My R-390A Cosmos PTO Observations

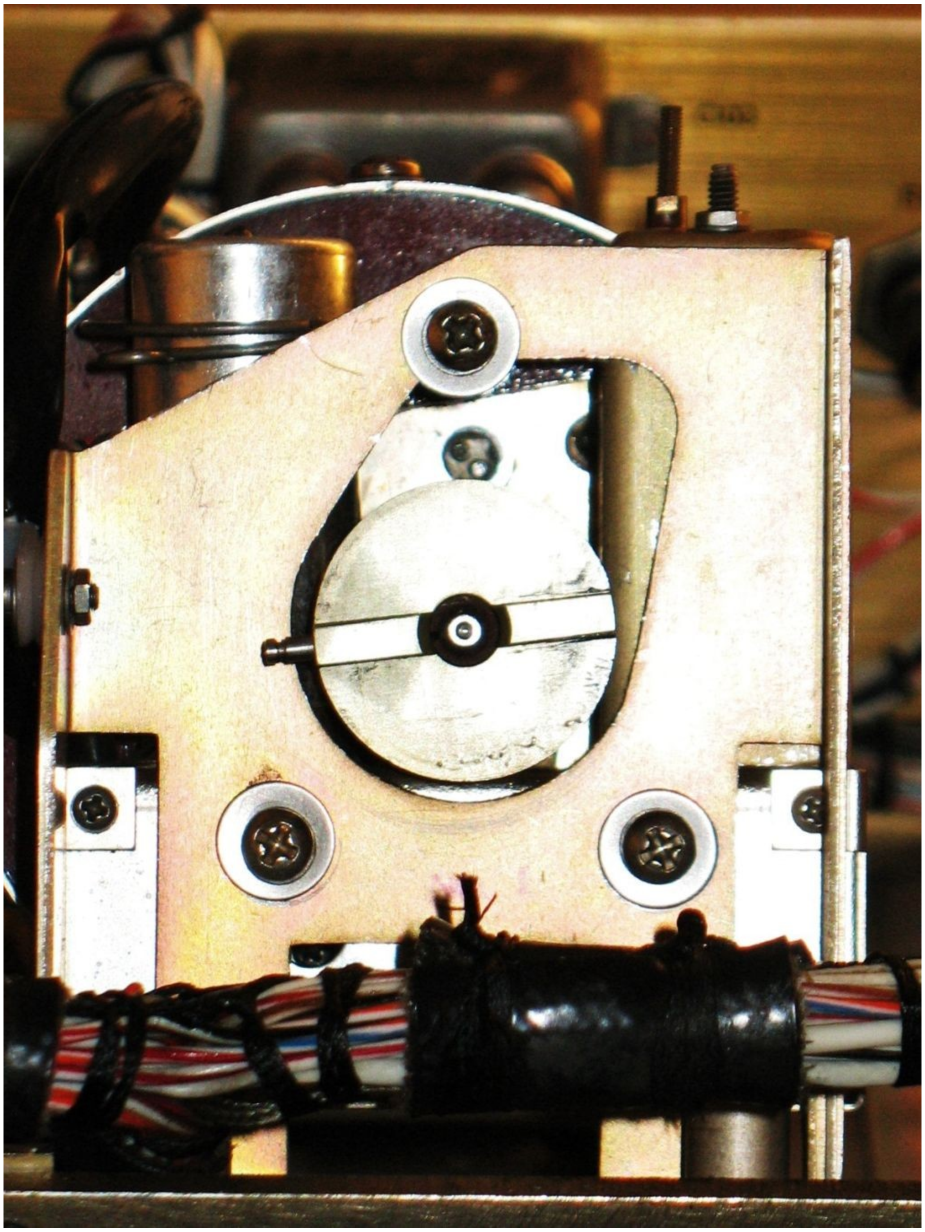
Larry Haney, 3-19-2018

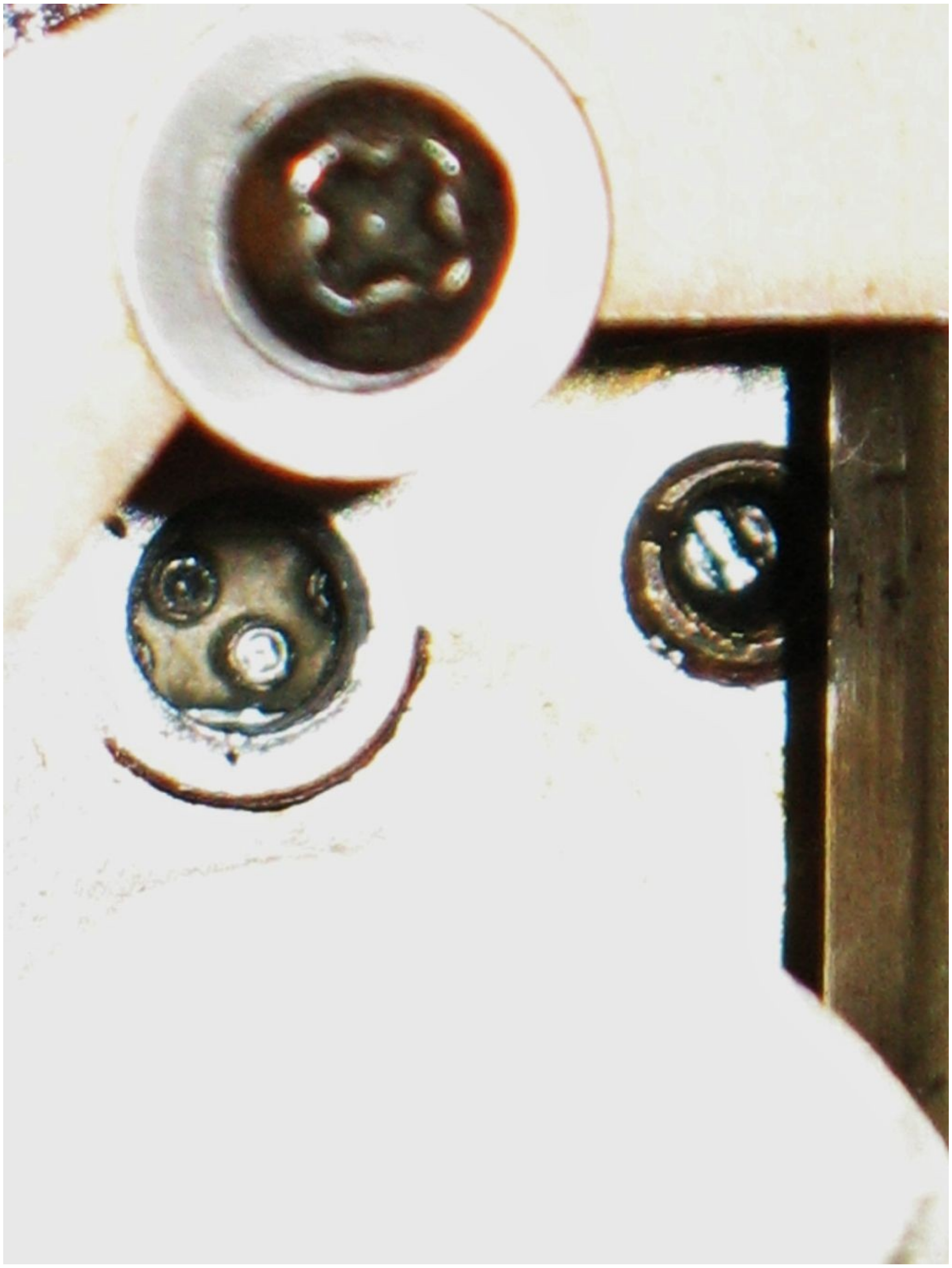
Revision 1, changes A - C, 11-10-2020, Larry Haney

When I first wrote this up and posted it on the R-390A forum, it contained links to pictures I put out on a hosting site on the internet. About a month ago, Gary Biasini mentioned that he imbedded the photos into a .docx file and asked if I'd like a copy. Thank you Gary.

I went through an R-390A Cosmos PTO and got it working quite well. I'd like to share my experience with you. There was a lot of great information online, and I studied it carefully. Thank you all very much who contributed. I like the design of the Cosmos when the linearity mechanism is in good condition and working correctly. If not it can be a big head ache. Opening it up is like any other PTO. Before you do, check the end play on the main shaft. There should be none that you can feel. If there is and it goes unrepaired, you will have forward/backward tracking issues, and probable warbles trying to zero beat a station or trouble tuning in CW or SSB stations. You should also check the rotational freedom and smoothness of the shaft. You need a slight resistance, but it must be very smooth from end to end. If not, it will have the same tuning and wear issues.

To help you locate a couple key components, look at these photos:





The EP adjustment is the slotted screw on the right. The linearity screws are on the left just directly above the tuning shaft. Note that the access hole is centered above it. There should be three adjusting screws visible in it. One screw should be centered in the large access hole, at each 25 kc point (¼ turn of the KC knob) on the dial. The centered one is the currently active one. Do not adjust the ones on either side. This is the one pressing on the cam on the metal spring that is pushing on the spring loaded core of the linearity adjusting coil.

