Welcome to W2BRI's Magnetic Loops

Images and Notes from Other Loop Builders, Inventors, and Enthusiasts

Adventures in Stealth Radio

Can a move to a new subdivision relegate you to becoming a stamp collector?

By Art Heft

Background:

A recent move to a brand new subdivision prompted a rethink in the way I do my ham radio. At the previous QTH (2 ½ acres), I had lots of wire strung around the property and a 50 foot tower sporting a 12 element 30 foot boom log-periodic. When I called, they usually answered. Upon moving to a beautiful new home on a small lot, I decided to run only indoor antennas, which for safety's sake means running low power. Let me describe what I have done.

The Old Standby:

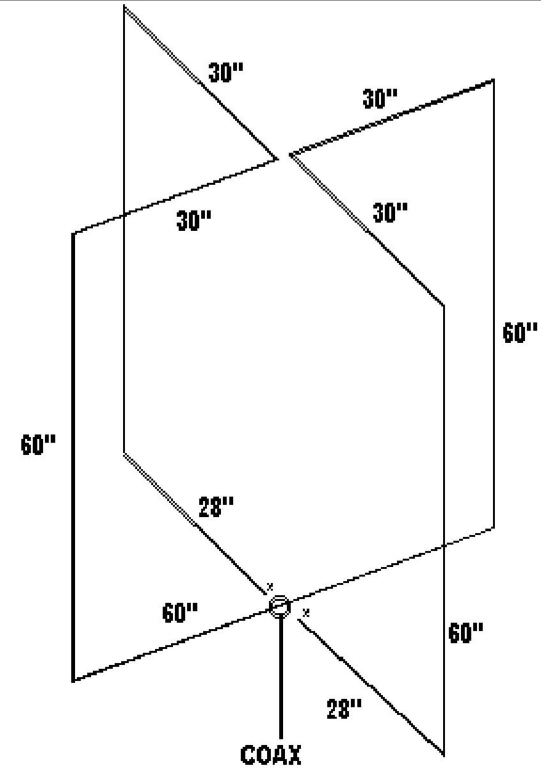
The first antenna to be installed was an old Mosley MP-31 trap dipole for 10, 15 and 20 meters. This is an antenna built from aluminum tube and looks like the driven element out of a small tri-band yagi. I hung it near the peak of the roof, just under the roof rafters. Since it follows the pitch of the roof, it looks like the usual inverted vee. Fed with RG-8X, and a 6 turn coax loop balun, it does a very good job on the three bands. At the feedpoint, it is 25 feet high. Nothing new here, just a run of the mill inverted vee. But what I really wanted was an antenna I could use on 80 and 40 meters for my favorite kind of QSO…local ragchews. I'm not a DX'er.

An Uncommon Antenna:

I have been avidly reading the occasional magazine article describing small loop antennas. My all time favorite is an oldie from Ham Radio Magazine dated April 1989[1]. The article describes a loop made of copper water pipe, folded up into a box-like affair. The most important detail these small loops have in common is this: ALL CONNECTIONS MUST BE SOLDERED – NO CLAMPS AND NO SLIDING CONNECTIONS ALLOWED!! Failure to follow this rule will result in failure. Why? These loops have extremely low radiation resistance and any small resistance (even a fraction of an ohm) introduced by the conductor or its connections will drop efficiency quickly. Depending on the room available, and the radiating efficiency desired, pipe lengths of 20 feet and up are considered. Since my available attic space was not all that large, I decided to go with a 40 footer. The result is an antenna that fits into a 5 foot cube. As W5QJR states, ¾” pipe (actual outside diameter of 9/10”) is a good compromise. At the local home center, four ¾” x 10 foot copper water pipes and ten 90 degree elbows set me back $30. Look for the “red” rather than the “blue” type of pipe. The red has a slightly thinner wall thickness, which is fine for our application, and it’s a bit less expensive. While visiting the home center, pick up some solder and flux. You can probably build this antenna with less than a foot of solder, so buy the smallest roll they sell. Perhaps a fresh tank of propane for your torch would be in order. You will also need to consider some means of cleaning the copper before soldering. Sandpaper works well, as do the wire brushes sold for this application. Assembly is pretty straightforward. See Figure 1. Before finishing the soldering of the lower elements, be sure to include the ferrite toroids used at the feed point. We’ll talk more about these later, but now is the time to assemble them. If your designated attic space is anything like mine, you will need to do the actual assembly in and around the truss work. I suspended the antenna with a few pieces of judiciously placed twine. This is perfectly adequate since the wind never blows and the antenna really doesn’t weigh much.

