Making a Portable Magnetic Loop Antenna

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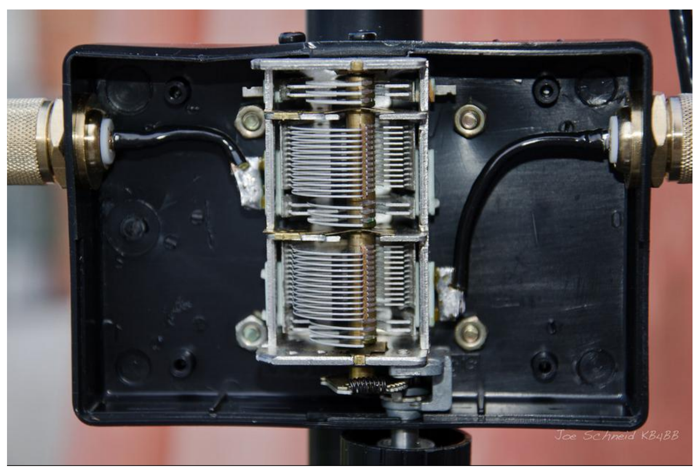
A friend of mine had purchased an AlexLoop Walkham magloop (more info can be found at http://www.alexloop.com/instructions2.html). The specifications are quite impressive:
Frequency range: 7 through 30 MHz
Maximum TX power: 20W PEP or 10W CW
Weight: about 3 pounds

The Walkham is very light weight and fits into a compact cloth bag for transport



On careful study and after taking some measurements of the AlexLoop Walkham, I found that the main loop was made from “Data Link DLC213 Premium Cellular 50 ohm” cable (similar to LMR400) with the center conductor and shield shorted together. Two gold plated PL-259 connectors are used to reduce resistance (even milli-ohms of resistance can be bad for a magloop) so that the total length of coax used (end to end) was 112 inches. The width of the plastic box is about 5 inches, so the diameter of the assembled magloop is about 37.25 inches.
The coupling loop is just under 7 inches in diameter and is made from solid copper plastic covered ground wire (possibly 10 gauge or larger) and was quite stiff to bend so holds its shape well.
The plastic pipe is 3 lengths of thin walled 1 inch O.D. (7/8” I.D.) about 14 inches long, allowing the antenna to be broken down small enough to fit the supplied bag.
The tuning capacitor is a two section model with the stators connected in series. This results in a capacitance range of about 6 to 180 pf (or 12 to 360 pf for each section).

There are several reasons why using a two section air variable capacitor in series is better than a single section one.

- A very low minimum capacitance is needed to cover the 10m band with this diameter of loop, so a typical single section cap with a minimum of 12 pf probably would not cover 10m and may not even cover the 12m band. Placing the two capacitors in series, halves the minimum (and maximum) capacitance.
- Very high voltages exist across the capacitor in a magloop. At only 10W CW, voltages can be between 500 and 1000 VAC. At the 40 to 50W level, voltages can reach almost 2KV; and at 100W, voltages can reach between 3 and 4KV. Placing the two capacitor sections in series is the same as doubling the spacing between the plates, thus a close-spaced capacitor (such as is used in the AlexLoop Walkham) can handle a higher power level.
- The bearings and friction contacts connecting to the movable rotor can create noise, can introduce resistance and can limit RF current through the capacitor. These problems are eliminated by using a split stator in series since no high voltage RF current flows through the bearings.

A 3:1 gear drive is used on the capacitor so going from minimum (30 MHz) to maximum (6.9 MHz) takes 1-1/2 turns of the tuning knob. Since a magloop can have a very narrow bandwidth (especially at lower frequencies) some form of gear reduction is a must, or you would have a difficult time tuning it for minimum VSWR.