Revision 1A start:
I use a small number 4 jewelers screw driver (about .8 mm in diameter blade) to do the linearity adjustments most of the time. The correct tool to use is a 4-flute .033” Bristol wrench.

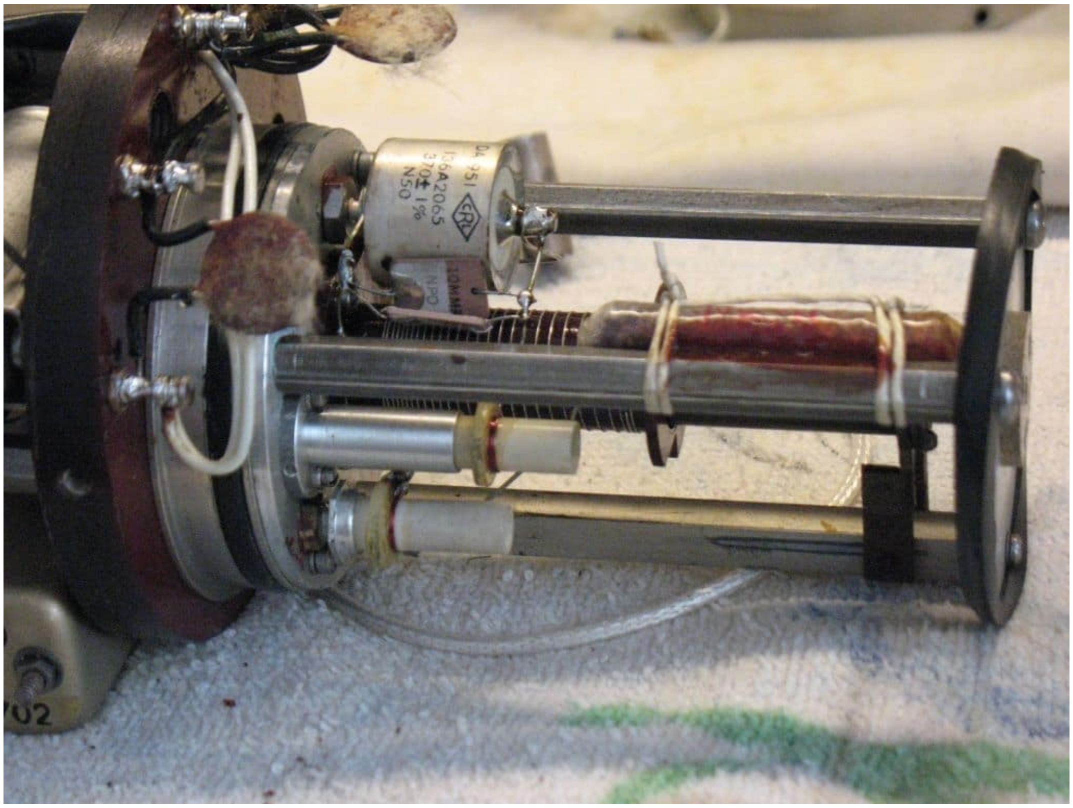
If the 'centered' adjusting screw is not close to center, that is OK if it is not off by more than about 1/32”. What you want to end up with operationally, is the transition from one adjusting screw to the next one at about one half way between the 25 KH points on either side of it. The reason for this is that the gears moving the disc holding the adjusting screws have some play in them. Having the cam transition about half way between 25 KH points minimizes any affect this will have on repeatability when changing directions of the KC knob. You can change the 'centering' by adding or removing a small amount of capacitance (3 to 8 pf) by changing one of the two 10 pf caps. This will also affect the EP adjustment.

I have found that removing both 10 pf caps and installing one 10 pf at N1400 with another low pf cap (2 to 8 pf) at np0 provides a very good temperature stability and puts the linearity adjusting screws close to the center of the window. It also improves the EP adjustment range.

The reason for changing the temperature compensating is that it is strongly recommended to turn off the VFO oven. I agree with this and so the temperature compensation should also be changed. With using the N1400, I usually see good stability after 4 or 5 minutes. This Cosmos that I just did drifts down 39 cycles starting at 1 minute after power on, to become fairly stable after another 4 or 5 minutes. At 5 or 6 minutes after power on, it varies +/- 10 cycles (around the starting frequency) for the next 3 hours. At this point it then improves stability to +/- 5 cycles per hour and stays very close to the original frequency the whole time.
Revision 1A end.

As the KC knob is rotated 25 KC, the next adjusting screw will become centered. There are 2 rows of screws on the disc. One from the top row will be centered, then one from the bottom row, etc.

Once it's open, you can easily see the two 10 pf wafer caps and the 3 inductors. You can also see the large 370 pf cap and the bag(s) of desiccant tied to the post with 2 strings. It's very fragile, so be careful with it.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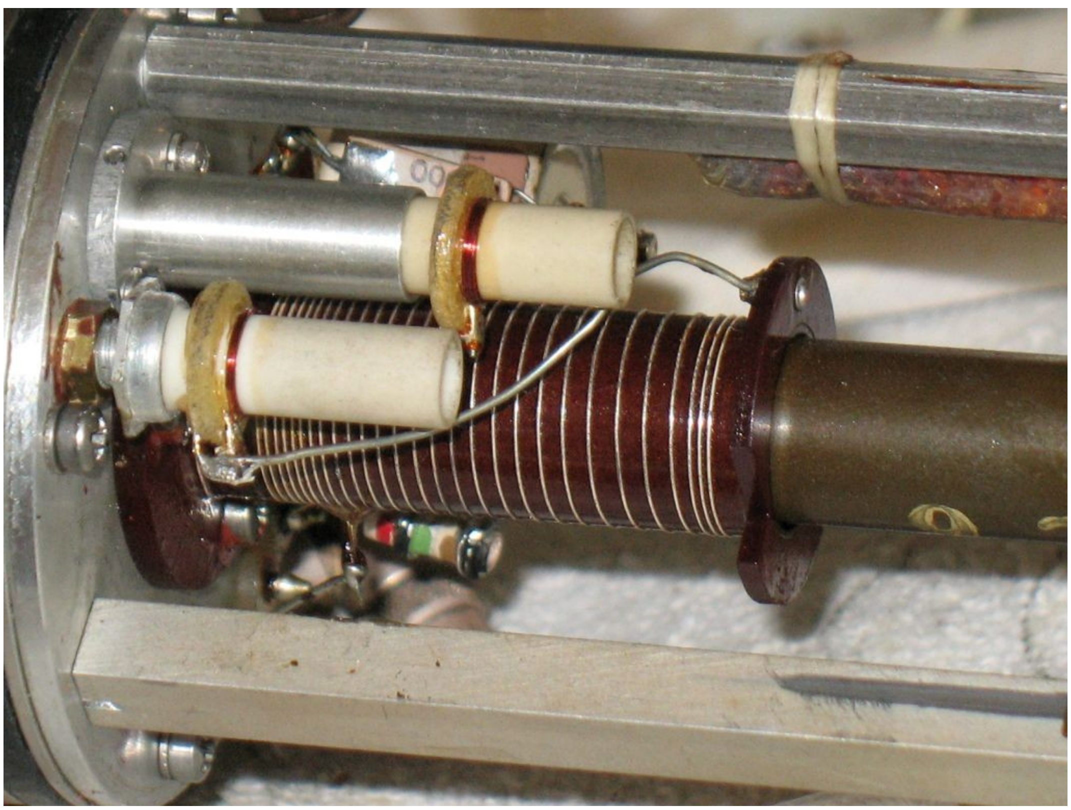
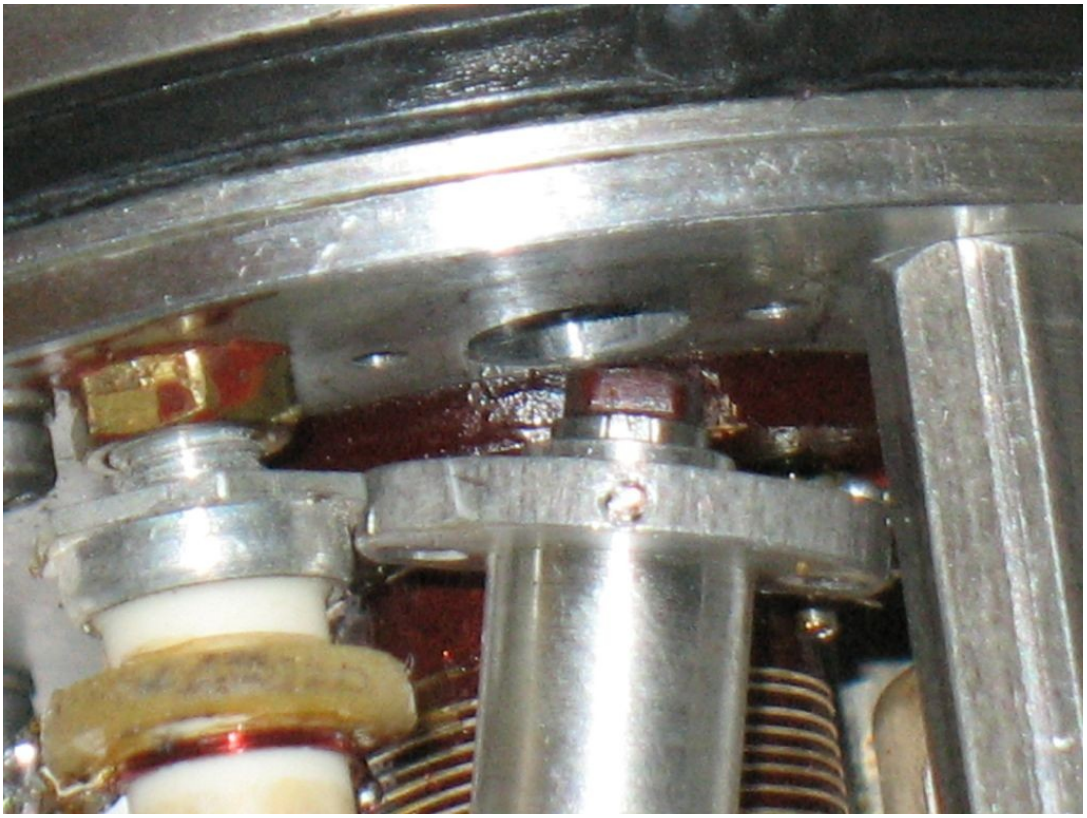
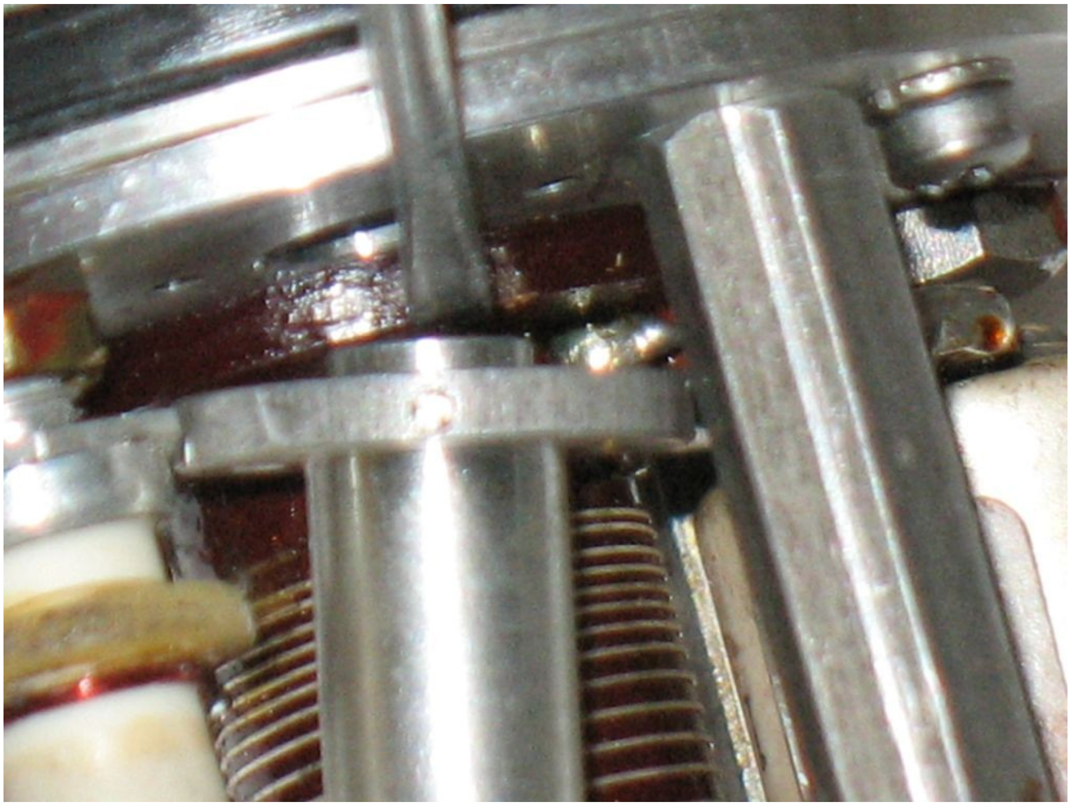
130A2065
370±1%
N50