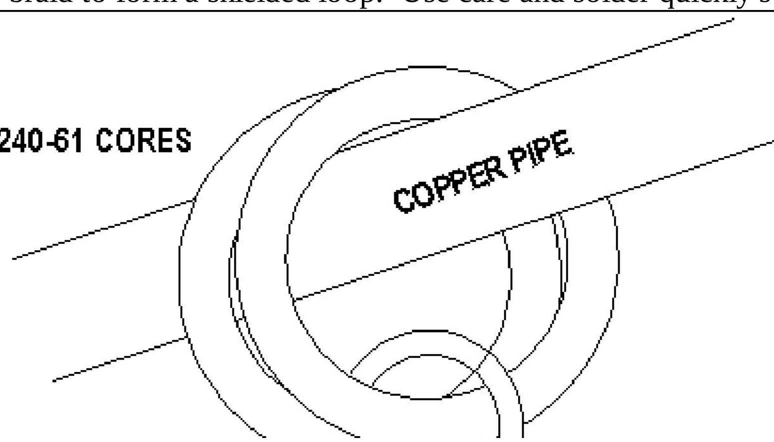
Figure 1

Use 3/4" copper water pipe
and 90 degree elbows.
Solder all joints securely.



Connecting a Feed line:

To transfer power to and from this antenna, we need to connect it with 50 ohm coax. There are several ways to feed a loop antenna, but the neatest and cleanest method I have found came from a QST Technical Correspondence article [2]. See Figure 2. I bought my FT240-61 ferrite toroid cores from Ocean State Electronics (www.oselectronics.com). They cost $8.75 each, plus shipping. Handle the cores with care. They are quite fragile and break easily. Loop your coax through the cores next to the copper pipe. Solder the center conductor of the coaxial loop to the braid to form a shielded loop. Use care and solder quickly so as not to melt the inner dielectric. What we have done here is to create a transformer with a one turn primary (the coax) and a partial turn secondary (the antenna itself). Keep the toroids centered on the copper pipe member. I hold them in place with tape. This feed method serves well at both 80 and 40 meters in my



antenna. No adjustments are needed. K6HPX's article shows a multiple bead balun to keep RF off the outside of the coax on the way back to the rig, but I find a 6 turn, 12 inch diameter winding of the coax serves the same purpose.

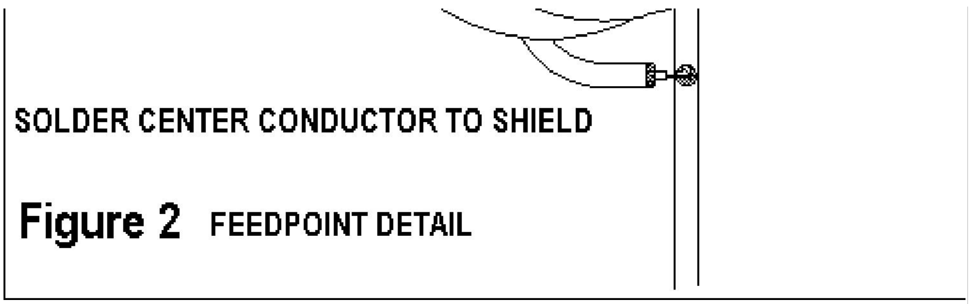


Figure 2 FEEDPOINT DETAIL

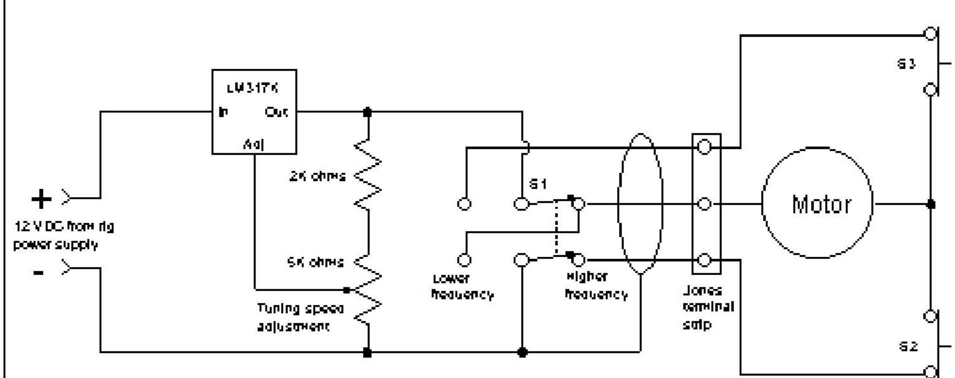
Tuning the Antenna to Frequency:

Now that we have the antenna assembled and a feedline attached, we need to resonate it to the frequency of interest. A capacitor across the two points "X" will accomplish this. With no added capacitance, my antenna resonates at 11.6 MHz. For PSK power levels (15 watts output), a short length of RG-58 coax fills the bill. On the low end of 80, I found I needed 63", which at 30 pfd/ft [3] equates to 157 pfd. On the low end of 40, I needed 11.5", which represents 29 pfd. For 30 meters I needed 2.25" or about 5.6 pfd. RG-58 is rated at 1400 volts RMS vs. RG-8's rating of 3700 volts RMS [4]. I found RG-8 would melt at somewhat less than the 100 watt level. These ratings are for solid polyethylene dielectric material. Foam dielectric coax has drastically reduced voltage ratings [5]. Of course, a fixed capacitor means a very narrow range of frequencies over which our antenna will function satisfactorily. I found that on 40 meters the 2:1 SWR limits were +/- 60 KHz. On 80 they were much less, and on 30 meters you could cover the whole band. For 80 and 40 meters, if we want to be able to QSY, we need a motor driven capacitor. There are several articles that address this subject [6][7][8]. Care must be taken here with regard to the capacitor, whether it is a fixed job or a motor driven variable. The voltages generated across this capacitor are very large, even with modest power levels. Be careful! We wouldn't want to burn the house down!

Remote Tuning:

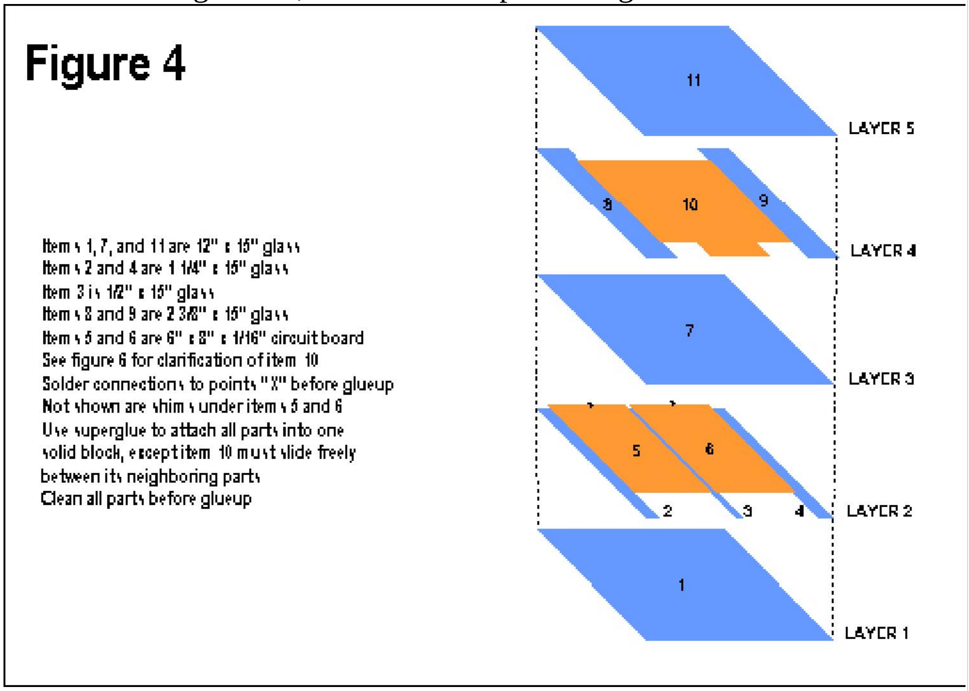
Well, great! Now we have an antenna that works on 80 or 40 or 30 meters, but it sure is a pain going up and down that ladder every time you wish to QSY. Lets see about some remote QSY capability, shall we? Earlier, I mentioned a motor driven capacitor that would make this a practical multiband antenna. We have a choice of three or four different types of capacitor. The first is the old standby with a set of stationary plates and another set of rotary plates. Remember our warning of no sliding connections? That would tend to rule out this type of capacitor, because the rotating set of plates is connected via a sliding joint. There is a related type of capacitor known as a split-stator. It is basically two capacitors on the same shaft. The rotary plates are solidly connected since they are on the same shaft. We could use this in our antenna by connecting the two sets of stationary plates to points "X". Unfortunately, not many junk-boxes have these available and they aren't cheap. Another choice might be a vacuum variable. These are the ultimate, but are even more expensive. Now we come to the realm of

