The inner assembly:

A hobby lathe is a very versatile tool! Here it is shown configured for sawing a servo mounting plate to the rough size. Later, the circular saw was replaced by a cylindrical router bit, and then the precise finishing was performed. Note that setting up a lathe in this way allows full milling functionality.

PA plastic generates lots of heat when frictioning against a tool. It will easily melt, thus loosing precision and finish quality. To avoid this, it's best to cool the tool with some liquid while working, but in my case, using the lathe in my wooden-floored apartment, this isn't practical. The solution is to work with very sharp tools at low speed.

I did not buy plastic sheet stock for this project. Instead, I turned my own plates from the same round 75mm PA stock used to make the base plate, base cup and top cone.





The two servo mounting plates and the mounting block have been joined to the servo, and test-fitted in the base cup. Note that one edge of each plate is chamfered. This is necessary to be able to introduce the assembly into the cup, because there is a rim, used to seat the coil tube, which has a narrower internal diameter than the rest of the cup. The rear end of the servo is tucked under this rim, so that its output shaft is precisely centered in the cup.

The servo is modified in three ways:

- The white output shaft internally carries a gear and a cam. This cam originally is used to keep the shaft from rotating over more than three quarters of a turn. This cam must be cut off, allowing continuous rotation.

- The rear end of the servo originally carries a mounting flange equal to that at the front (top in this photo), with two screw holes. This rear mounting flange would simply not fit inside the cup, and is cut off.

- The entire servo electronics, including the feedback potentiometer, are removed. Instead, the decoupling components C2, C3 and FB1 are installed inside.

This picture shows the servo assembly seen from the front (grounding) side. The servo has been fitted with its wheel, the rotor base plate and slip ring. Also, the contact springs and the entire limit switch and impedance matching assemblies have been installed. This is the complete assembly that goes into the base cup.

The limit switches are on the left side. They have the diodes D1 and D2 installed between their pins. The top switch will later directly interface to the bottom side of the limit rotor ring, while the bottom switch employs a wire lever to engage to the limit rotor ring's top side.

On the right side is the toroidal inductor L2, and the coupling capacitor C1. The ground connections of both sides are brought to the front via small holes in the two servo mounting plates, and joined there. The heavy wire pointing upwards is the ground connection. It will later be bent down, and soldered to the solder lug attached to the cup threaded insert, as the last step of building this antenna.

The live connections of both sides are soldered to the two ends of the center contact spring.

The slip ring contact spring can be seen contacting the slip ring on both sides, under the rotor base plate.





This side view shows the RF portion of the circuit. RF energy from the center contact spring is routed through a large capacitor to the contact spring on top, which applies this RF to the base of the loading coil, to the movable tap via the slip ring, and to the impedance matching coil that has its other end grounded.

Note that in principle it's not necessary to use a 400 Volt capacitor here, but I did it for safety reasons: Should I ever strike power lines with this antenna, or even get a lightning hit, the combination of

the toroidal inductor to ground and this capacitor in series should protect the radio to a very high degree.

The stranded wire protruding from the rotor base plate is soldered into a hole in the slip ring, and will later be connected to the lowermost grooved wheel, which doubles as the movable tap on the loading coil.

The limit switch side can be seen here. L3 and C4 are visible. The most interesting feature is the steel wire and associated parts, used to link the lower limit switch to the top surface of the limit rotor ring.





This is the bottom view of the servo assembly. The center contact spring is featured prominently here. It is screwed to the two servo mounting plates, and has a raised contact point, that produces a sure one-spot contact to the center contact button of the base.

Note the four holes drilled into these plates. These are the ones that take the screws which attach the assembly to the base cup. They are conically enlarged, in order to facilitate assembly. Without these conical enlargements it proved difficult to fit all four screws, given

the unavoidable imprecisions of home construction.

The servo assembly mounted inside the base cup. Note how everything fits precisely! There is relatively little room wasted.

When properly built, the assembly just barely can slip into and out of the cup, without forcing anything.



Note how the fingers of the coil end contact spring are bent into a rounded shape. This is needed for allowing the coil tube to be installed, with these spring fingers sliding off and on the contact plate during assembly.





The lathe is configured as milling machine to make the slots in the slotted tube. A simple core was made from PE before, in order to help support the tube. Due to the softness of the PVC tube, the finish quality of this slotting job was not very good, but this is of no consequence to the performance of the system, as long as the chariot legs can slide freely.

These slots are 14mm wide, giving the chariot legs enough clearance to avoid binding even if the chariot decenters because of some imprecision. The slots run almost the full length of the tube, excepting only the areas covered by the top and base plates of the rotor.

This is the bottom end of the rotor. The base plate has been pressurefitted into the tube, but it could also have been glued, or fixed with some screws. The slip ring, its sliding surface finished using fine sandpaper and polishing compound, was epoxied onto the servo wheel. This wheel is screwed to the rotor base plate, using two tiny M2 bolts that will make their own threads in the holes provided in the servo wheel.



