# Winding a Coil Condenser

How to wind a small copper coil condenser, by hand, without filling.

By Hook

This particular condenser in this tutorial is a 150 mm (6") long continuous double coil, for a 50 mm (2") diameter column, and uses 6.4 mm (1/4") copper tube. This size double coil condenser comfortably handles 2400 w of water steam. (Put some mesh or scrubber packing in the top section.)

You can increase the condenser length up to 200 mm without any problem. But longer than that and you start running into increasing back pressure, and hence a reduced maximum coolant flow rate.

You can also increase the coil diameter (width). I would not go bigger than to suit a 75-80 mm column. Larger diameter coils are much easier to wind than smaller diameter.

This tutorial only describes how to do a continuous double coil, but it is the same basic skills and techniques for a single coil, and a single coil is much easier.

Double (and single) coils can also be made using 4.75 mm (3/16") OD tube. This size tube is both easier to work and more efficient at heat exchange, though it is less robust than larger size tube, and might not be as easy to locate either.

Single coils can also be made using 9.5 mm (3/8") tube. It is hard to wind 9.5 mm tube smaller than about 32 mm (1.5") OD, which equals a mandrel of about 25 mm (1"). Winding continuous double coils in 9.5 mm by hand is more difficult, even larger ones for a 75 mm column. The changeover from the inner to the outer coil is particularly tricky.

6.4 mm tube is a very good size for our purposes.

Winding a coil, especially a double continuous coil like this, is not easy. You are likely to make mistakes the first time you do it, especially forming the first turn of the coil.

Read through the whole tutorial carefully before starting. It will help you understand the reason for some of the steps earlier in the process.

The pics were taken during 3-4 condenser builds, so the condensers will not all look exactly the same.

(My hands might look in a slightly awkward position in some of these pics. That is because I had to get into a good position for the camera and lighting.)

1. Tools and Materials

• Annealed, thick walled (0.8 mm, 1/32"), 6.4 mm copper tube, 3 m length. (Annealed comes as a coil, not a straight length. You can get it at refrigeration trade suppliers. Can be difficult to get by the metre, often can only buy a 30 m roll.)

For a 150 mm long double coil for a 50 mm column you need 3 m (10') of tube.

For a 150 mm long single coil for a 50 mm column you need 2 m (6.5') of tube.

Do not bend or straighten the tube, leave it in the coil shape it came in.

Using a nylon or stainless wool scourer to remove any ink markings on the outside of the tube.

• 3 m of tube.

• Hand held propane or MAPP torch.

• 6.4 mm (1/4") bending spring. I use an external spring. Very cheap, and available at refrigeration trade suppliers. Makes the job much easier.

• Tube cutting tool. I use a tube cutter, but a fine blade hacksaw or Dremel tool would be fine.

• Large blade screwdriver

• 16 mm OD (5/8") inner mandrel, rigid, can be solid or hollow (ie a tube). About 300-350 mm (12-14")long.

• Two 32 mm OD (1.25") outer mandrels, rigid and hollow. One about 65-75 mm (2.5-3") long, the other about 150 mm (6").

(Note the carefully positioned and clearly marked measuring stick, placed there on the expert advice of a retired archeologist, Professor B.)

Roughen the outside of the short outer mandrel, and the inner mandrel, with abrasive paper, so they are easier to grip. (In most pics in this tutorial the mandrels are not roughened. I have roughened them since.)

Round off about 1/2 of the outside of one end of the short outer mandrel.

(Note the rounded edge on the top of the right hand end.)

• Make sure mandrels and spring are clean, inside and out.

• Make sure the mandrels are made from safe materials. I use copper or stainless.

Notes:

• Annealing

You will need to anneal various sections of the copper tube during the project.

Annealing is done by heating the copper to red hot and letting it cool, either slowly in air, or quickly with water. If you use water then dry it off before working further on the coil.

Annealing copper makes it much softer and easier to bend (work). Freshly annealed copper tube can kink easily, so take it fairly gentle until you get the hang of working it.