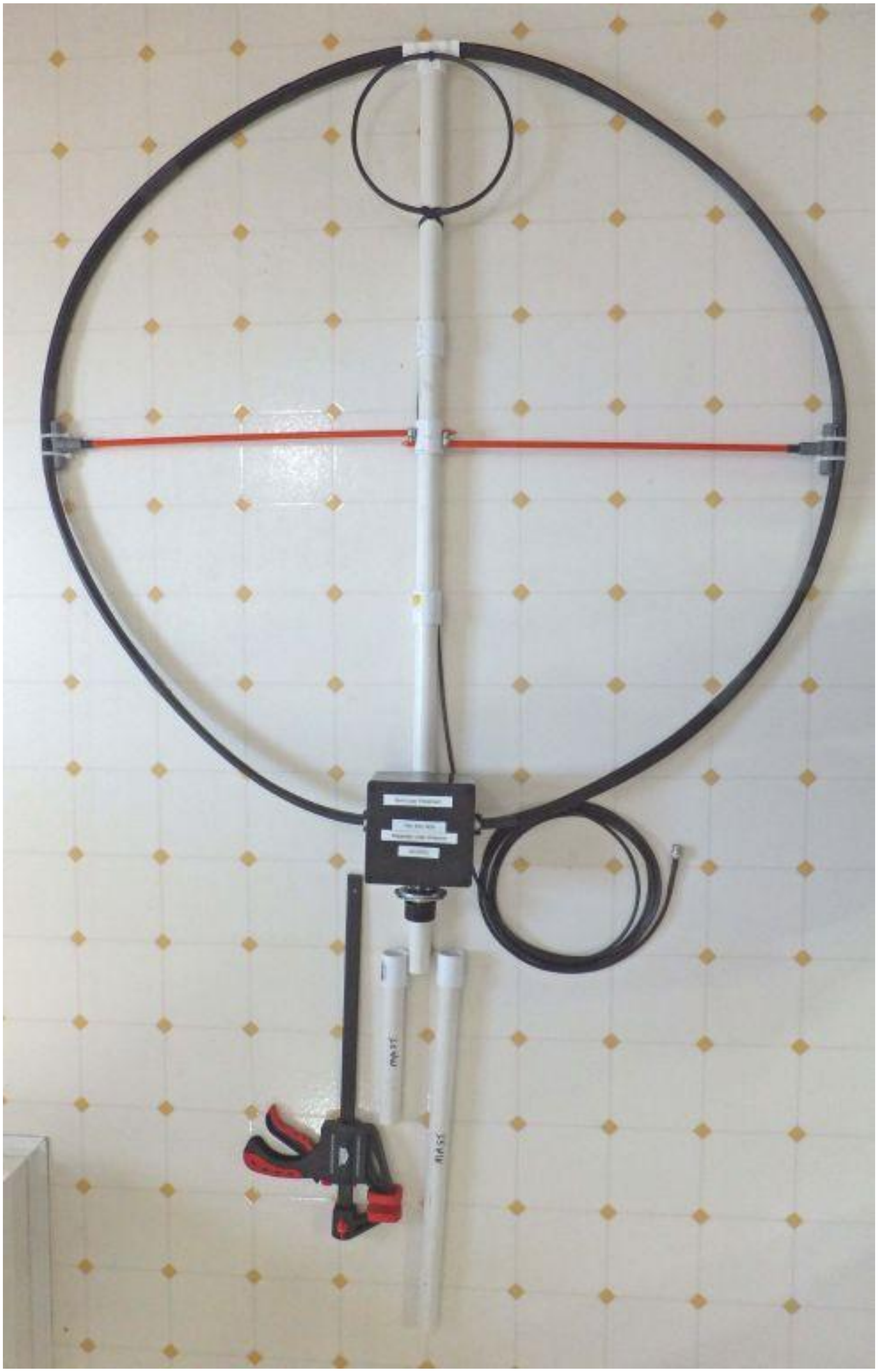
The AlexLoop Walkham is a great portable antenna, but is priced a little out of my range at about $400 plus Canadian. I needed to come up with a design that used up some of my junkbox parts so that it would be cheap to build, but would work as well as the AlexLoop.

Regular ¾” PVC pipe (1” O.D.) would work for the mast, although heavier in weight than what the AlexLoop uses. I had a single section E.F. Johnson air variable with a 2KV voltage rating and a capacitance of 12 to 244 pf, it had a better friction contact with the rotor than most and should handle 40 or 50W. I had some old 75 ohm RG-11 coax that didn’t seem to have a use, and a little experimentation showed that I could fold it up without applying any torque to the endpoints. So I wouldn’t need connectors (gold or silver plated), the coax can remain permanently connected to the capacitor. A friend gave me a piece of 8 gauge plastic coated solid copper ground wire which would work well for the coupling loop. I found a 5:1 planetary gear reduction at a hamfest which would give me 2-1/2 turns from minimum to maximum capacitance.

These and a few more pieces resulted in the birth of ----

The AlvinLoop PortaHam Antenna

Well, it's a little too heavy to walk around with while operating, but it is portable.



