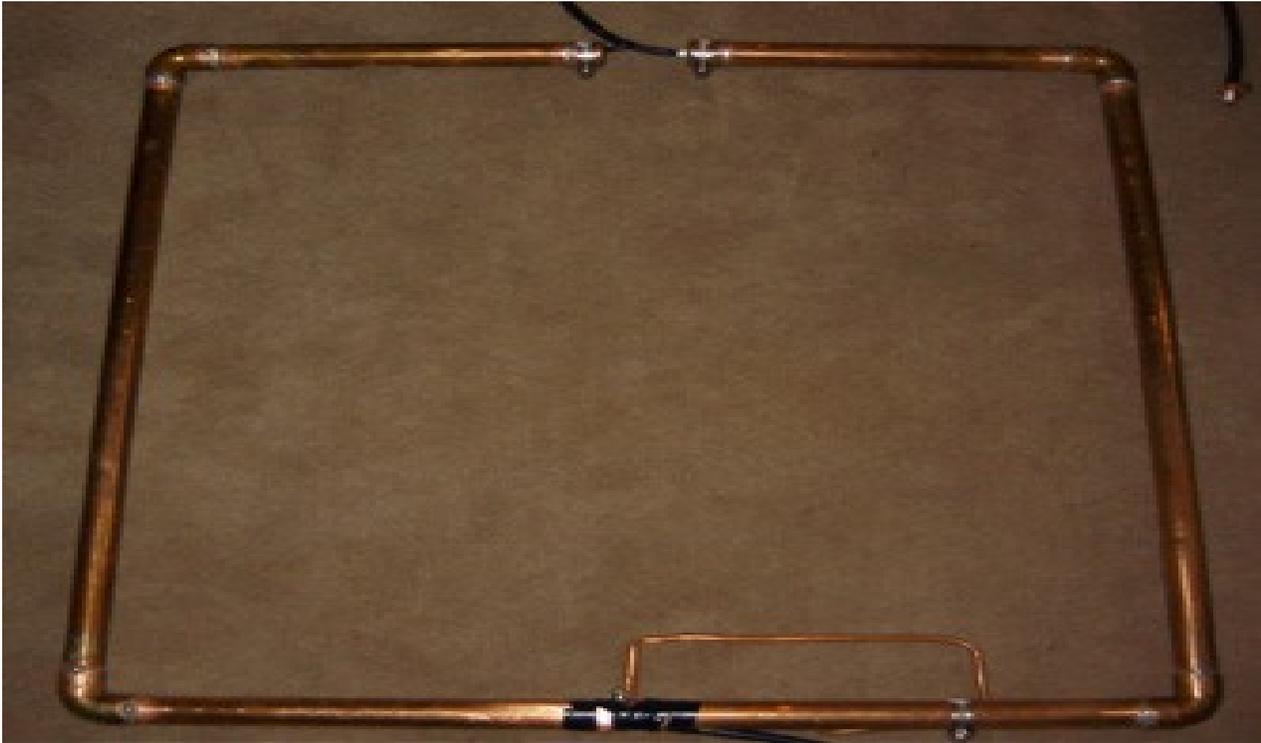


An **Easy Guide** to How to Build Your Own Magnetic Loop



For many people without building experience following instructions on how to make something is not always that easy. Many manuals and how-to sites can be hard to follow, not well explained, and simply assume too much. I hope to take you step by step through the process of building a magnetic loop out of copper pipe. I will list all the parts you need, where to get them, and how to put them together. If I can do it, I am pretty sure you'll be able to do it too! Just try not to get intimidated when I use words like torch or solder. I will explain that as well as I can.. So read through the article. Re-read it, and then go out and buy your parts and tools. And if you follow the steps, you should have yourself a nice loop antenna that works well and fits at almost any QTH.

Let's build a loop for **20 meters** that exhibits around **65% efficiency**. We'll make it out of **.5 inch** copper pipe and each side will be **3.5 feet long**. This loop is nice because is it so light and easy to place pretty much anywhere. Yes, I most certainly could and will give you other designs that are more efficient, but I want to start with something easy to make and use. Once you get the hang of it, you will be able to move on to more challenging projects. We'll do it easy and use a coaxial stub as a capacitor for each band and I'll show you how to change bands when you so desire.