Annealing also wears off quickly once the copper starts being worked. Because it work hardens quickly, try to get a bend right the first time. If you need to adjust an imperfect bend, some selective re-annealing can be very useful or even necessary.

Only anneal the area you need to work. You want as much as possible of the tubing in the finished condenser to be work hardened.

Nonetheless, don't be afraid to anneal, more than once if necessary. The right use of annealing is the key to solving most problems with winding a coil by hand.

• Try not to bend the tube feeding from the original big coil as you wind, it makes it stiffer and harder to wind when it gets to your hands. It is a bit tricky and you can't avoid some bending as it straightens out when it comes off the coil. Just keep it to a minimum, and do some re-annealing of the feed section if necessary.

• Always keep as much tension on the tube as possible as you wind it. It is this tension that stops it from kinking. This is not necessary when bending it with a bending spring.

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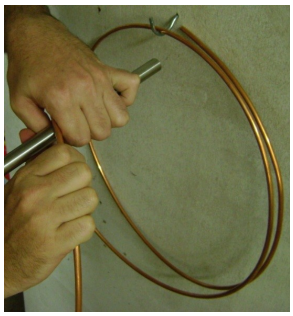
2. Starting the Wind

Hang coil on a hook or angled peg about chest height.

Arrange and hold the tube and mandrel like this. (The tail is coming out the bottom of the picture. I am right handed, lefties might prefer to do everything mirror image.)

Leave a 300 mm tail, and start with a 40-45 degree angle between the tube and mandrel



Holding it all as tight you can, and keeping as much tension on the tube as you can, pull the hand holding the tail down and around the mandrel, keeping the angle between the tube and the mandrel. Use your thumb as the pivot point.

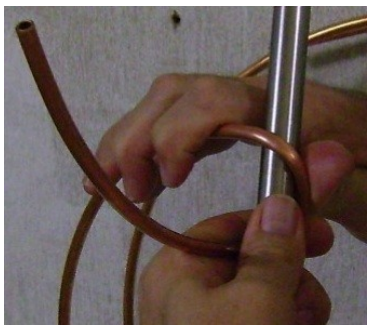
You will get some degree of flattening of the tube as you wind the coils, mainly on the inner coil. This is not a problem, as long as it is only minor.

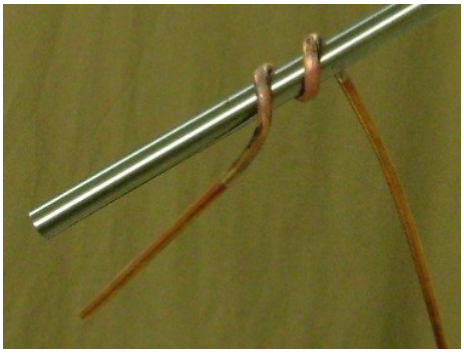
You might find it easier to use the bending spring to put the first 160 degree of bend in the tube (anymore than about 160 deg can make it very difficult to remove the bending spring). If you do it this way, then use a slightly smaller mandrel just for this first bend, to allow for the thickness of the bending spring. Remove bending spring and continue...

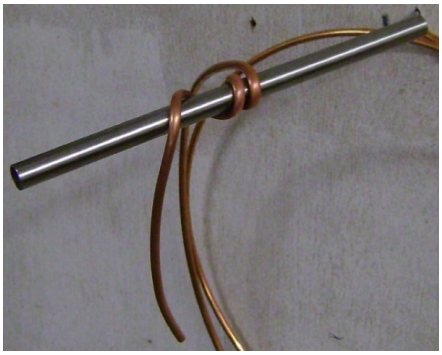
Reposition your hands, and continue...

Keep the original angle between the tube and the mandrel until you get most of the way through the first turn, then start changing the angle towards 90 degrees.

Swap sides and hands, and continue the wind until you have a full turn.







This is the hardest part of the whole project. If you can get this far, you are halfway home.

