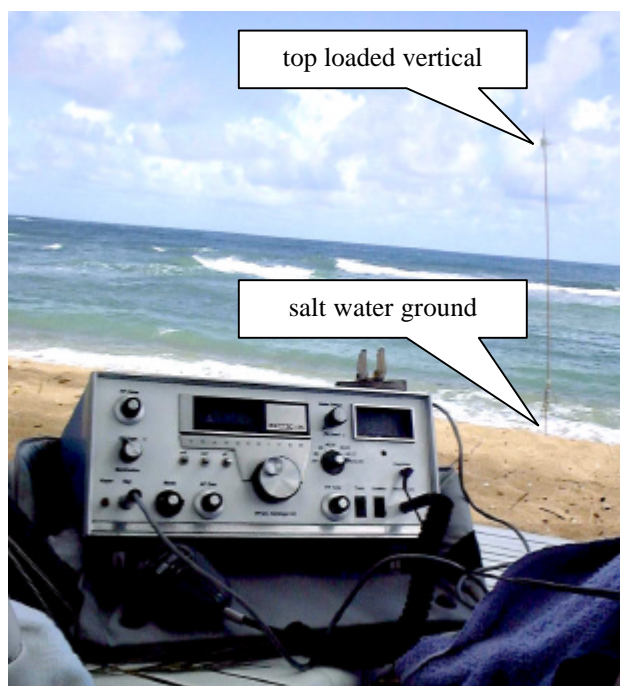


A Loop Antenna Covering 7 to 30 MHz.

This note describes a relatively small, but efficient, loop antenna initially created for portable operation. With suitable modifications, it can be adapted for fixed station use. In this age of CC&Rs, an antenna similar to this may very well be the answer to your problems. Have a look, be inspired, get out the torch / soldering iron and create your own version!

Background

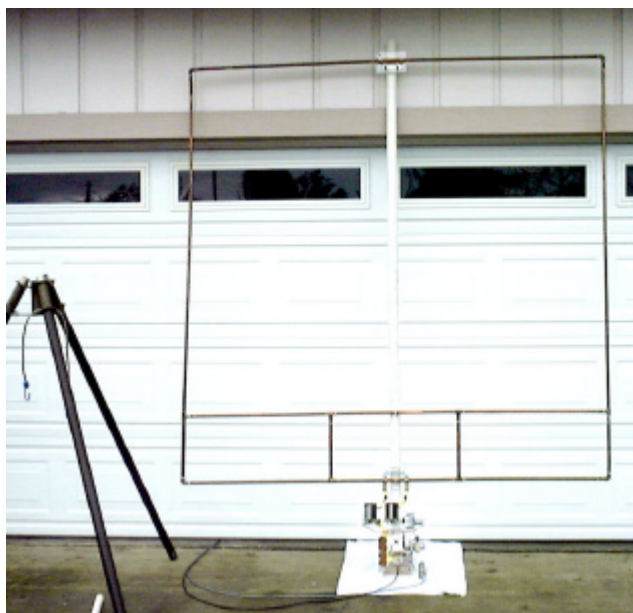
“Playing radio” at the beach is one of my favorite activities. Since moving to California 22 years ago, I have tried numerous portable antennas from simple wires thrown in palm trees, to dipoles suspended by kites fed with open wire ladder line. Each approach has its pros and cons. For instance, for ocean side use, a top loaded vertical with a hi-Q coil and salt-water ground works quite well. There are two problems with this antenna. First, you have to be very close to the surf to pick up the sea-water ground. Secondly, since it is a physically short antenna on 40, 30, and 20 meters, it is only resonant over a narrow band making tuning critical and challenging in the field.



Given the shortcomings of the vertical and other portable antennas I have tried, the goals for a new antenna were as follows:

1. **no radials** or ground system required
2. cover 40, 30, 20, 17, 15, 12, 10 meter bands
3. easy to transport, erect, and tear down
4. small enough to be carried on a mini van roof
5. **remote tuning** with simple dc gear motors
6. performance comparable to $\frac{1}{2}$ wave wire antenna

A high efficiency loop appeared to be the most viable approach to meeting these objectives.