Alternative Design: I would also recommend a loop that is 30 inches on each side and made from one inch diameter pipe. It won't be as efficient as the 3.5 foot version, but it will be close to it in performance. What I like about the 30 inch version is it fits in car trunks very easily. It will also store well in a suitcase. It is more portable than the 3.5 foot version and more sturdy.

DISCLAIMER: I take no responsibility if you end up getting hurt or damaged in the process of building this loop. Sorry guys, but considering the litigious nature of people these days I have to say this clearly. You hurt yourself, or damage your own property, it's your problem. If you have any doubt about your ability to build this loop, or follow these instructions without getting hurt, DON'T BUILD IT. Even if you think you can build this loop and not get hurt and do get hurt, your doing it at your own risk! This information is purely for your intellectual pleasure and if you want to go ahead and build it, that's your choice and your responsibility. Having said that. let's get down to details.

Parts You'll Need:

Quantity	Item
4	90 Degree Elbows
4	3.5 foot pieces of copper
4	Copper end caps
4	Small Radiator clamps
20 feet	RG8U or RG-213 Coax
10 feet	Thin copper pipe/thick copper wire



Tools You'll Need:

1. Torch for soldering plumbing
2. Silver Solder
3. Flux and brush to spread the flux.
4. Screwdriver
5. Razor blade
6. Electrical tape
7. Copper pipe sanding brush
8. Copper pipe sanding material
9. A good pair of leather gloves (highly recommended)
10. MFJ or other make Antenna Analyzer

How to Solder Copper Pipe

Let me start out by saying I am not a plumber and am sort of self taught in the area of copper soldering. If you have issue with the way I solder, that's OK, send me an email and let me know. For now I'm going to put down what I know and what has worked for me.

1. Preparing the Joint: Take 1 piece of 3.5 foot long copper in hand. Take your plumber's sanding strip or fine sand paper and sand down the final inch of the pipe that you intend to put into the 90 degree elbow. If you need to check the measurement, do so by placing the copper in the 90 degree elbow, it shouldn't get stuck and check the length. Now after you have sanded the area, this should take 10 seconds, put the copper pipe down. Now take the 90 degree elbow and use your copper sanding brush to sand the inside of the 90 degree elbow area that will eventually house the end of the 3.5 foot peice of copper. This should also be done in about 10 seconds. **Note: if you are working with .5 inch pipe, buy a .5 inch brush -- if you are working with 1 inch pipe, buy a one inch brush.** OK. So the end of your copper pipe is sanded, and the inside of the 90 degree elbow is sanded. Take your flux compound and a small brush, and brush on flux to the outside the area of the copper pipe that you have sanded down already. Try to get a nice even amount around the outside of the sanded area, not too thin. Now place the copper pipe end with the flux into the 90 degree elbow. You are ready to solder your first joint.



<http://www.curbly.com/alexrussell/posts/540-Discover-your-inner-plumber-how-to-solder-copper-pipe>

2. Soldering the Joint: Soldering is about using indirect heat, not direct heat. So when you turn on your torch and apply heat to the pipe, apply heat slightly off the center of where you intend to put your solder (you will apply your solder to the crease where the 90 degree elbow ends and meets your copper pipe). Your goal is to heat up the pipe to such a degree (in a specific place) that when you touch your solder to the intended target, the solder flows freely and melts around the joint crease. So step 1, you should have your copper pipe fluxed and inserted in the 90 degree elbow. Step 2, place your pipe in such a way where it won't move while your soldering it and yet you can still apply heat to the pipe and not set anything on fire (including yourself). I like to wear leather gloves too. Now, turn on your torch and apply heat to the bottom of the crease moving it side to side or up and down slowly. You might notice beads of flux forming and dropping to the floor (this is called "sweating the pipe"). I like to focus the heat on the bottom of the joint, because I touch the solder to the top of the joint occasionally to see if it will flow. This assures that the entire joint is hot enough so the solder will flow nicely around the entire joint crease. If you apply heat to the top only, and apply the solder to the top of the joint, it may be that the bottom of the joint isn't hot enough and you only get a partial solder around the crease. Now whenever you test to see if the solder will flow move the flame of the torch away from the pipe ... remember, the pipe should be hot enough for the solder to flow in that spot without any flame. You may have to leave the flame on the pipe for about 30 seconds to get it hot enough with some pipe sizes. It depends on the pipe and the torch, you'll have to see for yourself. I use Mapgas torches which burn hotter, so I don't have to wait as long for the pipe to get hot enough and the solder to flow. So the solder is now flowing and you find that you have a completed solder joint.