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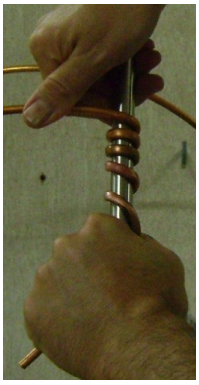
3. Inner Coil

Continue winding 1/3 a turn or so at a time, then repositioning your hands, another 1/3 turn, etc, until you have 150 mm of full coil. (When measuring this distance, allow for the fact that the widely spaced turn or two at the start will be compressed down in a later step.)

The first 3-4 turns can be a bit tricky, but just persist a little bit at a time. You will find that the tail will tend to wind around the mandrel in the opposite direction, because as you wind the main coil you tend to leverage against the tail. This is difficult to avoid, just keep it to a minimum. You will usually end up with an extra 1/2-1 turn, at the tail end. This counter winding reaction is why you start with some extra tail.

You can wind this way...



or this way...

Some might find it easier to swap hands and wind this way...

Ending with this...

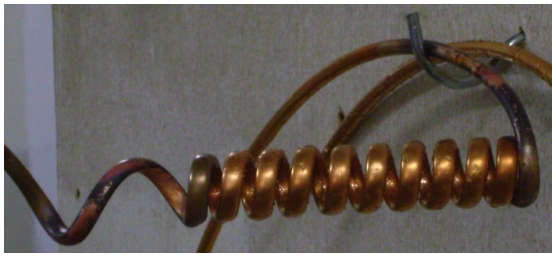
Notice the last turn (at the bottom of the pic) is straightened up so it comes back on itself, ready for the changeover.

Remove the inner mandrel. You may have to loosen the coil a little by gently twisting it against the direction of the wind. (Hand on left of pic is twisting up, hand on right is twisting down.)

Check to make sure you can easily re-insert the mandrel.

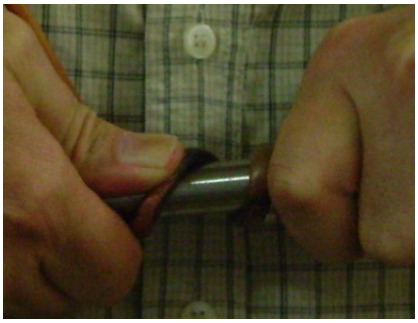
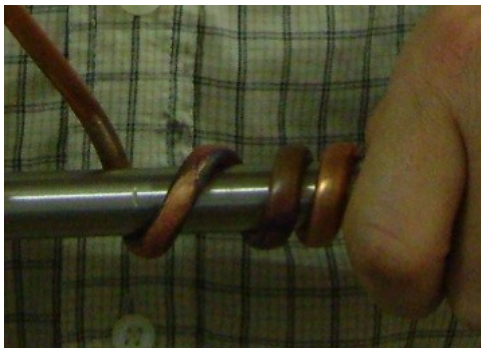
Anneal the transition between the starting tail and the first closely spaced turn of the coil. (Also anneal the first 75 mm or so of the tail coming off the last turn at the other end of the coil. This is for a later step, but might as well also do it now.)

You can clearly see the annealed sections in this pic, the dull, discoloured, burnt looking areas at either end of the coil:

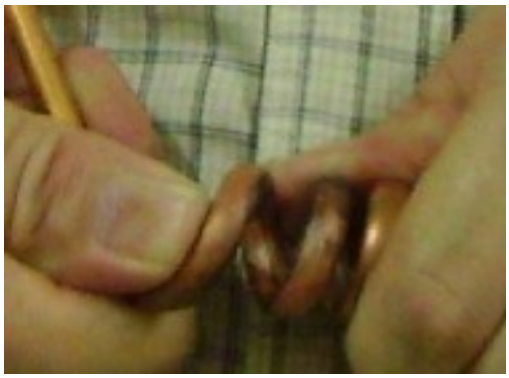


Re-insert the mandrel. Alternatively compress, tighten, and align the widely spaced turn or two at the top of the coil, in steps, and generally work it until it is matched up with the rest of the coil. You may need to re-anneal this section of coil about half way through this process.