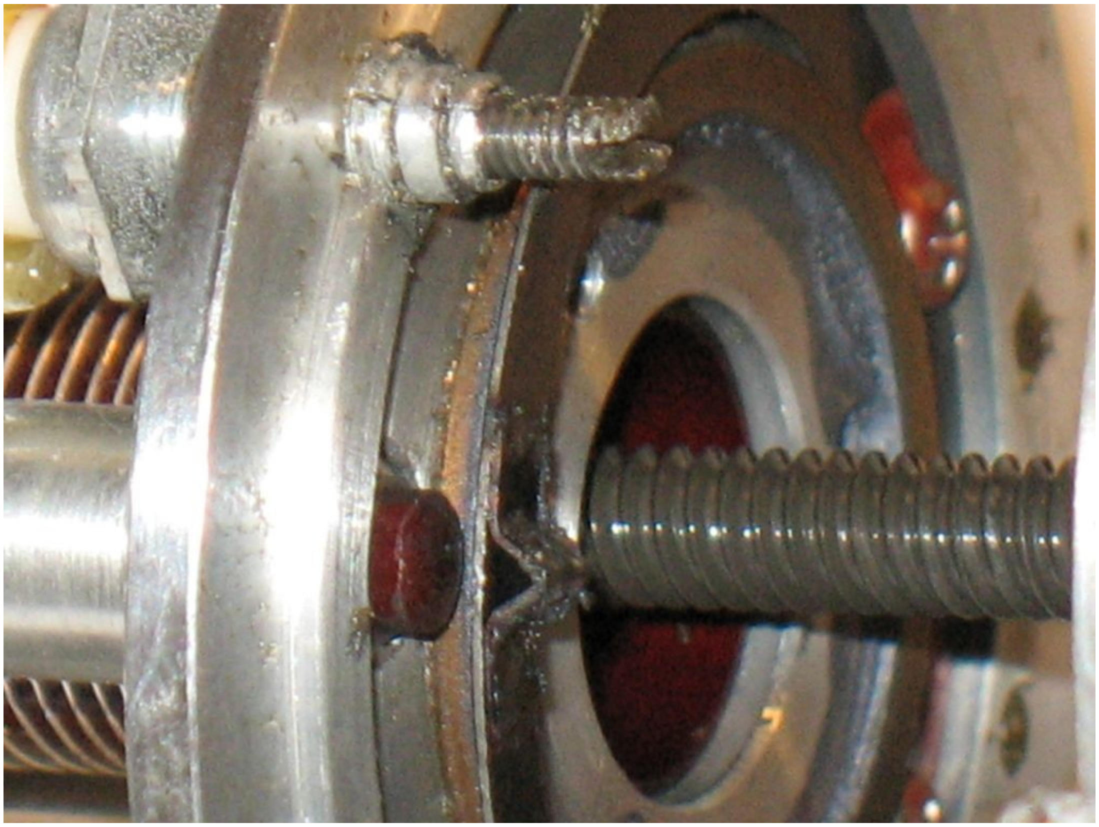
The short inductor in front of the main tuning coil is the EP adjustment. The one right above it is the linearity compensating coil. It is a spring loaded core controlled by the adjusting screws. This is part of the linearity mechanism.