3. Walking Away for a While: Shut off the torch and walk away. That's right, that entire pipe and joint are so hot that if you think your going to anything to it for a while your mistaken. It will take about 15-20 minutes for that pipe to cool enough to work on it. And I wouldn't recommend handling the pipe at all, I have burnt myself a couple times trying. Also, you do not want to use methods like dunking the joint in a bucket of water to cool it down, because my metal working friends tell me this softens the copper (it loses it form more easily) and can also crystalize the solder and make for bad solder joints. I have no idea of this is true, but I'll take their advice. If do want to cool the pipe in water anyway because your impatient, wear gloves and watch what your doing. The pipe will cool down, and you can continue working on the next joint, but be careful: you may have cooled one part of the pipe, but part of it still may be **hot!**

4. Completing the Other Joints: If you feel like you're getting the hang of the soldering business, you may discover that you can prepare each copper pipe end and 90 degree elbow, and then solder both sides of the elbow at once. That's what I do. I sand, flux, and then insert two copper pipes into an elbow, and then heat one joint side and solder, and while the elbow is still hot, heat a little more and then solder the other side. This saves a lot of time. Also, make sure all the pipes are straight when you solder them. You want a symmetrical square in the end, not a crooked square. So take your time, and if need be, solder joints slowly and in alignment, so you won't only be happy with the way the loop performs, but the way it looks too! By the end of this step, you should have a completely enclosed and soldered copper square.



5. The Final Cut and Solder: I almost forgot...we need to cut the loop to prepare the area where the capacitor is affixed. OK. Take your pipe cutter in hand and a ruler. Measure out the length of one of the sides of your square. It doesn't matter which side it is, they should all be identical. Slowly cut a 2 inch peice of copper out of the middle of one of these sides. This should be fairly easy. Once you have the gap in place, go ahead and solder on the two end caps we bought. Solder on each cap at a time, don't try to do them at once, because the the pressure change from the solder process will make one of them pop off! It happend to me once. All right, we have the basic loop completed. We are almost done...on to step



Creating A Coaxial Stub:

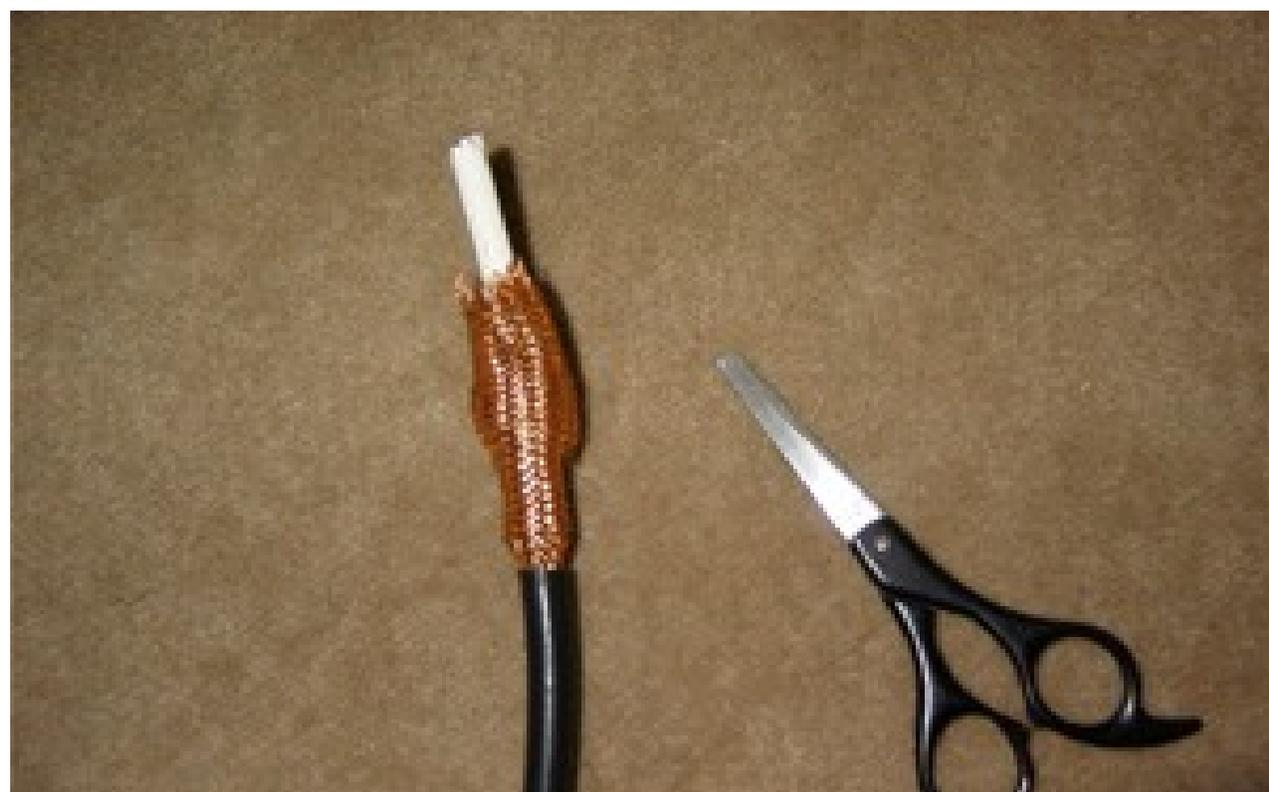
1. Coax Type: First step here is pulling out the razor blade and getting ready to work with coax. Not all coax is created equal. Some are better, and there's a lot of bad stuff out there too. So beware, and don't forget that I warned you. You're not going to get away using some cheap RG-8X, or any other small diameter coax -- unless you're running QRP. Your coaxial stub is going to carry a lot of voltage and current, so use quality products for your own sake. Or you might end up with a coaxial stub catching fire from the 'AM' I was running through it at 200 watts. Not a good idea unless you have a vacuum variable. However, coax is a heck of a lot cheaper and lighter, and pretty easy to work with. I would recommend not using double shielded coax, it's too hard to work with. I have tried using LMR-400 and those types of coax (which are usually excellent products, low loss, etc), but for the work we are about to begin, go with basic RG-8U or RG-213. Let's use a 3 foot piece.



2. Cutting the Outside Covering: You can use whatever tool you like to get the outside rubber off. I find the delicate use of a razor blade makes a nice tool. We are going to start with the part of the coaxial stub that gets connected to the loop, so we need to separate the braid from the center conductor. Measure about two and half inches from the end of the coax piece and with the razor blade and cut into the rubber lightly. Keep cutting till you have a complete circle. Try hard not to nick the braid underneath, but don't worry if it isn't absolutely perfect. You'll get the hang of it. OK, now take the coax length wise and cut a nice long slice down the center of the coax from the end to the point on the coax where you made your circle. If you have made the cut deep enough, it should now be easy to peel off the rubber coating.

3. Preparing the Braid and Center Conductor:

You should now have the peel off the coax, slightly pull back the copper braid from the coax so that it bunches up



Take your scissors and cut along the braid as pictured, leaving about 1/4 inch of braid intact towards the bottom. This will give your braid more strength when you pull it away from the center conductor of your coax.



