 17*). Do not worry about bending the coil to fit the curvature of the field case exactly. That will happen on its own when you install it. The finished coil may be sealed with a coat of insulating enamel for added protection. If you choose to dip the coil in varnish, we advise fitting it in the field case first.

After you have soldered the finished coils together, carefully matching the diagram you made of the original set, you should

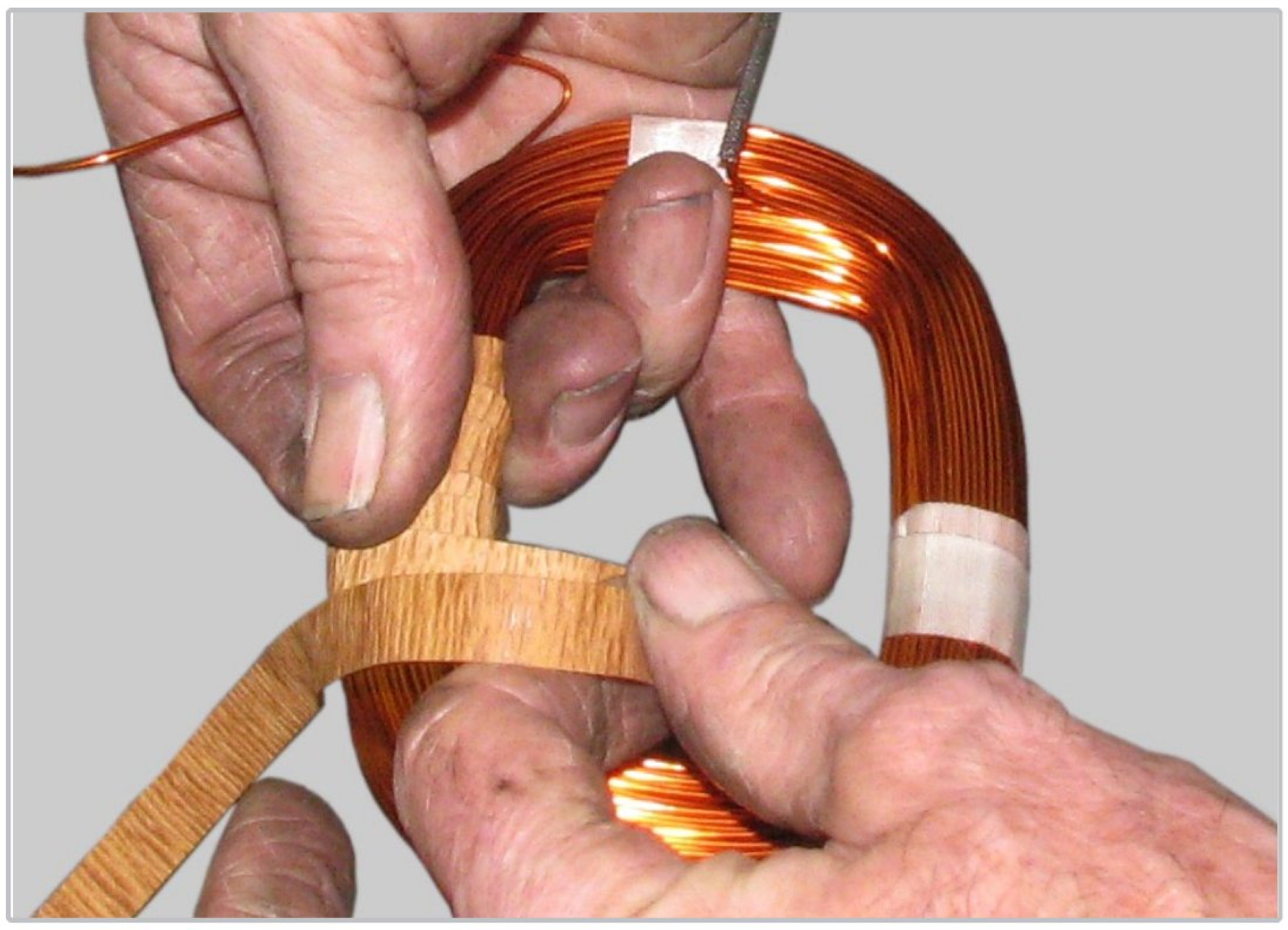

Figure 16—Wrapping The Coil

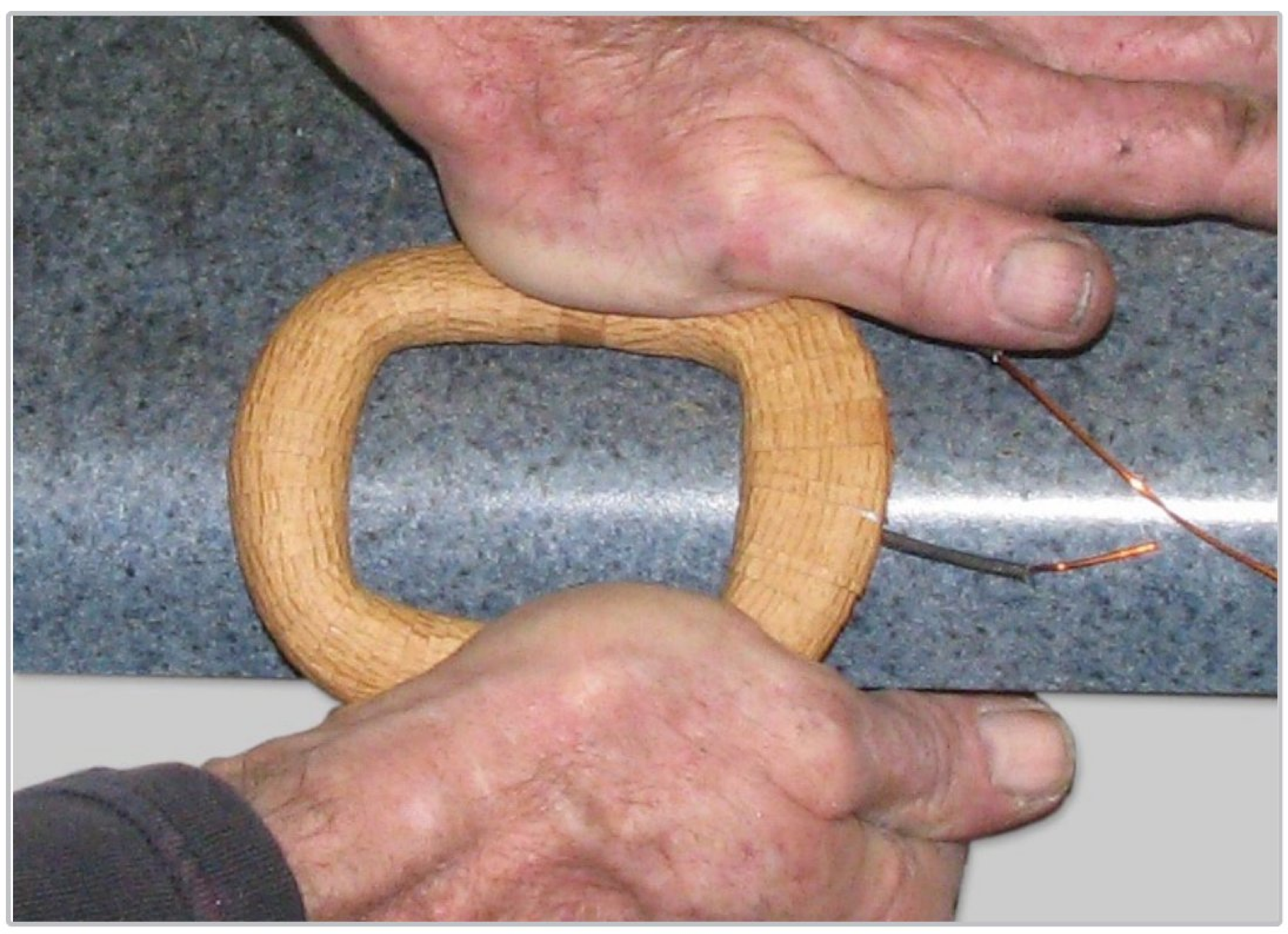

Figure 17—Shaping The Coil

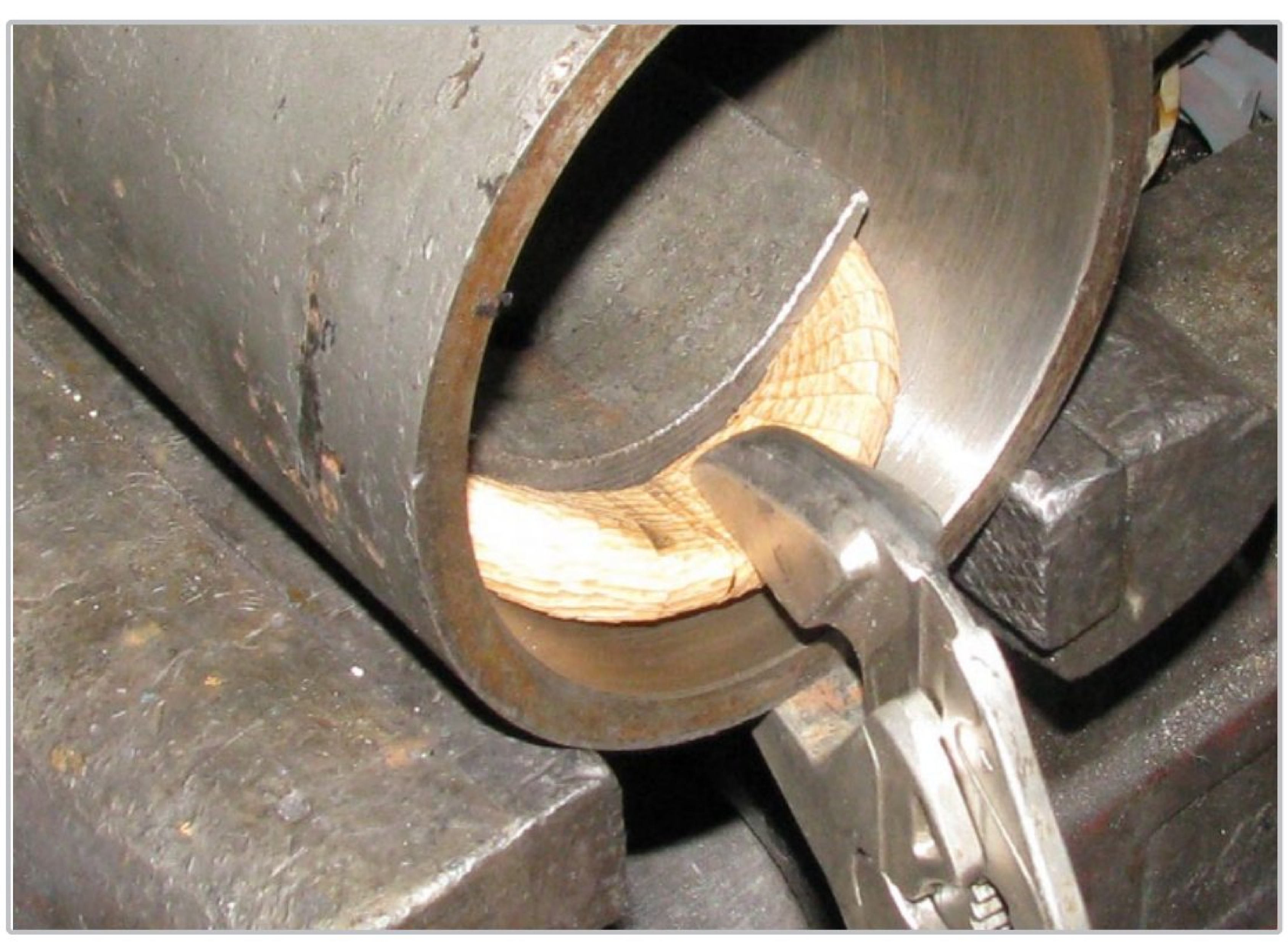

Figure 18—Press The Ends Down

test the new coils for amperage draw. For a 12-volt generator (using a 12-volt rotor tester) you should see a current draw in the 1.5 to 2.5 amp range. For a 6-volt generator, the draw should be 3 to 5 volts. In the case of a 3-brush generator, you may see slightly higher readings, because the third brush picks up voltage that is lower than output voltage. Because of Ohm's Law, this means that the actual amperage draw will be lower, too. You can also test the coils individually to test for balance. They should read very close to the same amperage. Remember that amperage draw results from resistance, and