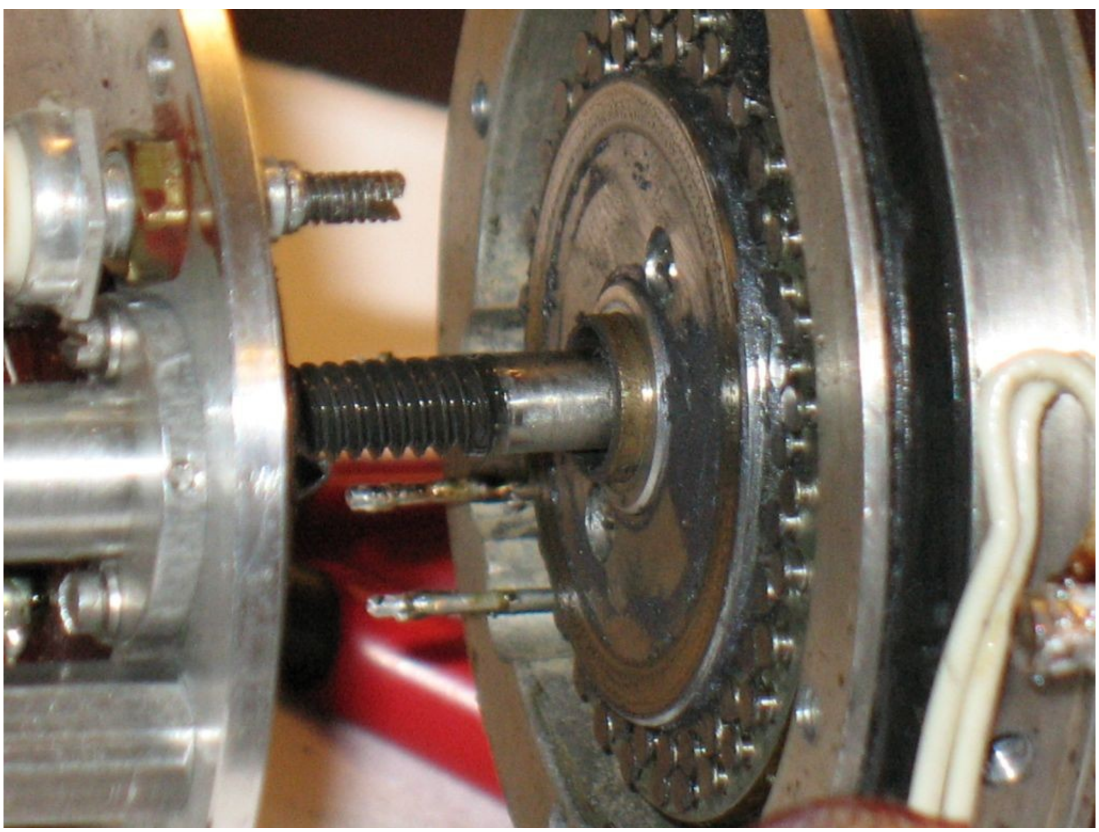


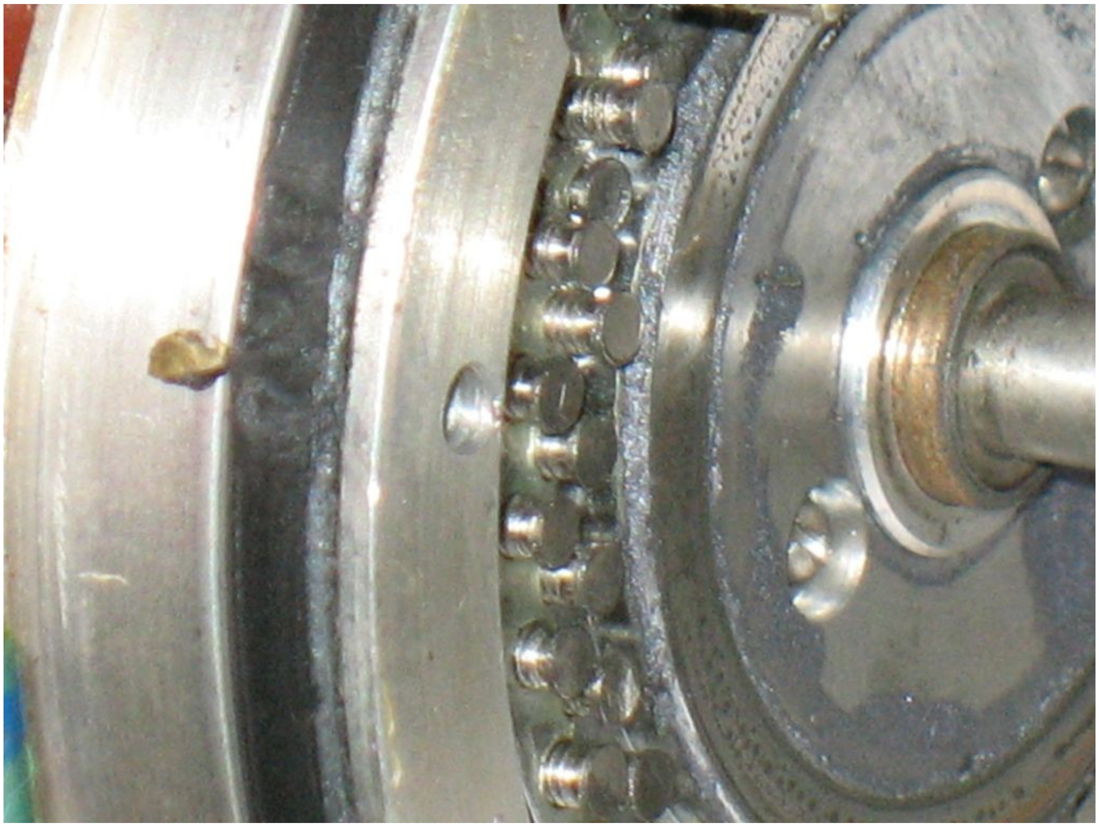


The first picture of the 2 above shows the red phenolic button that the cam actuates to move the core inside of the linearity inductor. The second shows my screw driver manually moving the core by pushing on it. I'm making sure it is moving freely and has good spring resistance.

The next 3 photos show the PTO opened up at the linearity cam operating area. It's the round flat metal spring with the cam on it on the opposite side from the red button in the next photo. The cam is moved by the position of the adjusting screws shown in the second photo.