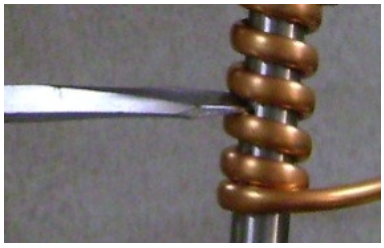
You do not have to do this step. You can skip it and go straight to bending the tail. If you do leave it like this then it would be better to have a slightly longer condenser, 175-200 mm (8").

Re-anneal at this point if required. Continue carefully...

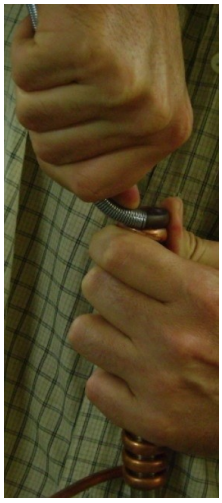


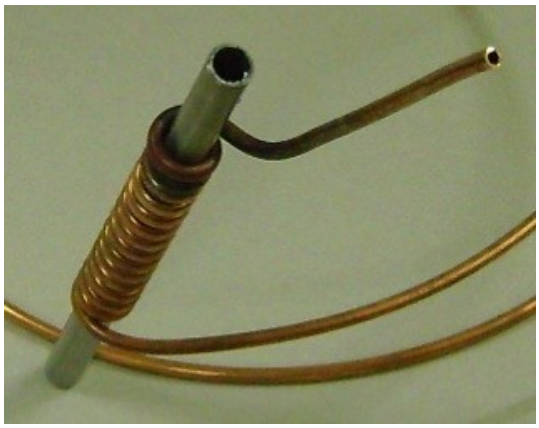

Re-insert mandrel, and use a twisting motion of the screwdriver to evenly space the coil turns (except that last one, at the bottom).



Remove the mandrel. Re-anneal the 40-50 mm section of the tail immediately coming off the first turn. Re-insert the mandrel to level with the bottom of the first turn (bottom right of pic).

Use the bending spring to turn the tail upwards, towards parallel with the coil axis. Pivot around your thumb.





Remove the mandrel and re-anneal the new bend down to the first turn of the coil. Re-insert the mandrel and slide it up so about 75-100 mm is sticking out of the tail end of the coil. Work the tail to be as close a fit to the mandrel as possible.

The aim is for the outer mandrel to be able to easily slide over the tail and inner coil.

Check the inner coil is straight overall, and carefully adjust if necessary. It should be fine, but check because you can't adjust it once the outer coil has been wound.

Sometimes the first turn or two on the inner coil will not come out quite perfect, but as long as there is no kinking and nothing is too out of alignment, then don't worry about it.

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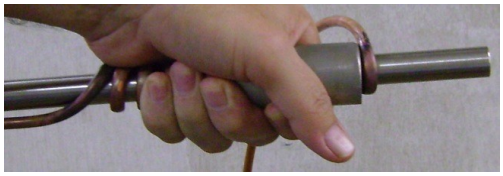
4. Changeover (from inner to outer coil)

Remember that you previously annealed the changeover section of the tube. It was for this step.

Insert the short outer mandrel over the inner coil. Line it up so the centre of the rounded edge of the mandrel is located where the tube will reverse wind direction and cross back onto the outer mandrel. (Top right of pic.)

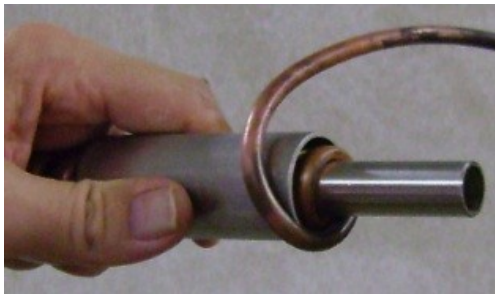
Hold the assembly firmly like this

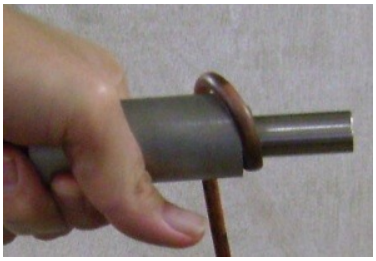


Place winding hand like this

Having a roughened surface on this short outer mandrel helps to get a good grip. It may help to clamp the left hand end of the inner mandrel in a vice for this step.