Figure 3



S1: DPDT toggle switch - center off
S2: normally closed micro switch - capacitor open
S3: normally closed micro switch - capacitor closed
LM317K: available from Debco Electronics (debc@debco.com)
mounted on suitable heatsink
Connect shield wire of cable to negative buss

homebrew. First let's consider the sliding concentric pipe capacitor. Building this type should be within the capability of most hams. According to KD7S's article [9], a capacitor large enough to resonate our loop on the low end of 80 meters would require a capacitor 6 feet long when open. This is feasible but I'm short on space. I do like his motor control limit switching circuit, however. It's part of Figure 3. I found another homebrew capacitor in the ARRL Handbook article showing a high power antenna tuner [10]. It's basically two metal plates with a piece of glass for the dielectric. We can utilize this idea and, with only a bit of imagination, end up with a high voltage motor driven variable capacitor with no sliding connections. Try to visualize a split stator capacitor with linearly moving plates rather than rotating plates. See Figure 4.

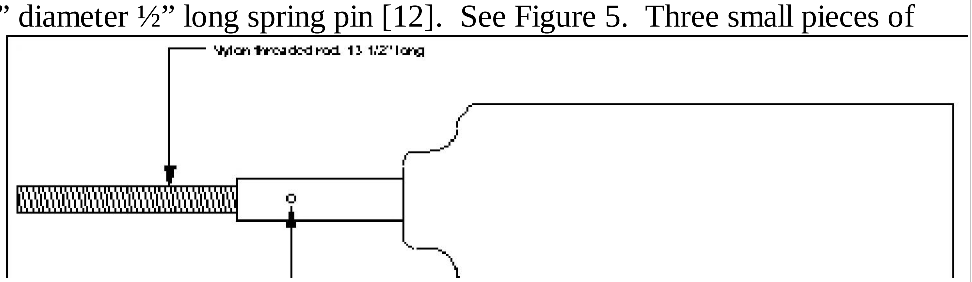


The Capacitor:

I built my capacitor from pieces of copper clad circuit board I found in my junk-box. For insulation, I used common "single strength" glass obtained from the local glass shop. Single strength glass is 0.088" thick. Since the circuit board is 0.062" thick, I utilized a few scraps of "vertical grade" kitchen cabinet laminate that was left over from a remodeling job. At 0.025" thick, it's just perfect to shim the circuit board so that it's tight against the glass. Doing this ensures maximum capacitance for the given area. Total cost for the glass was $9.45. Remember to ask the glass shop to grind off the sharp edges. I used super glue to hold things together.
Solder connections from points "X" to the ends of the copper pipes. I used the shield from a piece of RG-8/U
coax, but thin brass strips would also work. Don't use a skinny piece of wire. Remember our rule of avoiding high resistance connections?

The Motor:

Motive power for the moving plate comes from the ubiquitous electric screwdriver. Who among us doesn't have one whose batteries have died? You probably have discovered that new batteries cost about as much as a whole new tool set. Removal of the dead battery and switch takes only a few minutes. I used a ¼-20 threaded rod and matching nut to turn rotary motion into linear motion. I picked a nylon threaded rod [11] for three reasons: first, nylon is a great insulator; second, it's quite flexible and is able to compensate for any reasonable misalignments; third, it's got natural lubricity – we won't need to keep it oiled. The rod was a sliding fit into the ¼" hex drive on the screwdriver. I drilled a 3/32" diameter hole through the drive and the rod and then drove in a 3/32" diameter ½" long spring pin [12]. See Figure 5. Three small pieces of circuit board soldered together with a ¼-20 nut serve as a mechanical connection between the threaded rod and the moveable plate of the capacitor. See Figure 6. More



scraps of 2 x 4 work as a holder for the screwdriver motor. See Figure 7.
The whole capacitor was assembled on a scrap of ½" plywood, with hold down brackets made from a leftover 2x4. The two travel limiting micro switches are likewise fastened to wooden brackets. See Photo #1. All this wood! Isn't it great to be able to combine two hobbies?