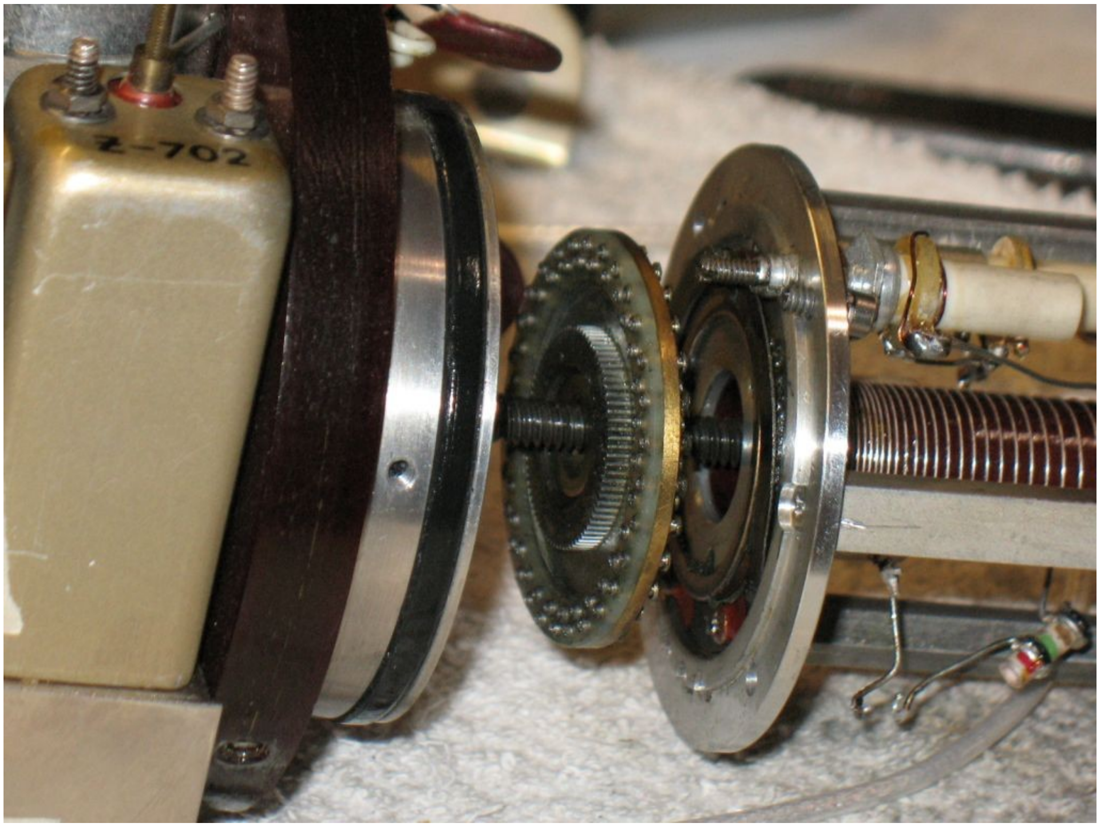




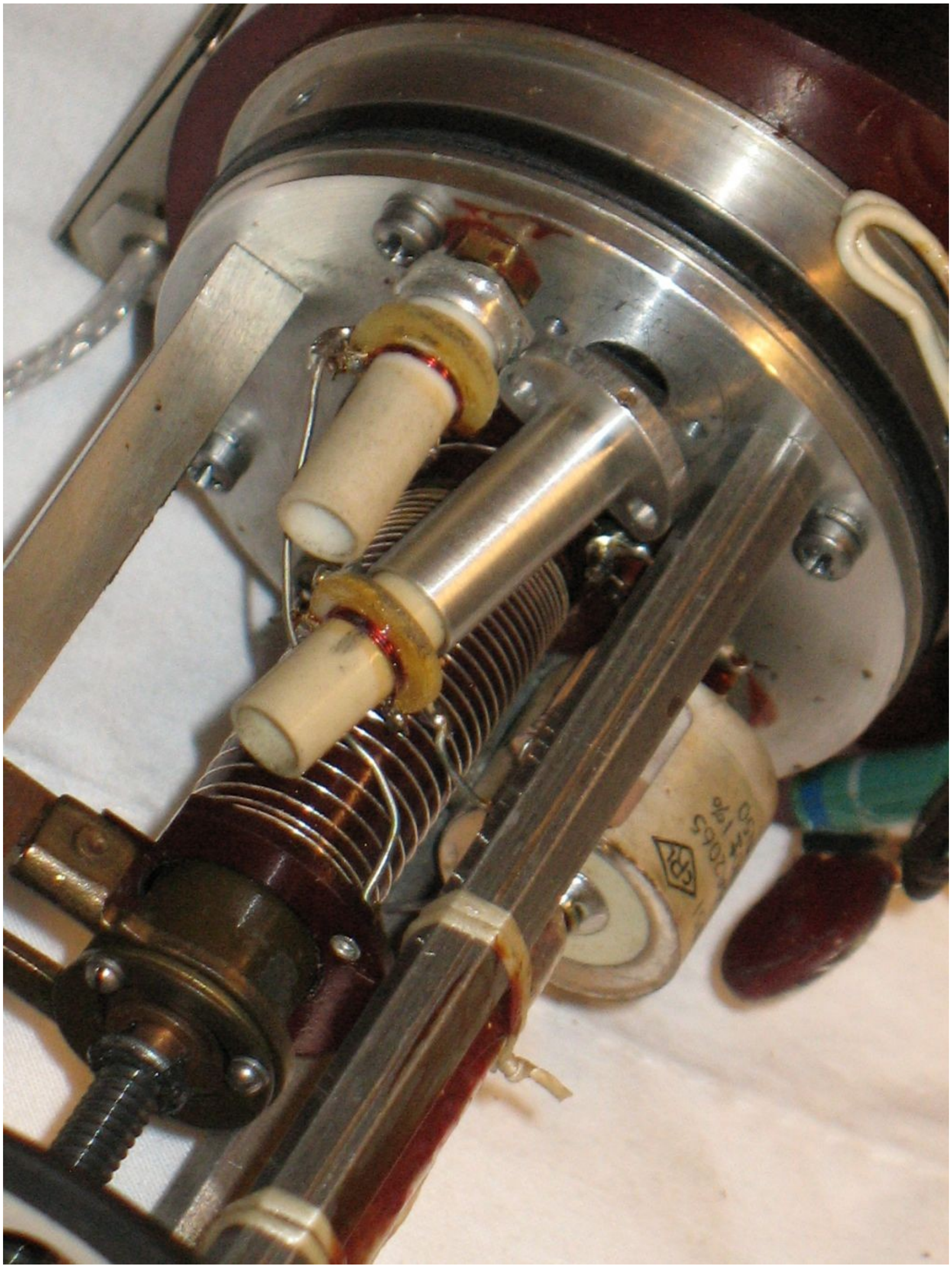


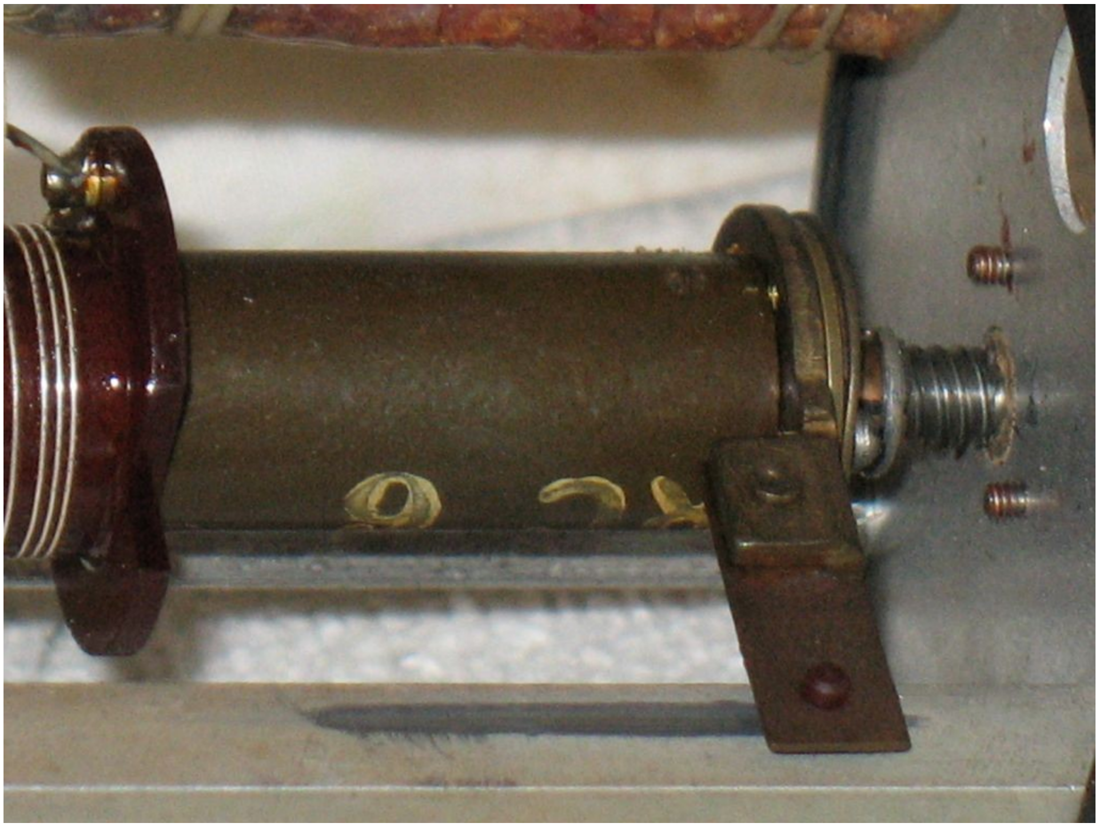
I believe that the linearity adjusting screws can turn a total of 5 CW turns before falling out. Be very careful that they don't fall, as it is difficult to get them back in. If you do, don't turn the KC knob. Try to carefully work it back in. If the KC knob is turned, I don't think you will be able to get it back in and you will probably have to take it apart. The previous photo shows a close up of the adjusting screws. When they are unscrewed as far as possible CCW, they will stop on the disc that holds them due to the flat head being larger than the threads. I used a jewelers screwdriver to adjust them, but be careful to not damage the splines. If one is stuck, you will need to use a .033 inch 4-spline wrench to free it up.

Revision 1B start:
This next picture shows the disc that holds the linearity adjusting screws and rotates when the KC shaft is rotated. If you are contemplating lifting it off of it's gear drive, be sure to read about the synchronization precautions of doing that in a later section.



Next are two pictures of the inside showing the main moving tuning core:
Revision 1B end.