Wind the tube back across the outer mandrel in the opposite direction of the inner wind, back up the mandrel.





The first turn after getting onto the outer mandrel is difficult, and this is one of the danger points for kinking. But just persist with it a little bit at a time. Try doing this turn in 3-4 steps, rather than all at once.

Re-anneal 1/4-1/3 the way through the first turn, and continue till you have most of the first turn.

The first turn on the outer coil usually ends up slightly larger and looser on the mandrel than the rest of the outer coil turns. Don't worry about it.

The outer mandrel will be kind of loose and slightly off centre from the inner coil, and so the outer coil will usually be slightly off centre too. But this is a minor problem that is difficult to avoid, and that can be corrected (adjusted) easily at a later step.

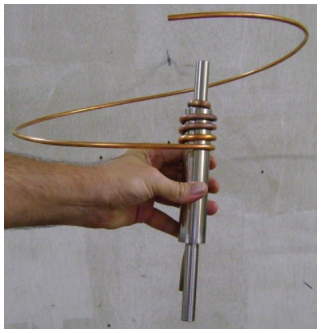
5. Outer Coil

The next 2-3 turns on the outer mandrel can also be difficult, but again just persist with it a little bit at a time. Again clamping the non-winding end of inner mandrel in a vice may help. Anneal the 150 mm or so section of tube coming into the bend if necessary.

Once the first turn has been done this way...

then I swap sides and hands like this, for the next 2-3 turns.

Once you have enough turns for you to be able to get a firm hold on the wound end (about 3-4 turns), then exchange the short outer mandrel for the long outer mandrel.



Swap sides and hands back, and continue winding the outer coil. This last section of winding is the easiest of all.

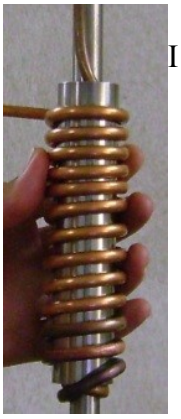
As you get towards the end of the outer coil, keep an eye on the alignment between the inner tail and where the outer tail will end up. You need to avoid the inner and outer coils or tails crossing and touching in the finished condenser.

Stop the wind about 1/2 turn past the inner tail.

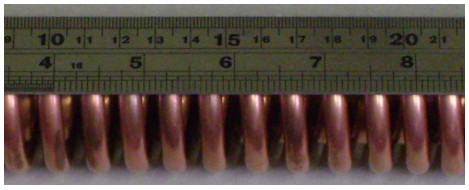
If you have some excess tube as you get near the end of the wind, then bunch up the coils a bit and use up that extra tube, (but make sure you leave enough unwound tube for the tail). You can adjust the spacing afterwards.

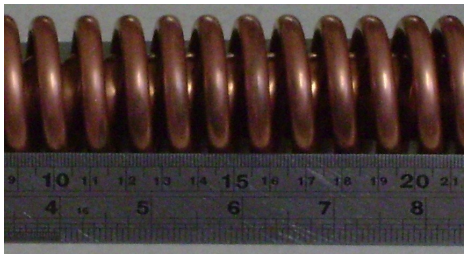
There are two ways to adjust the coil spacing for the outer coil.

First, spread and evenly space the coils with the screwdriver, same as for the inner coil.



I space the coils 3-6 mm apart.