The picture on the previous page shows the loop assembled and laying on the kitchen floor. I use a 12” Jobmate ratcheting bar clamp from Canadian Tire to attach to a picnic table etc. The shorter 8” mast prevents the metal clamp from reaching near the capacitor. The longer 19” mast is about as long as it can be and still fit in the bag (the PVC coupling adds another ¾” to both masts).
You will notice that I used two lengths of RG-11 connected in parallel. The centre conductors and shields of both lengths are connected together at each end. This produces a “wider” conductor for the loop which results in better performance. Some loop builders recommend a minimum conductor diameter for an HF loop of ½ inch, while the shield diameter of a single piece of RG-11 is barely 5/16”. Since the loop produces a figure 8 radiation pattern with maximum RF off each end of the loop, and nulls off the sides; I fastened the two pieces of RG-11 side-by-side so that the width facing the direction of maximum RF is doubled.
The squares on the floor are 4-1/2” by 4-1/2” for reference. The orange support rods are cut from two 4 ft long by 5/16” diameter fiberglass driveway markers (labeled as Blazer Reflective Staff) which I found at a Canadian Tire store (many markers are metal so bring a magnet to test them).

Below demonstrates how the double RG-11 loop can be folded up while still attached to the tuning capacitor box without the use of potentially lossy connectors.


Ready to fold


One


Two

Three

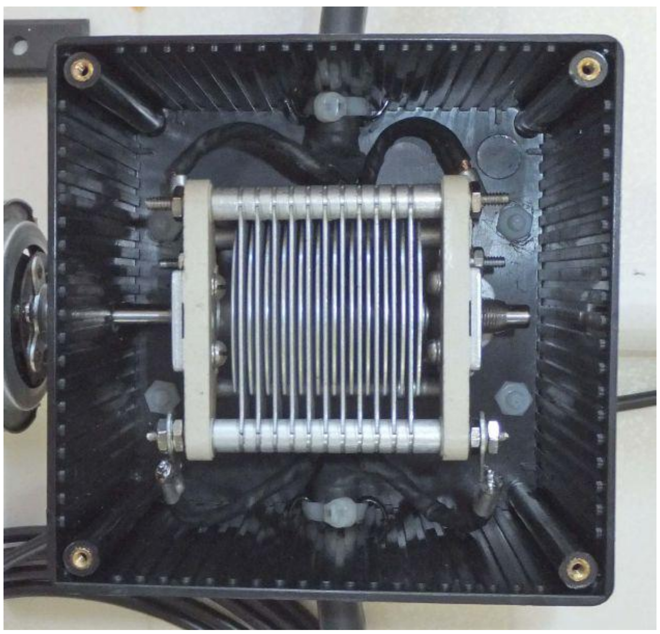

Into the bag


Ready to go

The antenna and supports fit into a 13 x 20 x 6 inch Air Canada bag I found at a Value Village store for $9. My loop, with all pieces packed in the carry bag, weighs about 10 pounds.

Construction Details

My loop ended up being just under 37” in diameter (36.8”). I cut two lengths of RG-11 (you could use a different coax such as RG-8) 119 inches long and removed 3-1/2” of the outer insulation from each end. I combed out the braid and stripped the centre conductor an equal length, combining the wires from the centre conductor with the braid wires and then dividing all the wires into two equal groups. After doing this to both ends of both pieces of RG-11, I used pieces of heatshrink at each end, at the top, at the sides and a couple more locations to secure the two lengths of coax together. I then twisted one of the pig tails from each coax together (repeating with the other pair) so that I ended up with two pig tails at each end of the loop which I trimmed to 3-1/2” and covered with heatshrink; crimped and soldered on a lug to each. I decided to use two connection points to the capacitor at each end of the loop, which is why I created two pig tails at each end.
For my capacitor, I used a 4-3/4” by 4-3/4” by 3-3/4” plastic box (Hammond 1591VBK from Sayal) which I attached to the PVC pipe with two ¾” grey plastic pipe clamps from Home Hardware.