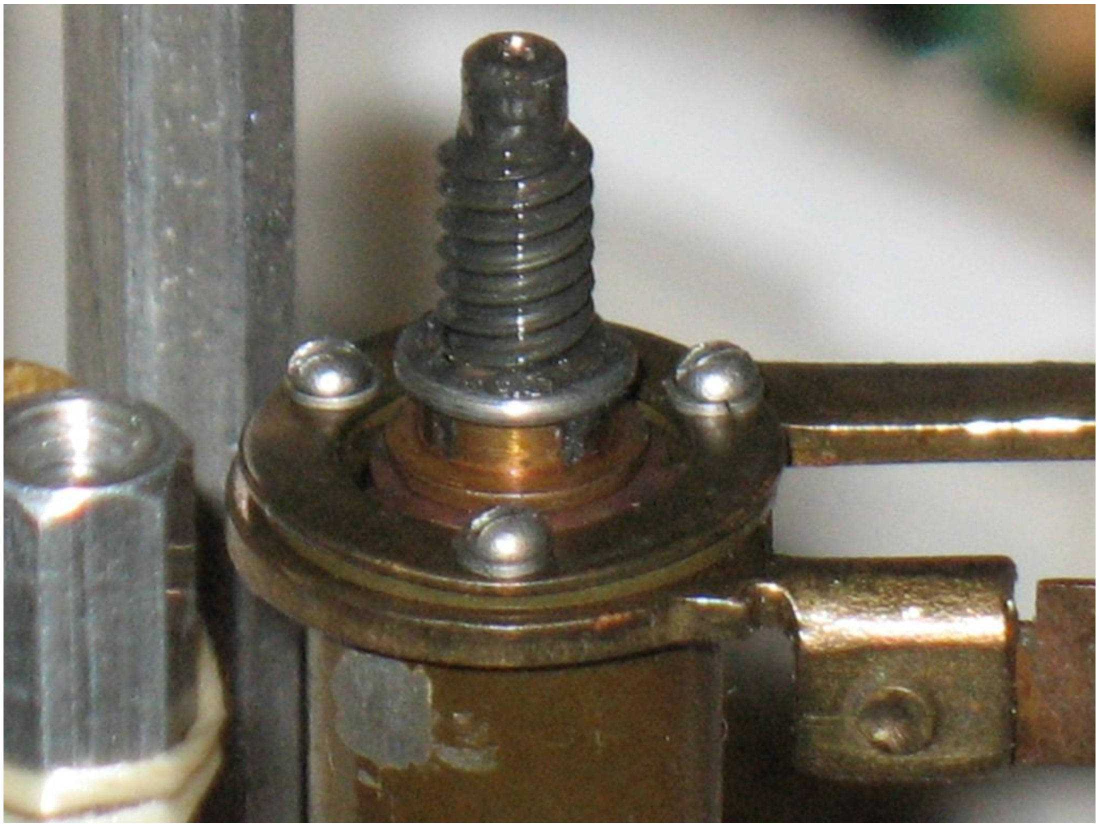




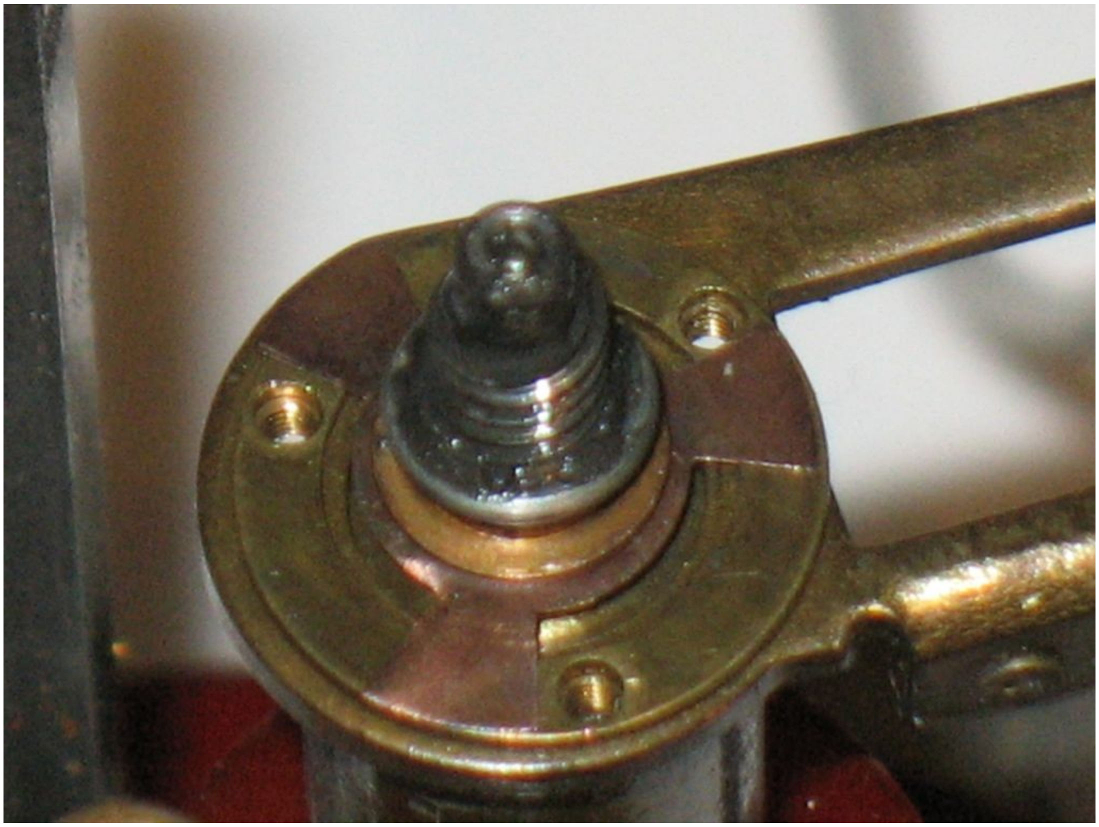
The photo on page 11 shows the linearity inductor pulled away from the frame. You will also see 2 flat compensating caps (hidden behind a metal post (there's a better view on page 5)). They are very fragile. Be very careful with them. In order to bring the EP adjustment into range, one of these may need to be reduced in value by 1.5 to 2 pf. On some PTOs, I needed to add an 82 pf NTC 200 in series with one of them.

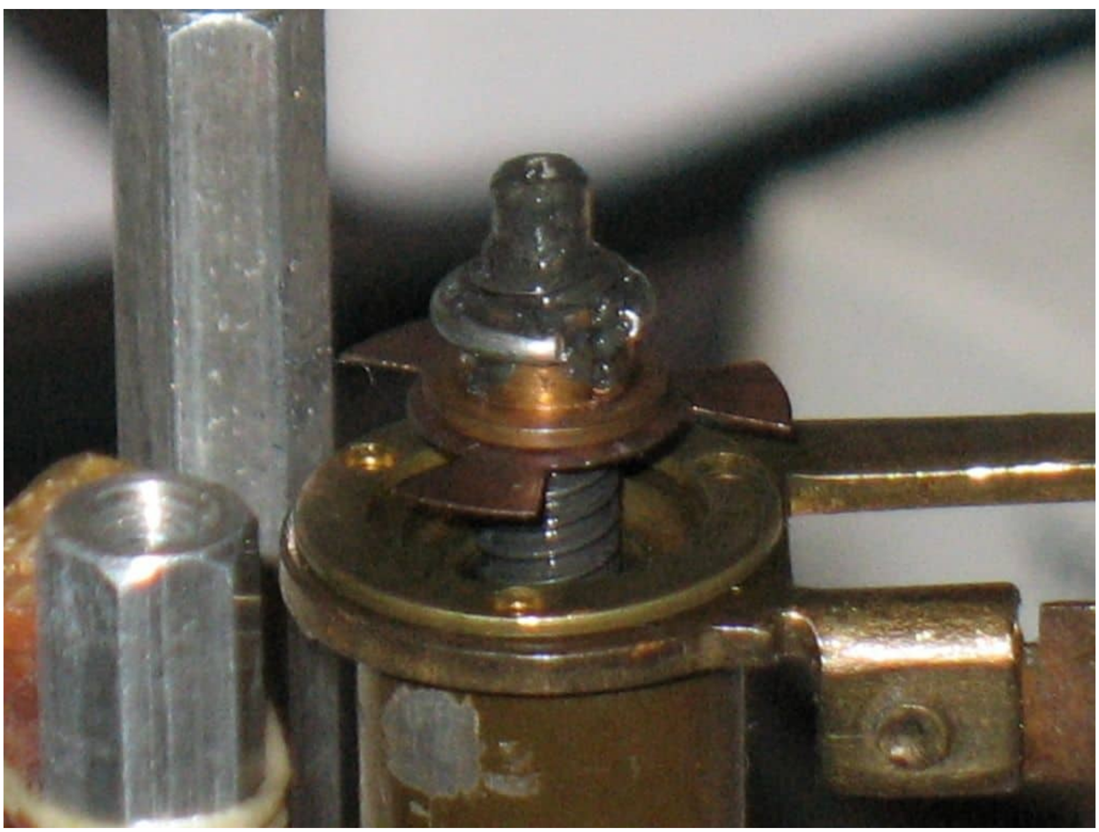
To get access for the next picture, I removed the large flat metal disc on the end that holds the end of the threaded shaft in place. It has the rubber gasket on it on the outer edge and is held in place with three screws in a triangle, each screwed into a metal post. Remove the screws and it will lift off.

The next picture shows the split nut on the end of the tuning core. It has a spring clamp around the end of it to maintain the correct pressure on the shaft. The next picture shows a closeup. The purpose of this mechanism is to eliminate end play between the core and the threaded tuning shaft. This is a critical point for minimizing forward/backward tracking alignment and creating smooth frequency change when the tuning shaft is turned. It needs to fit just right. Too tight restricts the rotation of the KC tuning shaft and will cause unnecessary wear. Too loose and the forward/backward tracking alignment will suffer.



This picture above shows the flat ring retainer held in place with three round head screws. In the next picture, it has been removed in order to unscrew the split nut a little. Notice that it has three wings on it. They are a little fragile, so be careful with them. I did this in order to check the tightness and play of the nut on the shaft. The nut can be removed for adjustment, if necessary.





When replacing the split nut, the three 'wings' should just touch the collar on the core. They should all touch at about the same time, so as to not twist the nut when the retainer ring is reinstalled. This is not real critical.

If you need to remove the core from the shaft, you might lose synchronization between the core position and the linearity disc position. If this positioning is lost, you will need to go through the linearization from the start.

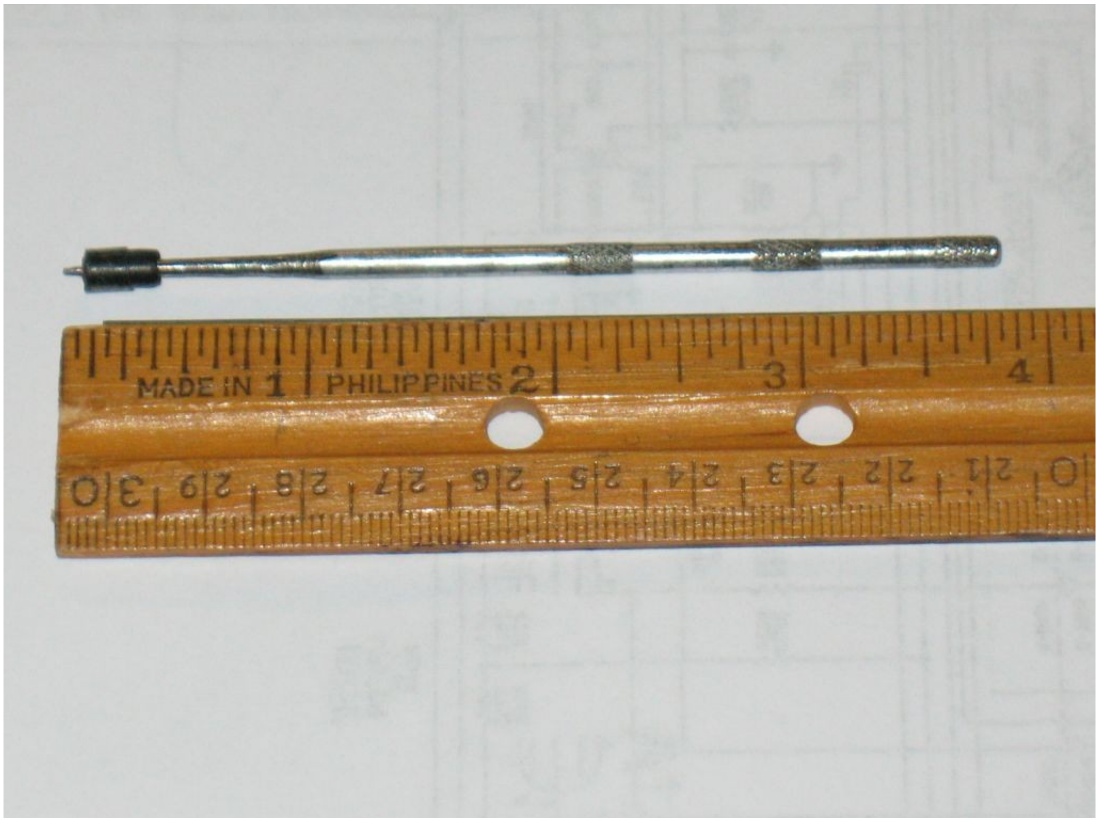
It is important that the metal guide arms and the base for the split nut attachment plate are rigidly attached to the core. If not, it needs to be repaired or replaced. One guide arm is rigid and the other has a spring attached to it in order to keep a reasonable amount of pressure on the aluminum guide bar (it should be lubed very lightly with a very thin slippery dry lube (not oil)).