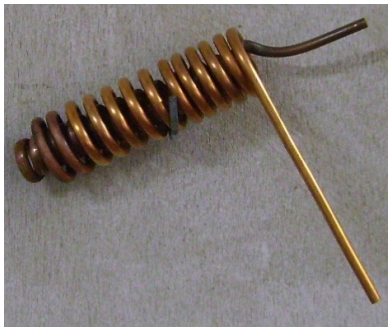


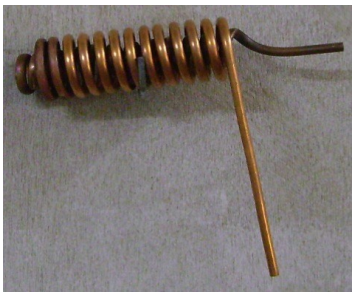


Then, if the outer coil is evenly spaced but is also still slightly shorter or longer than the inner coil, you can adjust the outer coil length by firmly (but carefully) grabbing both ends and pulling or pushing it. Be careful, it is easy to overdo it. You might want to put the outer mandrel back in to do this.

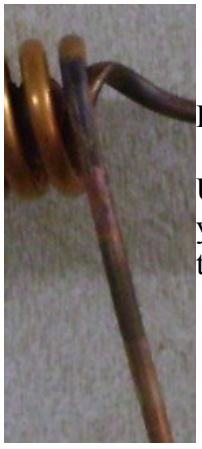
So using these two techniques, this...

…...can become this





Remove the mandrel and re-anneal the last 1/8 of the last turn of the outer coil, and the 40 mm section of the outer tail immediately coming off the last turn of the coil.



Re-insert the outer mandrel.

Use the bending spring the same way as with the tail of the inner coil. Make sure you use your non-bending hand to support the coil immediately next to and beneath the bending point.

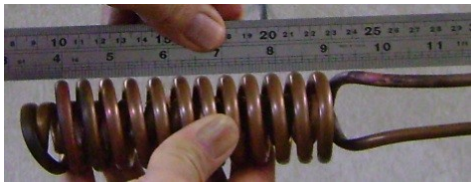

Remove the bending spring and mandrel, re-anneal the bottom half of the new bend.

Re-insert the outer mandrel, and work the tail up against it, in the same way as with the inner coil.

The outer tail has to be flush with or slightly inside the outside line of the outer coil, so that the whole condenser can slide easily and evenly inside the column.

Before adjusting the outer tail...

After adjusting the outer tail...



After you have used the mandrel and bending spring to adjust the outer tail, you may need to work the tail by hand a little further towards the centre of the condenser, to get it in the right position to fit easily and evenly inside the column. Do this carefully. I find it better not to re-anneal for this last small adjustment.

Check the fit in the column...

Finally, make sure the outer coil is straight. Adjust if necessary.

6. Aligning Coils

This is to align the two coils with each other, so they are nicely concentric.

There are two ways to do this aligning. Use both ways carefully, the adjustments required are usually small. (I do not re-anneal for this step, because only small adjustments are usually needed.)

Insert the inner mandrel 2 coil turns deep into the bottom of the inner coil, and lever the inner coil against the outer coil...

Or just working the coils with your hands...



Should end up looking like this (when the coil is vertical and viewed from directly above, this pic was set up for a horizontal shot).

7. Cleaning

Soak for 24 hours or so in fresh plain white vinegar.

You can just soak the outside of condenser only, not inside the coolant path. (See pic below. Note the tail ends sticking out of the vinegar.)

If you have a taller soaking container and can cover the tail ends with vinegar so the coolant path gets filled and cleaned too.  Keep the coil vertical until it is filled with vinegar, to make sure all the air bubbles have been flushed out of the coolant path.

A thorough rinse and flush with water, and a touch up with an old toothbrush and a bit of steel wool (especially any tail ends that were sitting out of the vinegar).  And...

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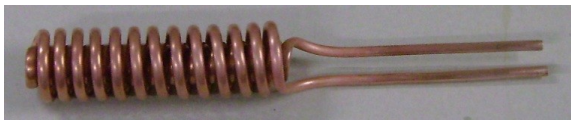
8. Finished Condenser






The End