On-the-air tests indicate that this 80 inch per side loop performs comparably to full size inverted V or dipole on 40 through 10 meters. The trade off is its high-Q resulting in a small operating bandwidth. A motor driven tuning unit solves this problem. The loop is normally mounted on the tripod, but was removed for the photo.

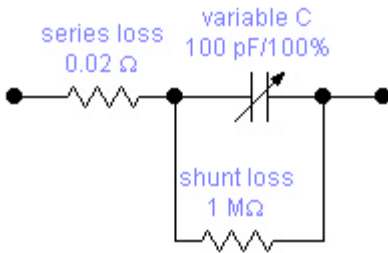
Loop Basics

The ARRL Antenna Book (e.g. 17th edition) has a good section on loop antennas (pp5.9 - pp5.16). After chewing on this material for a while, two conclusions were drawn.

First, for my application, the "army loop" method of feeding the loop is preferable to the method used by Ted Hart w5qjr. This approach uses 2 variable capacitors (3 are used but 2 are ganged) and a 50 ohms drive point impedance can be always be achieved. This was important to me since I did not relish having to tweak yet more knobs and switches on my transceiver trans-match to QSY within a band.

Secondly, I wanted to avoid using any exotic variable capacitors in the tuning section. The losses in the resonating capacitors used with the loop have an important effect on overall performance. There are 2 primary loss

mechanisms in variable capacitors as shown in the following sketch.



First, there is the shunt conductance from the insulators used to hold the stator. Secondly, there is a series loss due to the electro-mechanical interconnection of the plates and the wiping contact(s) used to establish the electrical connection to the rotor. In the ARRL antenna book article, Ted Hart goes to great lengths justifying the need for a tuning capacitor that has no wiping contacts and therefore providing low loss at high RF current flow. Although special capacitors can be ordered from w5qjr, I am of the "use what you have" school. The key is to minimize the circulating current in the loop. Not only does this lower the series resistive loss of the capacitor, but it also lowers the skin effect loss of the loop.

Without boring you to tears with the loop inductance and radiation resistance equations, the simple bottom line is: make the loop as big as you can while still having it look inductive at the target operating frequency *and* meeting your space requirements. By making the loop as large as possible, you improve the radiation efficiency *and* minimize the series resistance losses in the tuning capacitor.

Aside from taking more space, consuming more materials, and being less "stealthy", there is yet another downside to making the loop larger ... it limits the upper operating frequency that can be achieved with a fixed tuner topology. As the loop size is increased the reactance at the loop terminals will eventually go from inductive (+jX) to capacitive (-jX) therefore it cannot be resonated with the "tuner" based on variable capacitors. In fact, since the tuner must always present a finite capacitive reactance to couple power into the loop, the loop must present an inductive reactance. This makes for a bit of a conundrum since on one hand you want to make the loop large, but yet you would like to cover from DC to daylight !

Loop Details

The loop is constructed using standard 1/2 thin wall copper tubing and fittings. The important dimensions and a photograph of the loop feed point and tuner are shown on

the following page. A solution to covering a wide frequency range was found as shown in the diagram. It involves nesting 2 smaller loops within the large one and constructing "switches" from teflon insulators and copper sleeves as shown. This appears to work quite well and is a good compromise given that the loop area is maximized.

At resonance, the impedance of the loop driving point is remarkably high. As an experiment, a 100K ohm resistor was shunted across the feed point to the loop after it was properly tuned to resonance on the 30 meter band. The vswr changed from 1:1 to about 1.6:1 indicating that the feed point Z was extremely high. This raises at least 2 issues: soldering flux and weather. Given the hi Z nature of the feed point, it is imperative that the flux be cleaned from all the joints that are associated with the switches or it will be "activated" by the weather rendering the loop virtually useless.

As can be seen from the diagram, the loop has a natural break down its vertical center line. The top section of the loop was cut at its midpoint and one of those slip over "repair couplings" is used to re-connect the top section. This allows the loop to be split in half for transport on the mini van roof.

Although standard copper "Ts" were used, I bored them out on a small lathe so the copper tubing would pass through them and not require cutting. This was mainly done to facilitate arriving at the dimensions shown in the diagram for the inner loops.