After it's in good condition and before you put the covers back on it, see if you can operate it on the bench. A good test is to hook up your counter to it and put forward and backward pressure on the core to see if it will move. I used a plastic tuning tool. Don't worry about the actual frequency, as it will change 40 to 50 cycles when the cover is put on. It should move about 7 to 10 cycles and then go back to the original reading when pressure is released. Do not use a lot of pressure, but enough to move it at least 1 cycle. If it moves about 15 cycles and goes back to the original setting, it's probably ok. Ideal would be about 7 cycles. If it does not go back to the original reading within 1 or 2 cycles, repair is needed.

Also check the guide arm operation. Rotate the tuning shaft slowly and quickly in both directions and make sure the arm contacts do not move away from the guide bar. If they do, there is probably too much friction between the shaft and core and repair is required.

Some time ago I started working on an R-390A Cosmos PTO that needed end point adjustment. After reading the immense amount of doc graciously posted about PTOs, I decided to make the adjustment tool suggested by David Wise, Mar *10, 2009*. I thank you! He suggested making it about 3.5" long, so it could be inserted into the adjustment hole while the VFO and the front panel were still installed. This made the EP adjustment very easy. Thank you!

Here's what I ended up with:



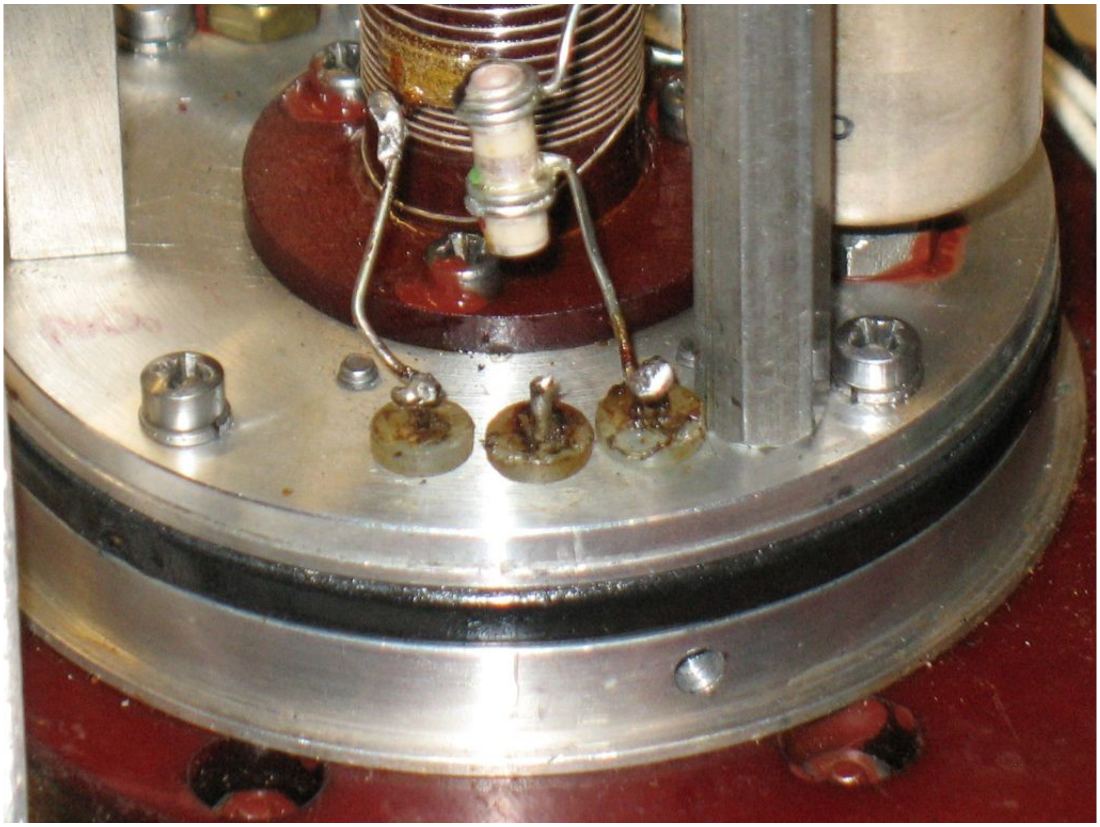
As you can see, its 3 13/16" long. That's as long as I could make it and still sneak it into place to make the adjustment. The shaft is aluminum so as to not distort the tuning. There is tape and tubing on the adjustment end. It did not start out that way, but I found that the tool usually found its way between the EP adjustment shaft and the access hole. That is not good as the adjustment coil could be damaged. So I added the tape and tubing to keep it centered in the access hole. Now the adjustment is so easy. I've used it on 3 different PTOs: Collins, Cosmos, and Progressitron, and it was easy to use. I am very glad I made the tool, as getting the Cosmos EP correct was a long drawn out experience due to mechanical issues with the unit that required repair.

Revision 1C start:
I recently finished work another Cosmos PTO and found more information that would be very helpful, so here goes. My first objective was to loosen up the shaft rotation, as it was way too hard to turn. My concern here is it may be causing unnecessary wear or damage. My first check was to see if the resistance was in the tuning core or the split nut attached on the end of the core. After removing the covers as previously shown, I removed the plate on the end that holds the end of the screw shaft in place. There may be a shim washer or two on the end of the shaft, so watch for them. I removed the split nut retainer ring (as previously shown) and found that the nut was not the problem. Be very careful with the three little tabs that stick out on the split nut (shown on page 14) as they are very fragile. They break very easily, so do not use pliers on the nut to remove it. If it is tight on the core, turn the main tuning shaft to unscrew it until the split nut is loose.

Before reinstalling it, this is a good time to see if the core is binding on the shaft. It should be very easy to turn. Unscrew the shaft until the guide arms on the core run off the end of the guide bar. Be careful that the small phenolic glides that ride on the guide bar do not fall out of the mounting holes in the arms, as they go off the end of the guide bar. Once off the end, you can easily tell if the core is binding on the screw shaft or not. If it is, try a little super lube, first. If that does not loosen it up, try some penetrating oil. Try to not take the core all the way off of the shaft, as you will loose synchronization if you do. Work at it for a while and it should loosen up OK. Don't use any liquid that will leave a residue – it will turn sticky and guess what that will do. If that does not work, you will need to try a cleaning solvent, like alcohol.