resistance, in this case, is determined by the length of the wire. The balance test tells you how close you are to having identical lengths. The number of turns is irrelevant to electrical balance but essential to magnetic balance. Magnetic force is the product of current flow (amperage) and the number of turns.

When you install your coils in the field case, the ends will probably stick up too high for the armature to clear. You will find them quite flexible. We used a pair of slip-joint pliers with smooth jaws to press the ends down below the level of the pole shoe as shown in *Figure 18*. You could use your thumbs to do this, but our pliers really made it easier. However, do not use pliers with serrated jaws. You could damage the wrap, or, worse yet, the wire underneath it.

Now, are you still wondering why the original field coils in our subject generator most likely burned? Once any functioning generator spins fast enough, it will begin to produce voltage on its own through the armature. That voltage travels through two circuits in parallel, the field coils and the cutout relay coil. Both of these circuits are grounded inside the regulator. The voltage passing through the field coils increases the magnetic strength in the poles and, in turn, increases the voltage produced by the armature. Once that voltage reaches a determined threshold, the cutout relay coil pulls the cutout contacts closed, which connects the generator armature to the battery. Once they are joined, the load of the battery will limit the voltage that can be produced by the armature.

If those cutout contacts do not close, the voltage will continue to build upon itself inside the generator. The field terminal is grounded through the regulator's voltage relay contacts and sometimes through a resistor. Because the resistance of our field coils is fixed, the amperage flow through them increases as the voltage increases—it's Ohm's Law.

This creates an avalanche of increasing magnetism, increasing voltage and increasing amperage flow through the field coils, which in turn, increases magnetism. Meanwhile, the voltage relay contacts in the regulator may get hot enough to stick before they can open. The end result is almost always burned up field coils. The armature is usually not damaged in this scenario. Because the armature is not connected to the battery, all of the armature output is channeled through the field coils. The coils are not designed for this kind of load and only a few minutes are needed to burn up a set. So, if you are rebuilding a generator that comes in with the field coils burned up, while the rest of the generator seems undamaged, be aware that the cutout relay is probably the real culprit. The regulator that came in with our subject-generator had a burned out coil in the cutout relay as well—another sign that the relay contacts never closed.

Generator Field Coil Resources

International Winding - *offers custom winding of any type of armature or field coils*
729 North Harvard Ave
Villa Park
IL 60181
800-323-7521
iwico.com

Eurton Electrical - *offers custom rewinding of armatures and field coils*
9920 Painter Ave.
P.O. Box 2113
Santa Fe Springs, CA 90670
800-423-4789
eurtonelectric.com

Tech Fixx Magnet Wire - *an excellent source of the right wire in the right sizes*
www.techfixx.com

ERA Website - *an excellent source of information on rebuilding DC generators - you must be a member to download documents*
www.electricalrebuilders.org -

Wilson Auto Electric - *manufactures new generator coils, does some custom coil rewinding and offers a coil finder program you can use to cross reference field coil numbers*
www.wilsonautoelectric.com

Dixie Electric - *manufactures new generator coils does some custom rewinding*
www.dixie-electric.com