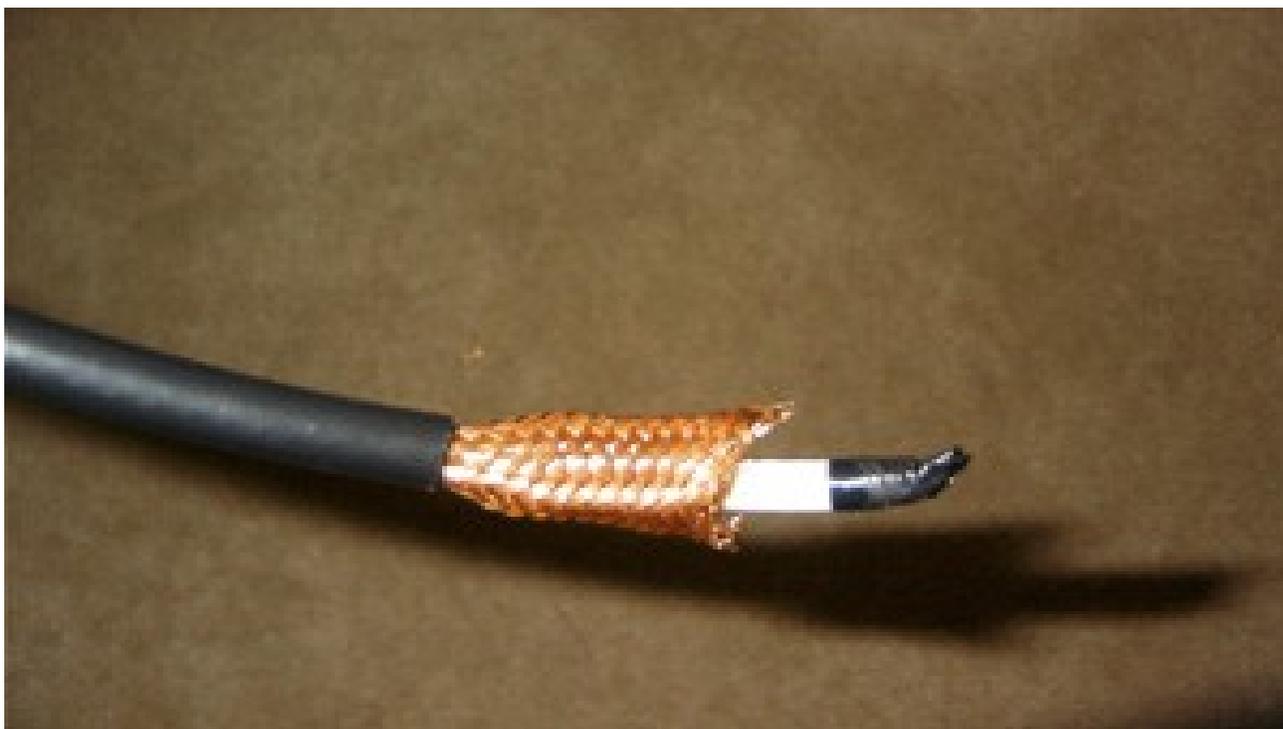
Pull the braid away from the center conductor and place some tape on the base of the braid where it separates.



.Once you have this re-enforcing tape on the braid, tape up the rest of the braid as shown leaving a half inch exposed This will give you a nice strong Y at the end of your coax for attachment to the loop. Also tape of the outside white foam dielectric of your cable too. I beleive each layer of electrical tape has a 1 KV tolerance, so let's beef up the coax a bit anyway. I have seen the white foam dielectric melt at high wattage and burn and vaporize -- so it can't hurt!



This is important, leave a half inch or so of center conductor without tape so you can cut off the white dielectric and expose the copper inside for attachment to the loop. I would recommend using a wire cutter for this, and gently pull off the white covering on the center conductor. You now should have a stub with a nice Y with both braid exposed and the an exposed center conductor. This is the part of the coaxial stub that will eventually be attached to the loop.





4. Preparing the End of the Stub: In general, the way these stubs work are as follows: the more coax you have, the more capacitance you have. The more capacitance you have, the lower the resonant frequency of the loop. The less coax you have, the less capacitance, the higher the resonant frequency. So we want to start with a longer coaxial stub than a shorter coaxial stub and keep trimming the bottom end of the stub until we reach the frequency patch you want to work. I'll go into a lot more detail on this topic in later chapters on actually tuning the loop, but I think this important information to mention. For example purposes, I have demonstrated in a picture what the end of the coax should look like when you're done. An exposed center conductor with its surrounding braid exposed. We accomplish this by using our razor blade and cutting a circle in the coax again. This time about one to two inches from the end of the coax. Let's cut a horizontal slice in the rubber so we can peel off the coating and once again have the copper braid exposed. Now pull the braid away from the center conductor just slightly and tape the end of the center conductor. That's it. You now have a piece of coax that will work as a capacitor for your loop. Congratulations. The last picture in the series to your right shows how the coax feed is attached to the loop. More information to come! Let's move on...