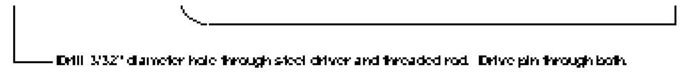


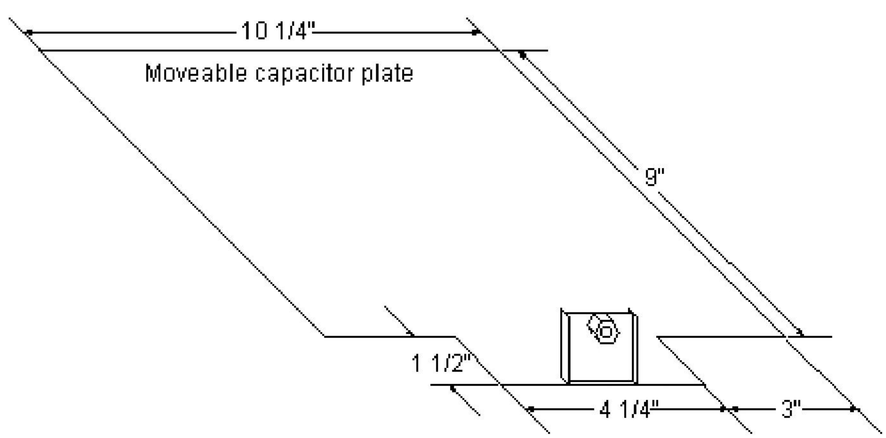
Figure 5

Detail of screwdriver , as modified and threaded rod assembly. Remove switch and battery. Cut off excess plastic handle behind motor. Solder wires to motor.

The Controller:

I utilized a Jones terminal strip for the interface between the micro switch and motor wiring and the cable that goes back to the shack. The same home center store can supply "security wire", which is a cable with four #18 conductors with a foil shield for only 18 cents/foot. My screwdriver unit was a Black and Decker. It was made to run on 3.6 volts and it drew about 1 amp at that voltage with no mechanical load. Our homebrew capacitor will be a very light mechanical load. Now we need to build a device to regulate the voltage from our 12 volt rig power supply to a range of 1 to 5 volts. See figure 3. Don't try to run the screwdriver motor at 12 volts. The motor won't live very long and the capacitor will move through its tuning range too quickly. The idea here is to tune the antenna as we watch the SWR meter.

Figure 6

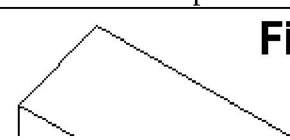


Connection point of threaded rod to moveable capacitor plate.
Use two pieces of circuit board 1/4" x 1 1/2", and one piece 1 1/2" square.
Solder in place as shown.
Drill hole behind nut to clear rod.
Use brass hex nut for ease of soldering.

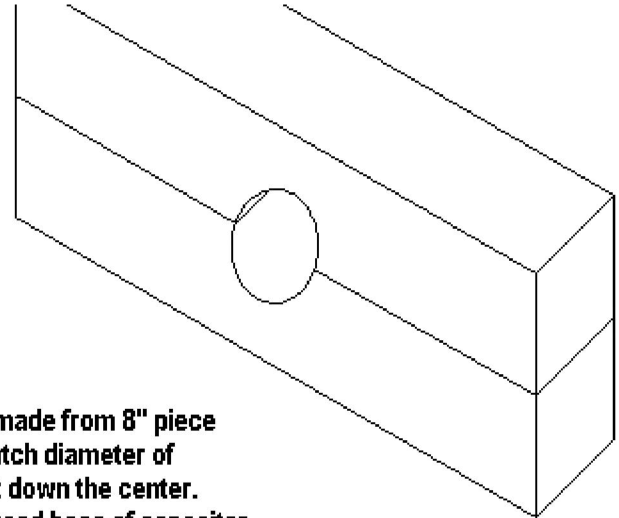
Results:

As it turns out, my capacitor design has too large a minimum value. At minimum capacitance, the antenna resonates at about 8.7 MHz. So that leaves us out in the cold for 30 meters. Perhaps someday I will try to build a Mark II model and be sure I can reach 30 meter resonance. Additional spacing between the two stationary plates would result in a lower minimum value of capacitance. At maximum capacitance, the antenna resonates at about 3 MHz, so it covers all of 40, 75 and 80, and we're ready for the 60 meter band, whenever we get it. Tuning is smooth and precise, especially with the controller set at a slower speed. On the air reports are very satisfactory. I have noticed that signal reports drop during heavy rain when the shingles are soaking wet. I suspect snow would have a similar effect, but since this is being written in April, I can't be sure. Remember, this is an antenna designed to permit operation where no visible antennas are allowed. You may never be king of the frequency, but you will be on the air, making QSO's. The SWR on 80 meters is 1.7:1. On 40 meters it is 1:1. All SWR and capacitance values were observed on an Autek Research RF Analyst model RF-1. My total cash outlay for copper pipe and elbows,

Figure 7

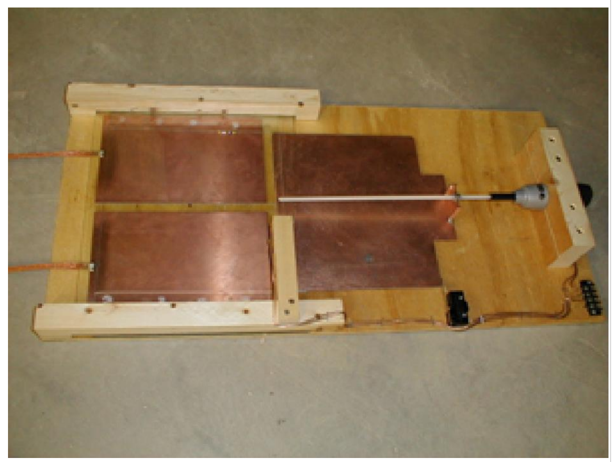


toroids, glass, control cable and the threaded rod was $82.69. I found the circuit board, micro switches, coax feed line, and wood scraps in the junk-box.



Screwdriver hold down made from 8" piece of 2 x 4. Bore hole to match diameter of screwdriver handle. Cut down the center. Screw lower half to plywood base of capacitor assembly. Place screwdriver into cutout. Screw upper half to lower half.

Things I would do differently next time:
As stated above, a too large minimum value of capacitance precludes use on 30 meters. I should have gone with a larger spacing between the two non-moving capacitor plates. This would result in a lower minimum capacitance and allow us to use the antenna on 30 meters.
Be sure to test the capacitor – motor – micro switch assembly on the bench before installation in the attic. If the motor continues to run after contacting the micro switches, then reverse the two wires going to the motor. It's no fun trying to solder small wires in the attic environment.



Acknowledgments:
Thanks to all the hams that encouraged me, asked questions and gave signal reports during QSO's.
Thanks to son Brian, KB8RTV, for the donation of his old electric screwdriver.
A special thanks to my dear XYL Karen, KB8CZL, who made sure I got the manuscript right.

73, and see you on 80 and 40 meters.

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Notes:

[1] Ted Hart, W5QJR, "The Convoluted Loop", Ham Radio, April 1989, pp 89-95.
[2] Ken Hirschberg, K6HPX, "Toroid Coupling Feeds Compact Transmitting Loop", QST, March 1995, pp 72-73.
[3] ARRL Antenna Handbook, 18th edition, p 24-17.
[4] See note 3.
[5] See note 3.
[6] Gene Gardner, W9RWZ, "High-Q Vertical Loop", WorldRadio, June 1993, pp 61-63, 75.
[7] Robert Capon, WA3ULH, "You Can Build: A Compact Loop Antenna for 30 through 12 Meters", QST, May 1994, pp 33-36.
[8] Bill Jones, KD7S, "A Home-Brew Loop Tuning Capacitor", QST, November 1994, pp 30-32.
[9] See note 8.
[10] ARRL Handbook, 76th edition, pp 22.59-22.62.
[11] McMaster-Carr Supply Co. (www.mcmaster.com) part # 98831A028. $2.82 plus shipping.
[12] Available from any well stocked hardware store or auto supply for a few cents.

Captions:
Photo 1 - Capacitor assembly

Figures:
1. Antenna assembly
2. Feed point
3. Voltage regulator, motor and micro switch wiring
4. Capacitor assembly
5. Screwdriver modification
6. Connection from threaded rod to moveable capacitor plate
7. Screwdriver attaching clamp

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