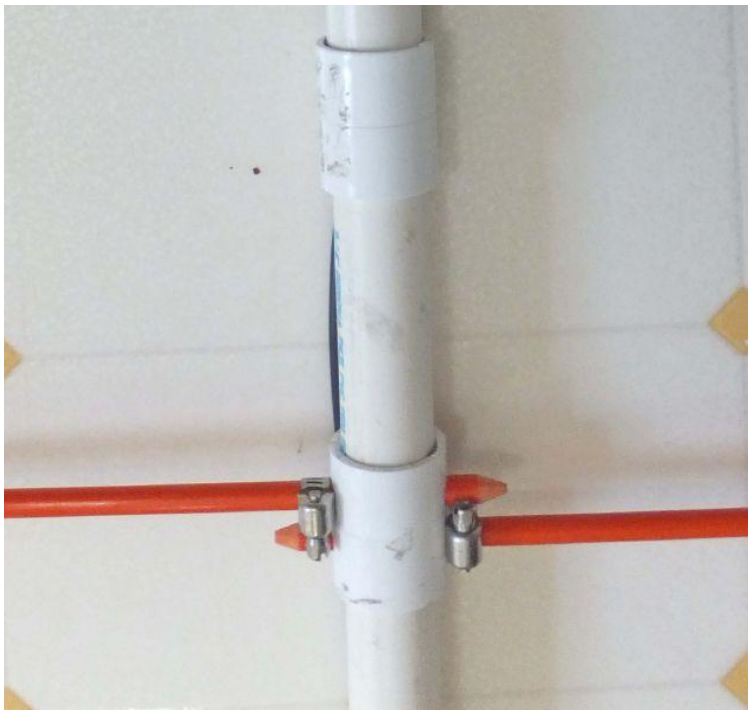
The two wire pig tails at the top connect to the rotor, the two at the bottom to the stator.

The plastic clamps (and the capacitor) are attached with ½” x 3/16” nylon bolts.

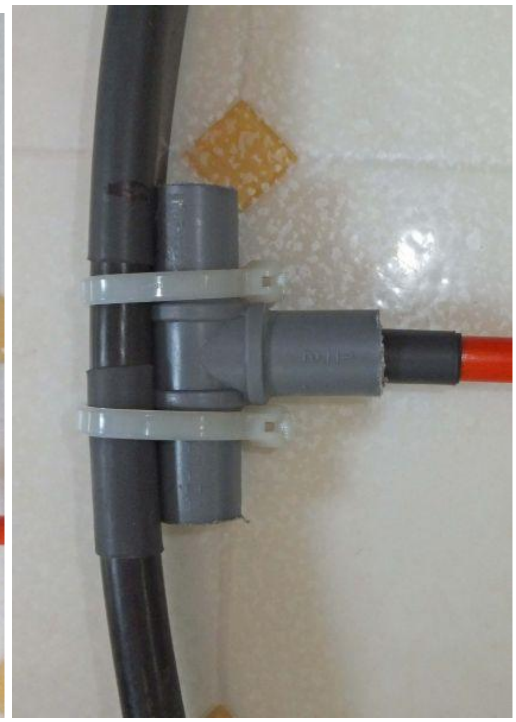
You may need to add heat shrink to the PVC pipe to make the clamps grip it securely. I didn’t have to because the two bolts securing the capacitor are on the centerline of the box, I had to drill two holes in the pipe for the bolt heads – this prevents the box from moving.
I drilled two 3/8” holes beside each other about 3/8” apart and filed them out till I could pass the double RG-11 (covered in heatshrink) through them. A cable tie inside and outside secure the loop (white in the picture), while two more smaller (black) cable ties through a small hole about ¼” to each side pass through both white ties and jam everything together so they can’t shift on the RG-11 loop.

The mast is made from 3 sections of ¾” PVC schedule 40 pipe. The bottom section I cut to 18” and mounted the box so the holes for the loop were 10” from the top of this section. This left about 5-1/2” below the box for a handle. There is no PVC coupling glued to either end of this bottom section.

The centre section ended up being 13-1/2" with the coupler glued to the bottom end). Because the flexible coax forming the loop needs additional support at each side, I needed two support rods passing through holes in the centre section. I added a coupler at this loop centre point for more strength/stability. This made the lower pipe half 8" long and the upper pipe 4-1/2"; each coupler adds about 1/8" so the total length (including coupler at bottom) was 13-1/2". I drilled two 11/32" holes through the centre coupler ½" apart for the 5/16" support rods to pass through.
The two fiberglass support rods I cut with a hacksaw to 19-3/4" and then added a 2" piece of heatshrink which extends 1/8" or so past the cut ends to protect you from getting fiberglass splinters. A very small hose clamp works as a stop and let me adjust the length for the best round loop shape. Two garden hose type tees with the hose clamp portion cut off work to plug the support rod into.