Creating A Feed:

1. Coax and Connector Type: We've talked about different types of coax to use for your capacitor, and all I'm going to say about your feedline is to please use a decent piece of coax. You can certainly be little more flexible on the feed side, but quality makes for quality. Done. OK, there are several ways to hook your radio to the loop and you can do that by using different types of connectors. I'll tell you what I do, and then you can decide for yourself. I actually solder on PL-259s to a long piece of coax and attach the other side to the loop. I'll go into more detail on how this is done. You can also solder on a SO-239 and run another piece of coax to your loop. It's really up to you. The important part here is getting the feed to from the coax to the loop done right. So let's go...

2. Preparing the Feed: Take a fresh piece of coax and either solder on a PL-259 or SO-239. Detailed instructions on how to connect coax connectors can be found in many places and is beyond the scope of this project. If you do not feel comfortable soldering connectors on to coax, go ahead and take an existing piece of coax that has connectors and cut off one of the connectors on the end. So now we can begin the feed system. Remove the outside rubber from the coax for about three inches on one end, leaving the braid exposed. Cut and separate the braid with your scissors. Pull the braid away from the center conductor and tape the bottom to give the braid strength. Add more tape between the center conductor and the braid so if pressure is applied it won't break off.



3. Attaching the coax to the Loop as a Feed: You now have your coax with a connector on one end, and the separated braid and center conductor. Good. Now let's take our constructed loop in hand, and we'll take the bottom of the loop -- the side opposite where we made the gap at the top, and attach the coax braid to the loop with our radiator clamp. You may want to sand down the spot where the braid gets attached the loop before you do this just to make sure the connection is as ideal as possible. Now the center conductor should be pointing up towards the inside of the loop.





Take your copper wire or thin copper pipe and get ready. Strip off the center conductor dielectric for about 1/2 an inch. Take your thick copper wire or thin copper pipe -- it should be around 10 inches long -- and wrap it around your center conductor wire, or place your thick copper pipe over the center conductor of the coax and crimp it on with a tool. You can also solder the connection, but use low heat so you don't burn the coax, or the dielectric. Now we'll complete the loop.