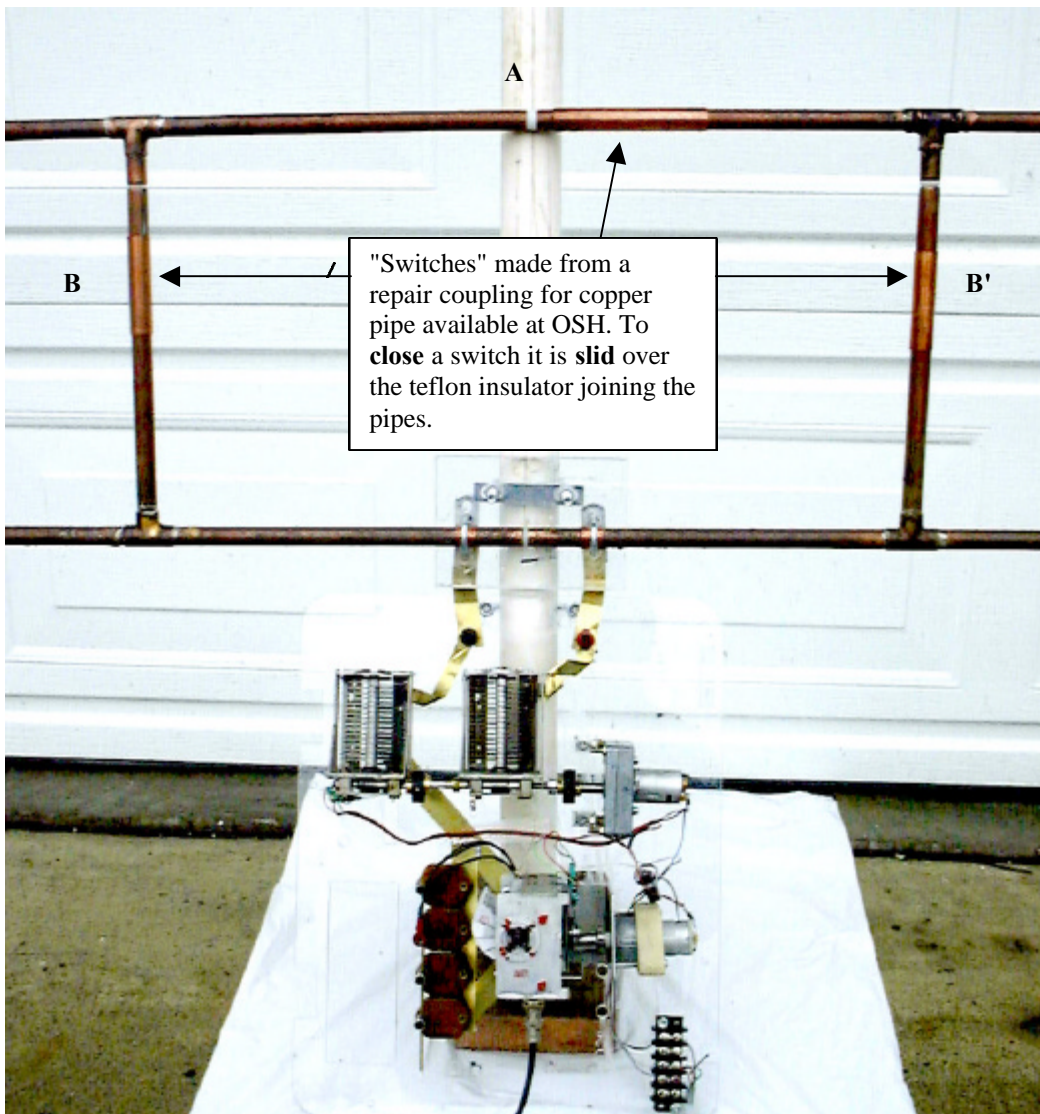
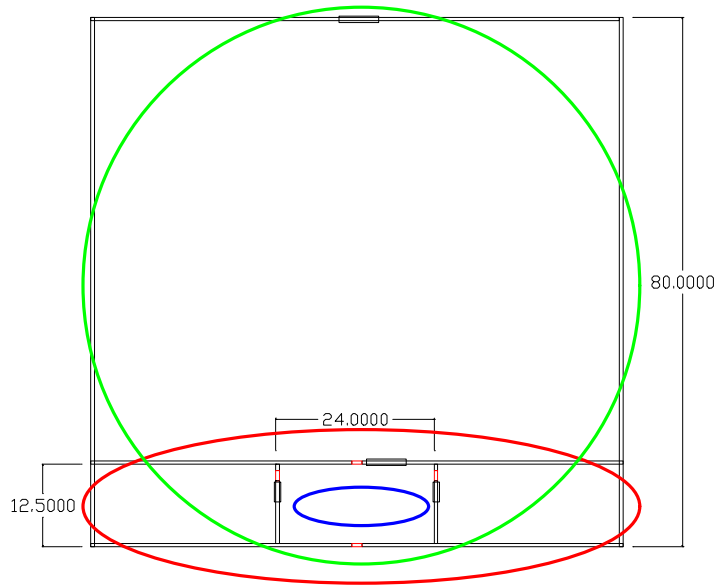
When a pipe cutter is used on the tubing, the ID of the tubing is reduced where the cut is made. Normally this is not a problem, but it is a problem where the teflon inserts are used to isolate the sections. The end of the tubing should be reamed back to its nominal ID so you can use the full ID for the teflon (or other low loss material) insulators.