The screw that holds the servo wheel to the servo must be inserted before attaching the rotor base plate



to the servo wheel. For mounting the wheel on the servo, the screw head can be accessed through the hole that will later take up the limit coupler axle.

The stranded wire runs through a slanted 1mm hole drilled into the rotor base plate, and continues through a similar hole drilled straight into the slip ring, where the contact is soldered before gluing the parts together.



This picture shows the same assembly from the front. Some solder residue can be seen.

Here are the complete innards of the antenna, from the centering cup on the top to the servo assembly! You can see how the limit rotor ring activates the two limit switches, and how the yellow wire connects the wire coming from the slip ring to the lowermost grooved wheel. More about this wire later.

The limit coupler axle on this picture is the first one I made. It is nylon, which proved to be a little too flexible for best performance. I later replaced it by one made from durocotton, which is much stiffer. You may ask why not making it from metal. The reason is that any long conductive piece inside the coil would degrade the Q, lowering the antenna's efficiency! Also there would be risk of arcing at the top of the axle. The entire reason for placing the limit switches down in the base, and activating them with these mechanical linkages made from plastic, is preserving the coil's high Q!

To adjust the limit switch trip points, first the conical spring is bent such that the limit rotor will rest in the center of its range. This allows it to move 2mm in each direction. Then the lever of the upper limit switch is bent to make it trip



when pushing the limit rotor down. Finally, the lower limit switch is adjusted by loosening the screw fixing the plastic block to the coupler wire, and sliding the block to a suitable position so that lifting the limit rotor will trigger the switch.

The chariot floats loosely inside the slotted tube. It has considerable clearance, so it won't bind if there is some excentric motion because of imprecisions. The wheel that pokes forward in this photo is the spring loaded, telescoping one.



After a few tests, the simple yellow jumper wire showed to be insufficient. It bent away from the correct shape, and caused friction by scraping against the coil. This did not keep the antenna from working properly, but it slowed down the tuning process and forced the mechanics. For that reason I conceived a simple guide for the wire, made from a segment of PVC tube, which eliminated this problem. It is mounted with two M3 screws self-threaded into the slotted tube, and some junkbox spacers.

Notice how the three legs are installed at different heights in the chariot center piece. Since the coil pitch is 3mm, and the legs are 120 degrees apart from each other, the height difference between each leg and the next is 1mm. When this is done correctly, the chariot will end up perfectly leveled inside the coil.

This frontal view allows to see how the wire bends in this guide. It does not bind anywhere. I did all the tests of the antenna using this yellow wire, which has a finely stranded conductor, and thick, rubbery insulation. But in the end I opted for replacing this wire by a piece of RG174 coax line, with the braid and center conductor shorted. Thanks to the braid, this coax cable has much greater torsional stiffness, without being much harder to bend. This proved an advantage in this application.

Also the direct connection to the headed axle was used only for the tests. It would break in the long run, since the wire would be flexing here! Before final assembly of the antenna, I looped the coax a half turn around the chariot leg,



soldered it on the top side, and wound a few loops of magnet wire around, which I then secured with epoxy glue. I expect this to last for a long time.





Here's the complete assembly (except for the wire guide) installed in the base cup.

The loading coil assembly has been installed. This was done only for the photo, which shows how the top end of the coil runs through the slot in the centering cup.

Final assembly of the unit starts with the coil tube removed from the base cup. It requires first screwing the top cone into the coil tube, sealing the thread with silicone



caulk. The drilled and tapped stainless steel bolt is screwed into the top cone, also sealing it with silicone. Then, using a long screwdriver, the M3 stainless steel bolt that connects the top of the coil



can be inserted through the coil. This screw is sealed with low or medium strength Loctite thread locker.

Holding vertically the base cup with installed innards, the loading coil with the top parts is lowered onto it. The telescoping chariot leg is compressed, and the chariot inserted into the coil tube. Then the coil is gently rotated, while manually guiding the grooved wheels, one after another, uppermost first, so they will climb onto the start of the coil wire, in the proper sequence. When this has happened, the coil tube's lower thread is engaged with the base cup, and screwed down a few turns. But before the centering cup at the top jams (it will rarely be perfectly centered during assembly), you need to apply a trick I came up with: Connect a 6 Volt power supply to the unit! The servo will run, the chariot will screw itself up the coil, and any imprecise centering of the centering cup will transform into an orbiting motion. While the servo runs, SLOWLY finish screwing down the coil tube. The centering cup will cleanly latch its notch on the end of the coil wire, and then cleanly engage in the circular groove in the top cone! It's incredibly easy to do, once one has figured out the trick of doing it with running motor! Before that, I was close to pulling my last hairs out!

Leave this thread without silicone caulk, until you have completed all testing. Once the antenna has been found to work perfectly, open it a last time and reassemble with some silicone caulk in this thread.

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