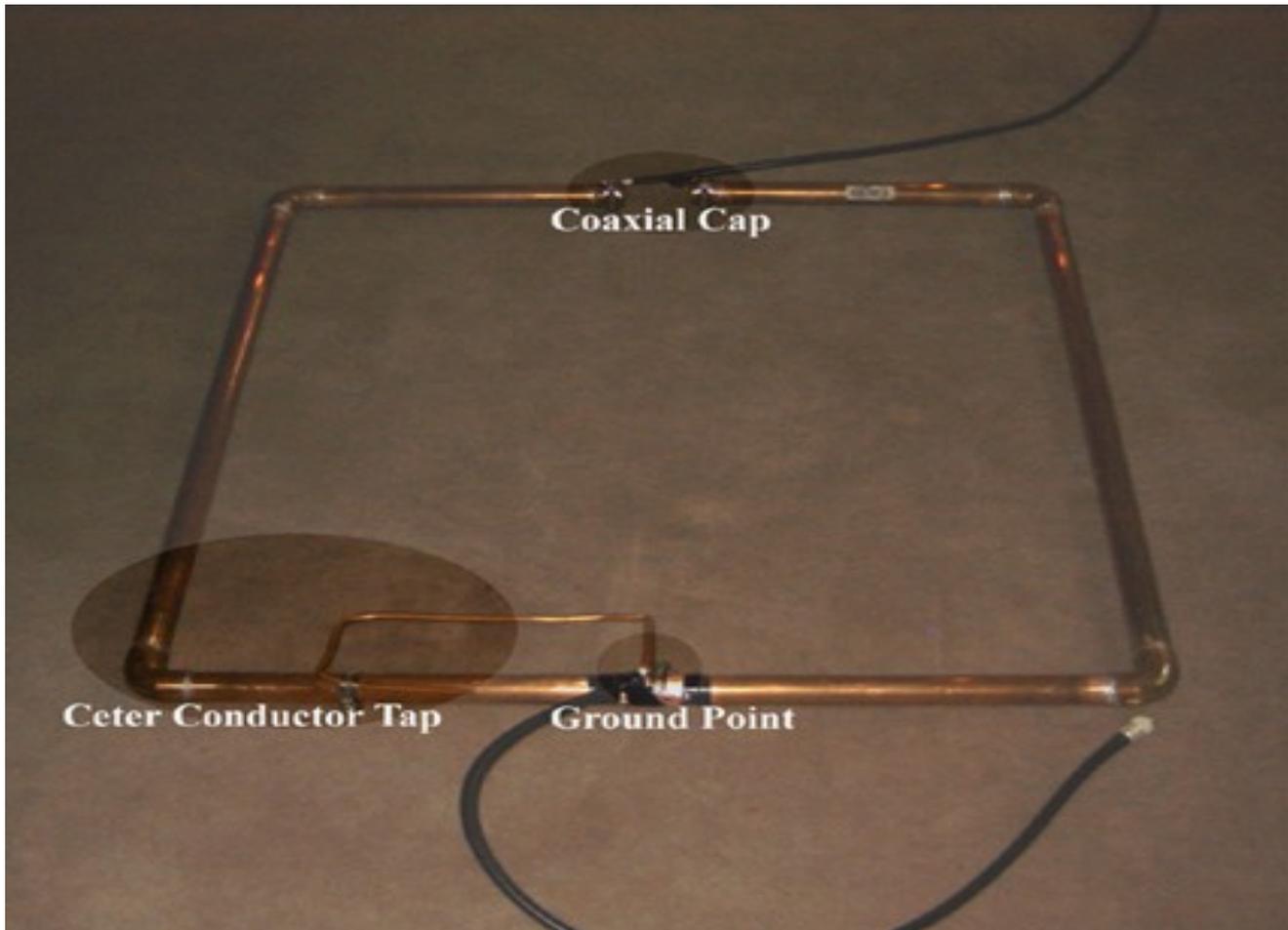


4. Finishing the Feed: Take your second radiator clamp and put it on the loop loosely on one side 5 or six inches from either side of the loop. It doesn't matter which side. Now place your thick copper wire, or think copper pipe through the radiator clamp off the one side and tighten it so it's secure, but you can still move it. It isn't important if you have too much wire or pipe, you may need it later, so don't bend it too much just yet.

You have now completed your loop from a mechanical level. Now comes the fun part. Tuning it and getting it on the air. Let's move on...

Hang in there, it isn't that hard to carry a tune:

We've come a long way. We've soldered, cut coax, separated braid, clamped on radiator clamps, and what you have before you should look something like what's pictured on this page. I think it's appropriate at this point to make a strong suggestion: tuning loops can be made easy if you have an antenna analyzer. Without an antenna analyzer, well, let's just say you are going to be a frustrated ham.



You see, you need the ability to see where the loop is resonant, and that may be outside the ham band area (before it's tuned). So go out, and borrow one -- do anything you have to in order to get your hands on one of these babies. It will make your life easy peasy and you'll get where you want to be a hell of a lot faster. Having said that, let's go ahead and make some other important issues clear. You are going to have to tune this loop up wherever you plan on using it. If you tune it in place A, and then move it inside your house, you'll need to tune it again. It's like ANY antenna. Surrounding objects couple to the antenna and change impedances. However, on the bright side, once you understand the basics of loop tuning, re-tuning it is as easy as using a coffee maker.

Here we go:

Placement: Mount the loop on something non-conductive. I think between two supported PVC pipes will do fine. You can also hang the loop from each corner (from a tree) or whatever clever way you want to mount it. BUT, please, no metal masts, no conductive materials. If you want to tape PVC as a mast, that should be fine. Even if it's indoors, try to keep it away from metal. However, get it in the clear as much as possible. Make sure you have the coaxial capacitors mounted on the loop.

Tuning the Feed First: There are two parts of loop that relate to tuning, the feed on the bottom and the coaxial capacitor. First we are going to focus on the Feed. The feed is very important. Here is the general feed principal, memorize it if you have to: the more efficient the loop is, the smaller the distance will be between the ground tap and the center conductor feed tap. In other words, that thick copper wire, or thin copper pipe will be closer to the center if the loop is efficient. On the flipside, if the loop is incurring losses the loop feed will be larger, and the tap point will be farther away from the ground tap. For example: if you tune the loop inside the house where there is usually a lot of metal, the loop will be less efficient than if it is high off the ground and away from coupling objects. So, if you tune the loop in the house, the tap will probably be farther away from the center ground. If you take the loop outside and get it off the ground, the tap point will be close in. Experiment with this and see for yourself, it seems to be the case every time.