The loop is mounted to a section of PVC pipe using U bolts and a 1/4 inch thick plexiglass plate on both the top and bottom of the loop. The feed point is attached with 2 brass strips clamped under the U bolts that hold the lower loop member. Note that the plexiglass is hard to see in the pictures.

Finally, it should be noted that a 20 foot section of copper tubing produces three 80 inch sections ... what a remarkable coincidence ☺ !

The drawing to the right gives the important dimensions of the loop and shows how "band switching" is accomplished by nesting 2 smaller loops within the large one. The red breaks in the tubing are made from teflon inserts that are a tight fit with the inside of the copper tubing. These were turned on a small lathe and have a ridge in the center to keep them from getting lost inside the copper tubes.

To cover 40 and 30 meters, all "switches" (A,B,B') are open, current flows in the green loop. To cover 20 and 17 meters, switch A is closed and the major portion of the current flows in the red loop. To cover 15,12 and 10 meters A, B and B' are closed and bulk of the current flows in the blue loop.



Tuner Details

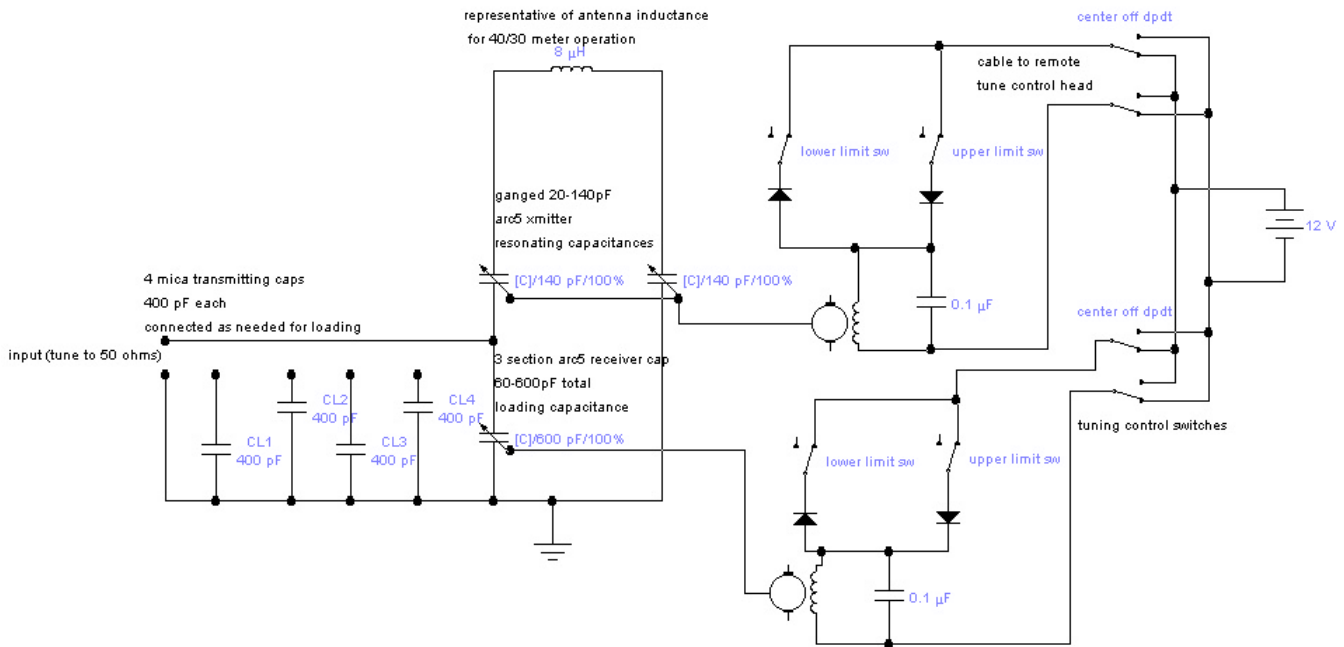
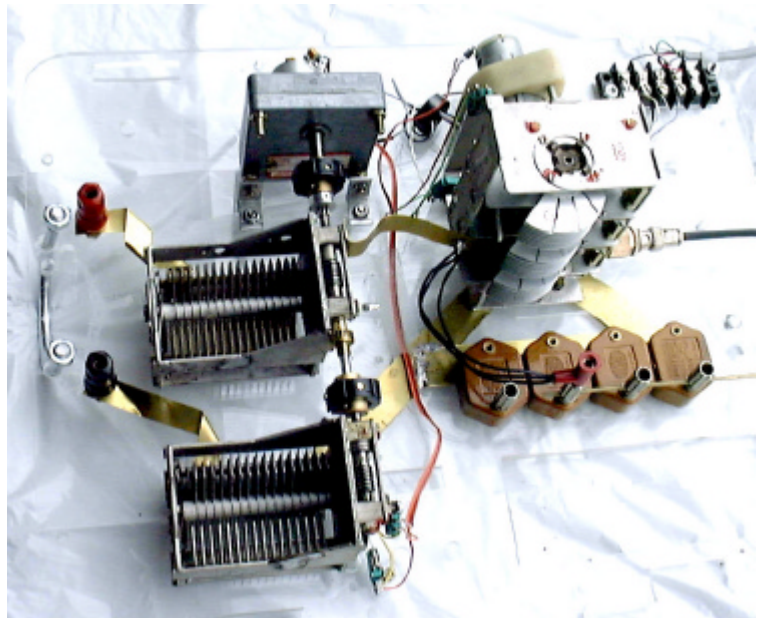
The tuner is built using 1940s vintage worm drive variable capacitors from the venerable ARC 5 series of radios.