Fiberglass support rods pass through holes drilled in the PVC coupler. Hose clamps work as adjustable stops.



A hose tee with shortened arms is used to secure the loop to the support arm.

The coupling loop I made from 6 gauge solid copper wire is about 7-1/4" in diameter and is permanently attached to the upper section of pipe with a 12 foot length of RG-58 attached. I measured a length of wire 22-1/2" and added an extra 3/8" to each end. After carefully straightening it of any bends (you can roll the wire between two boards to do this – standing on the upper board helps), I bent it around an approximately 6-1/2" diameter pot from the kitchen and when I let go of the ends, it sprung out to a perfect loop slightly larger than what I wanted. I drilled another hole on the back side of the pipe just above the bottom coupler for the RG-58 coax to pass through (round the edges of this hole).
Place two pieces of heat shrink tubing onto the loop and remove 3/8" of insulation from each end of the coupling loop; bend sharply at right angles so that the two ends will pass through a ½" hole into the centre of the pipe. Run the RG-58 into the lower hole and out the ½" upper hole preparing it by stripping 1" and forming the braid into a pig tail. Solder the braid to one end of the loop and the centre conductor to the other end; cover the bare wires with the heat shrink. Carefully pull on the RG-58 and force the two ends of the loop into the hole, they can be secured there with a cable tie as shown in the following picture. The two soldered ends were separated about 1/8" when in the ½" hole.

As can be seen in the following pictures, the top of the loop is attached with a cable tie through a hole ¼" from the end of the pipe; the ½" hole ended up being 7-3/8" from the top of the pipe.

In the above two pictures, you can see how I modified a ¾" Tee by sawing off the upper half (or enough so the cable ties can grip the coax). I then plugged a scrap piece of pipe into it and hand sawed down the side (making sure I was aligned with the T) until reaching the "stop" (ridge inside the pipe). I filed into this stop so that the black cable tie wouldn't keep the pipe from fully seating.

I glued a coupler to the bottom end of the top section, and to the bottom end of the middle section, there is no coupler glued to either end of the bottom section. The two mast sections I use with the table clamp have a coupler glued to the top of each one. I used PVC-40 solvent cement.

Final Thoughts

The white ¾" PVC couplers and Tee connector were found at Home Hardware, as were the two small stainless hose clamps, the two grey plastic ½" insert hose Tee connectors and the two grey plastic ¾" pipe clamps. The nylon bolts and nuts were found at Canadian Tire. Since this is a portable antenna that would not remain set up outside for long periods of time, I didn't worry about using UV stable cable ties (or painting the PVC to protect it from UV).

A couple of ways to reduce the weight of this loop antenna would be to use RG-8 foam dielectric coax which is lighter than the solid plastic dielectric type. Also using some form of light weight table clamp would get rid of the heavy metal one I have. If you could find a 1" O.D. PVC pipe with a thinner wall thickness than the schedule 40 which I used, that would also reduce the weight (as in the AlexLoop).

I used a BNC connector at the end of the 12 foot length of RG-58. This will let me connect directly to my QRP radio, or to a regular UHF connector by using a PL259 adapter.
The 6 gauge solid insulated copper wire may be a little hard to find, try asking a Bell installer – they use this wire for grounding some types of equipment.

The biggest expense in building a magnetic loop antenna is the capacitor. A vacuum variable (the ultimate capacitor for a magloop) can cost $200 to $300 or more. The next best choice may be a "butterfly" capacitor which is available from at least two sources in Canada:

Monarch Capacitors in Ontario: http://www.monarchcapacitors.com/
VA6POP in Calgary: http://forums.qrz.com/showthread.php?411955-BUTTERFLY-CAPACITOR-KITS-VA6POP-253pF-15KV-3-quot-OD-rotor-1-2-quot-spacers
Butterfly capacitors can also end up costing quite a bit and may not have the minimum capacitance needed for your loop to cover 10m. But like vacuum variable capacitors, they are available in high voltage versions which will handle 100W or more.