With this understanding, loosen the radiator clamp just a little so it moves a bit if pushed on the feed where the center conductor pipe connects to the loop near the edge of one of the sides. Turn on your analyzer, and sweep through the frequencies near the band you want to operate and then keep going up and down on the analyzer in frequency, eventually you will find a dip in the SWR. Sometimes the dip can be as low as 7 MHz, do don't be afraid of checking most of the HF frequencies. This dip in SWR, however, will probably be about 5:1 or so -- but you will see a dip. It will be obvious.

Now, slowly move the the center conductor thick copper wire or thin pipe right and left and see if the SWR starts to go down at all. It should start to drop as you lengthen or shorten the distance between the two feed points. If you start to go up a vertical side of the loop and that's where you find resonance, so be it, clamp it there. The important thing is to get the SWR as low as possible. When you find that low SWR, even if it's not on your desired frequency, tighten the radiator clamp. Step 1 to tuning is complete!

Finally, Tuning the Coaxial Capacitor: This is the coda folks. Once your feed is matched, even if it's on 10.225 and you want to work 20 meters, that's OK, because our coaxial capacitor is now at bat. Take a good coax cutter. Grab your antenna analyzer and check to see where the loop is resonant. Let's say it's 1.1 on 10.225 -- we'll need to trim that coaxial capacitor to the desired frequency choice. Let's say that we want to work 20 meters on 14.225 MHz...we'll here's how. Each piece of RG-8U or RG-213 equals about 50 Pf per foot of capacitance, which means every inch of coax is worth about 100-200 KHZ. So if we are down on 10 MHz and want to go up to 14 MHz, we have some room to cut. Go ahead and make a one inch cut in the coax, just snip off the end. OK, what does the analyzer say? Probably about 10.665 or there about. The resonant frequency went up. Cut another inch off, and check the meter. Keep cutting until you get to about 13.800 or so. Don't worry if you end up going to high. It takes practice and we can use the shortened stub for 17 meters later. Folks, this is where we have to be careful, when we are so close to 20 meters our ham noses can smell it (and the analyzer confirms it), stop. Take a deep breath, and then take the end of the coaxial cap and cut lightly about one inch up from the end and remove the rubber coating. You should end up with a nice piece of braid on the coax. Check your meter again. Your frequency will probably have gone up again. Let's say at about 14.000. Now, we want the phone bands, so push the braid away from the end a little, that's right, bunch it up slightly. Boom, the frequency went up again, maybe to 14.100. Bunch it up a little more, now we have 14.250. And there you have it...a tuned magnetic loop. If you've gone too far, pull the braid back down onto the center conductor dielectric. Once you have your loop just where you want it, tape up the end of the center dielectric and it's conductor. This will keep the coax from arcing and catching fire.

There you have it, a completed Magnetic Loop, be proud!

O-p-e-r-a-t-i-o-n:

Your ready to run, you have the rig on. The loop is up in the air, it's in the clear as much as possible. Where are the signals? Make sure your in the resonant bandwidth of the loop. Check out the SWR...clear your voice, and get ready to QSO. But keep some things in mind:

A. Your coaxial cap cannot take more than 100 watts at SSB, and I wouldn't run more than 30 watts of FM or CW. Some say if you put RTV on the end of the coax and cover the center conductor and the braid you can run over 100 watts (maybe 200). However, if you exceed the coax's power limit, don't be surprised if you find the SWR go outta wack and the coax catching on fire.

If you want to run power, then we'll need to look into a nice vacuum variable capacitor, or cermamic variable. But that will cost ya.

B. No antenna tuners...don't even think about it. The magnetic loop is a high-Q tuned curcuit, which means that it will not operate at all outside of its narrow bandwidth. So if you can't get at least 2.1 when you tune your coaxial stub, retune!

C. Remember, the Magnetic Loop has a pattern when mounted vertically, this means there is a null in respect to the perpendicular plane of the loop. So if a station is weak, turn the loop and see if you can get the station into the pattern. Play with this and you'll see that you can also use the loop's null to get rid of bothersome interference.