The ARC-5 transmitting capacitors, used to tune the loop to resonance, use 3 glass bead insulators to hold the stator making the shunt loss very small. It is important to make sure these glass beads are clean and not damaged. To minimize the series losses, the wipers used to make contact with the rotor were carefully cleaned.

The schematic for the tuner is shown below and another view to the right. I used a Dayton 50 RPM 12 V drive to drive the 2 arc 5 tuning capacitors. Its just about the right speed, and you can bump the center off tuning switches (not shown) to do fine tuning. The 3 section ARC 5 receiver capacitor was used for loading. It is driven by the guts of a cordless electric screwdriver. I had the screwdriver mechanism on hand (as was all this stuff) so it was used. On 40 meters, about 1700 pF of loading C is required, hence the bank of 400 pF transmitting micas. These caps can be selectively put in shunt with the ARC 5 loading C using the banana plug, jacks, and brass rod as another "fancy" switch. The entire tuning unit was built on a hunk of (well used) 1/4" plexiglass and the components were connected using brass strips. Achieving low residual inductance in the loading capacitors is important, so substantial brass and 3 wires in || to the banana plug were used. Micro switches are used for limit detection and the drive motor

noise was almost entirely eliminated with simple bypassing. Connections to the loop are made with a couple of robust banana jacks. The plate spacing on the ARC 5 transmitting capacitors is adequate for 100 W power levels but not much more.

For fixed station use, a weather proof container would be a must.