The capacitor I used is available from Cardwell Condenser (Johnson Capacitor Division) as their type "E" single section part number 154-1-1, see:
http://cardwellcondenser.com/johnson-capacitor-division/type-e-154-series/type-e-154-series-single/
In an email received from them they state that all capacitors are manufactured to order with the following prices (in U.S. dollars) for the 154-1-1 (they estimated shipping to Canada as another $60):

P/N: 154-1-1
Qty: 1 to 9 units, $90.10 each plus a $150.00 setup charge
Qty: 10 to 24 units, $90.10 each no setup charge required
Qty: 25 units and above, $83.18 each

A better choice may be a split rotor design which has many of the advantages of the butterfly capacitor. In both, no RF current is passing through moving parts (such as the rotor bearings), and the maximum voltage is increased due to the effect of doubling the plate spacing. These may be found at a hamfest or as part of a junked high power manual antenna tuner. The maximum capacitance with both sections wired in series may be a limiting factor since you need 80 or 90 pf to cover 10m through 20m and more capacitance if you want to cover 30m or 40m. Some hams are using a high voltage fixed capacitor in parallel with the variable to extend coverage (it could be plugged in using "banana plugs"). Thus for example your 8pf through 80pf capacitor becomes a 58pf through 130pf with a 50pf fixed capacitor in parallel. A second 50pf in parallel would make it a 108pf to 180pf.

For QRP operation (such as what the AlexLoop Walkham is designed for), you may find cheap two section capacitors with close plate spacing will work fine. I recently picked up one for $5 at a hamfest which measures 7pf to 233pf with both sections in series; it should be good for 5 or 10W. I may use it in a light weight QRP version of my AlvinLoop.

There is an online magnetic loop calculator that lets you try different sizes/frequencies, I am not sure how accurate it is but it is found at: http://www.66pacific.com/calculators/small_tx_loop_calc.aspx

A gear reduction unit attached to the capacitor is a must to let you tune it properly. You may find one at a hamfest or you can buy a 6:1 planetary reduction drive from RF Parts https://www.rfparts.com/capacitors/capacitor-vernier.html or from Oren Elliott Products at: http://www.orenelliottproducts.com/planetary-reduction-drives .
A 6:1 will result in 3 turns of the tuning knob to go from minimum to maximum capacitance (180 degrees of rotation of the capacitor shaft).

When tuning the magloop, adjust the capacitor for maximum noise in the receiver. This will place you very near the minimum VSWR point. Applying a low TX tuning power while monitoring SWR will let you fine tune to as close to 1:1 as possible. Due to the narrow bandwidth of a magloop, you will need to readjust the capacitor often as you tune across the band.

So how does it work?

A magnetic loop antenna, like a mobile HF antenna, is a compromise antenna on HF. Due to its small size (small fraction of a wavelength), efficiency can be low if you are using it at lower frequencies. Following are some efficiency numbers – on the left are values from experiments by AB2EW, and on the right are values calculated by the online magnetic loop calculator:

15m	61%	15m	82%
17m	43%	17m	73%
20m	25%	20m	53%
30m	11%	30m	26%
40m	4% - 5%	40m	9%

I don't know which are correct, but they give a rough idea of small magloop efficiency.

My first two-way contact with my AlvinLoop PortaHam was with W1AW/1 in New Hampshire on 40m using my KX3 at 10W SSB. He was S9 and although he said I was a little light he could copy OK (he gave me a 59 naturally). This wasn't too bad considering the loop was clamped to a wooden chair about 2 feet above a concrete floor inside of a workshop with lots of tools etc. around it. I had turned off the internal ATU in the KX3 and after peaking the noise on RX, was able to fine tune the loop capacitor (in the 3W tune mode) for a 1.1:1 SWR quite easily (although I did notice some change when I took my hand away from the tuning knob due to body capacitance).

The "figure-8" pattern off the ends of a magloop with a null off the sides means that you only have to swing the loop through 90 degrees to cover all directions. The side nulls can be used to reduce the strength of another station causing QRM (if he isn't in the main lobes).
It is best to position yourself off the side of the magloop to reduce RF exposure, and getting it up 6 feet will also help (in addition to helping to keep people from walking into it).

I try to keep the RG-58 feedline in the side-null as it drops down towards the ground; pulling it out at a slight angle would be even better. Maybe another short support rod as a standoff would be the answer.

Some magloop users have reported improved performance by mounting the loop about 2 times the loop diameter (6+ feet) above the ground, and then placing an X made from 18 or 20 gauge wire on the ground under it. The 4 legs of the X are each 2 loop diameters (6+ feet) long and are electrically connected at the centre (but not connected to the magnetic loop antenna).

Remember that you can't use an antenna tuner with a magnetic loop antenna, the magloop is in effect an antenna tuner (with fixed "L" – the loop, and variable "C" the tuning capacitor).