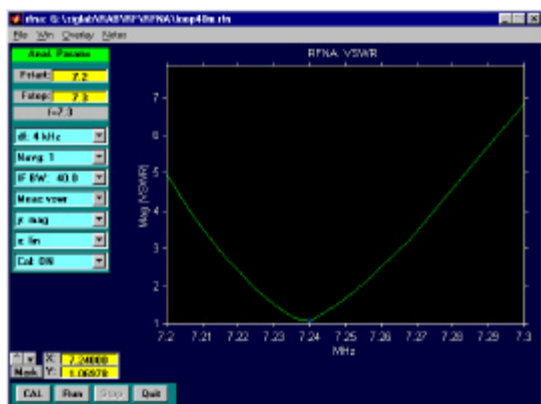


Performance Tests

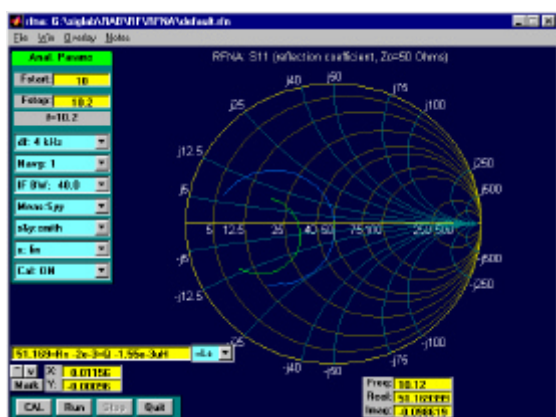
On the air tests while rapidly switching between the loop and a fixed antenna have been encouraging. With few exceptions being reported, the loop works as well as my full size wire antenna for 40 meters and actually better than the "double bazooka" I use for 30 meters. In fairness, the bazooka antenna is intended for 75 meter phone, but it has a reasonable resonance on 30 meters (vswr < 2:1).

On 20,15 and 10, when compared to my 4 element KT-34 at 50 feet, the loop is about 6 to 10 dB down. This is not terribly surprising since 4 elements at 50 feet should be better than a loop on the ground !

On 17 and 12 meters, the loop is waaaay better than the KT-34, again not too surprising since the KT-34 is not intended for these bands.



The VSWR plot above gives an idea of just how narrow the loop resonance is. The loop was tuned to 7240 and the 2:1 VSWR spread is only about 30 kHz. Not quite a quartz crystal ... but Hi-Q for sure.



The blue curve above shows the driving port impedance variation over the 10 to 10.2 MHz range under normal conditions. The green curve shows the effect of adding a 100K resistor in parallel with the loop ... wow ... 100K in parallel with a shorted turn ☺ !

RF Fields

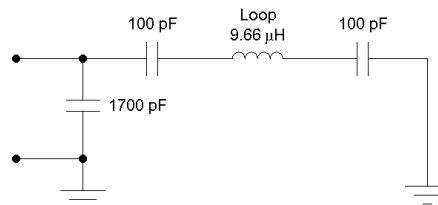
Since the loop is compact, there might be a tendency to use it close by. I am no expert on this matter, but I would not stick my head in the loop while transmitting even with my meager 40 watts ☺! Use common sense, keep it away from yourself and other folks.

Fixed Station Use

As stated up front, this antenna was not intended for fixed station use. However, with proper weather proofing, there is no reason that it could not be used for this. It could even be disguised as a garden trellis. I would not use wood or any other lossy material to do this, but look for some plastic material or make one out of pvc irrigation pipes.

The biggest complexity of the antenna is the tuner. For fixed station use, this **might** be replaced with a fixed resonating capacitor and a ¼ wave section of true open wire transmission line to a standard antenna tuner. The capacitor would have to be the low loss transmitting style like the CentralLab door knobs. Or you might try a section of foam core RG 8. As a point of reference the plain 80 inch loop resonates at about 7.2 MHz with 50pF.

A fixed matching network could also be used and driven with coax like the one shown below for 40 meters. The loop would have to be constructed so that the upper portion could be slid up and down on the 2 vertical legs to tune for resonance. This could be accomplished by using copper Ts with the insides bored out so the vertical pipes can go right through.



Conclusion

I have been pleasantly surprised at how well this antenna works. A full size antenna will always be the best choice, but sometimes this is simply not a viable option. I make no claim as to this being some great original work, but this note provides dimensions, component choices, a novel band switching technique, and some inspirational real world results. Thanks to all that participated in the tests.

Stay tuned ... and 73, Dick