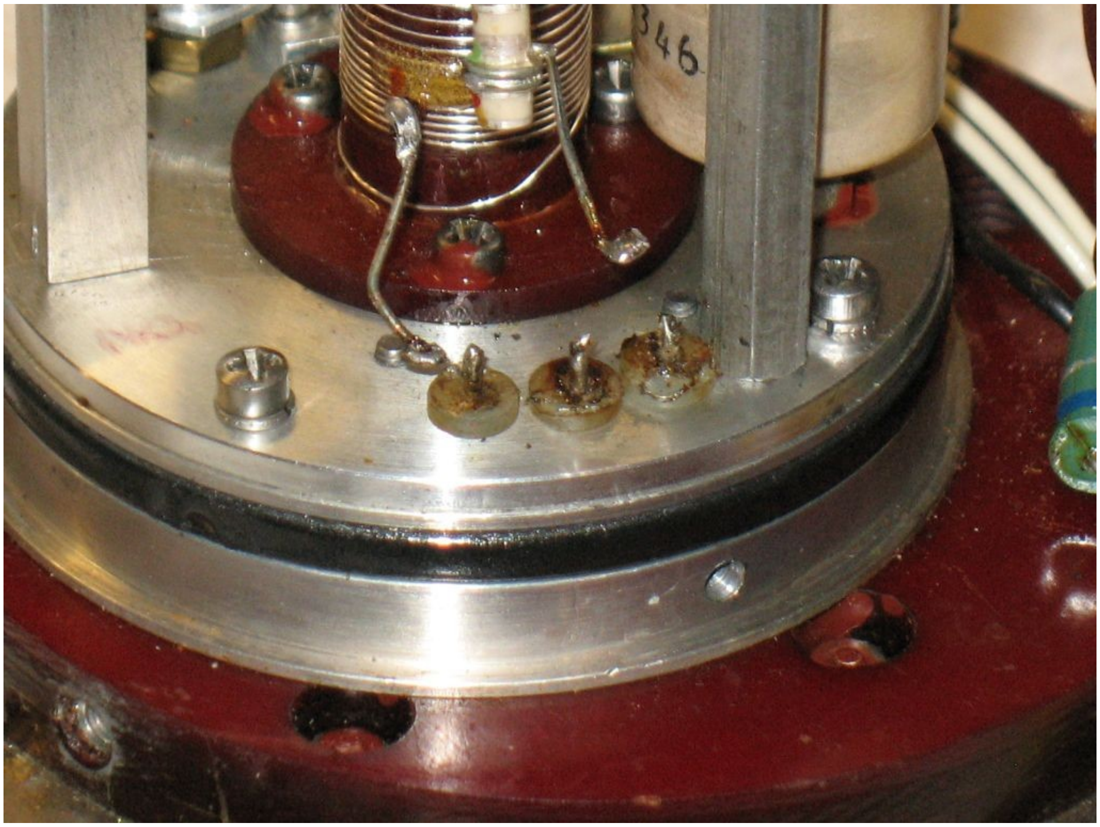
When the core is free and smooth, reinstall the split nut. The purpose for it is to eliminate core end play on the shaft. This is very important to the correct operation of the PTOs for the 390s. Adjust the split nut as required, but not so tight as to make it difficult to turn the shaft.

So, as the hard turning shaft was neither of them, I thought about the construction of the unit and decided that the next thing to check was the freedom of rotation of the linearity screw disc. You can gain access to the linearity mechanism fairly easily. Remove the two wires on the feed through wire pin terminals as shown in the next 2 pictures:



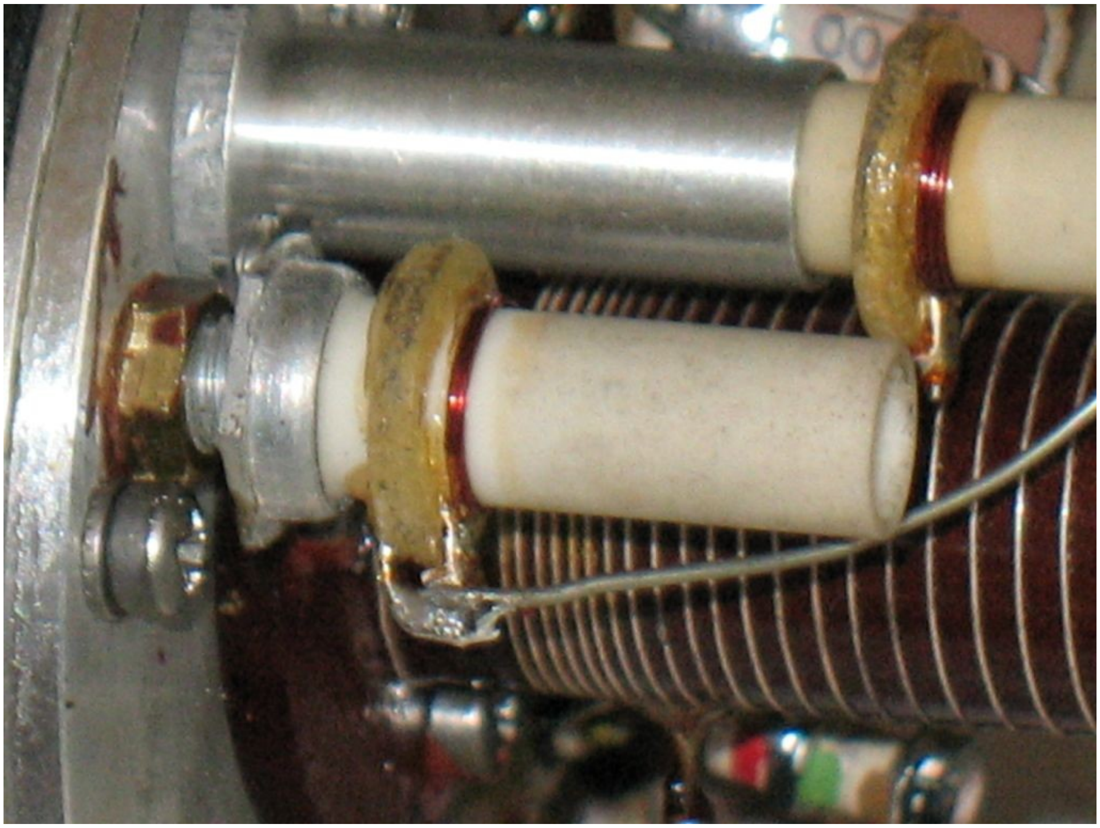
The above picture shows the two wires that need to be disconnected, are still attached.

The next picture shows the two wires disconnected. Be very careful with the left one. It is connected to the tuning coil and can be easily broken. That can be difficult to repair. Then, remove excess solder from the pins they were soldered to and the three or two insulators can be removed and set aside so as not to lose them. These pictures show plastic insulators on the pins, but others I've seen have brown wooden ones and they will split easily when removed, if too much solder is left on the pins. Be careful to use very little force when removing the wooden ones.

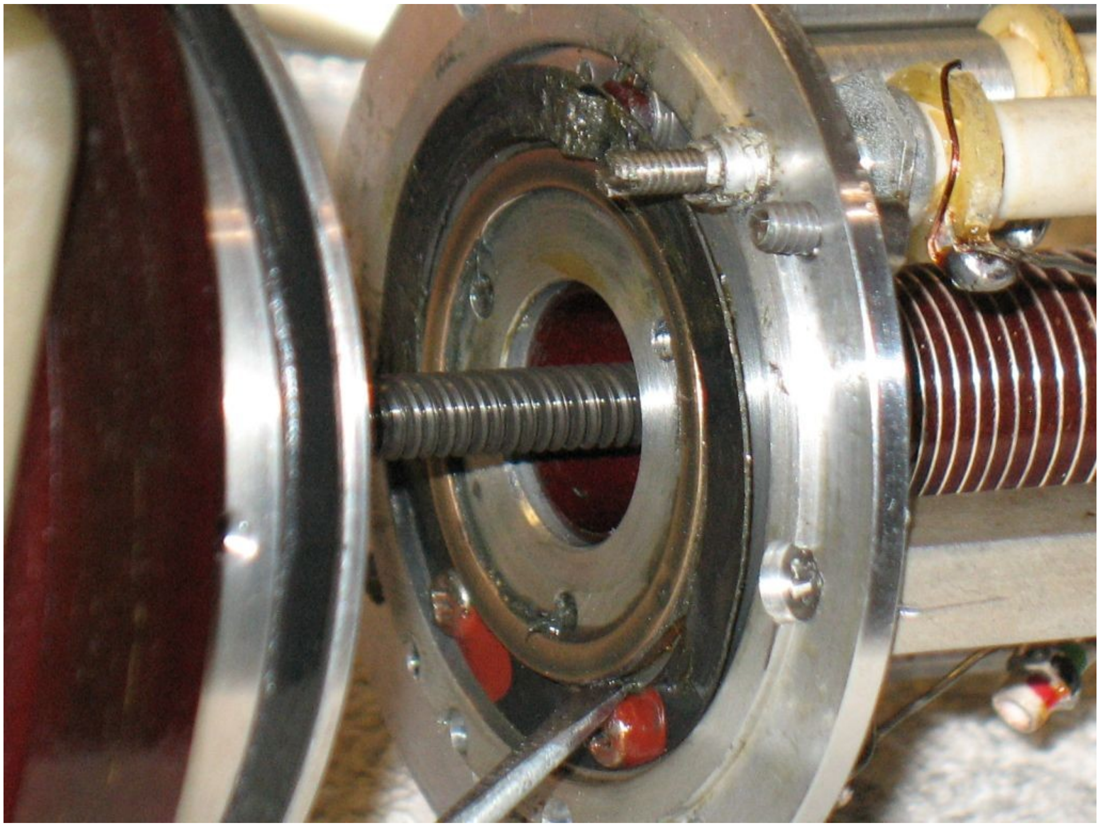


Now you can remove the four screws holding the two units together. Two of them are shown in the above picture, one on the left and one on the right of the signal feed through pins. The other two are on the opposite side and make a square. One of them is very close to the EP adjusting coil (shown in the next picture) and should be unscrewed as you slowly lift up on the tuning coil unit. I use a small flat blade screw driver on it. When separating the two units, first loosen the 4 retaining screws mentioned above, about a 1/16" and turn the shaft so that the tuning core is completely out of the coil assembly and about a 1/16" from the end of travel. It's best to keep the VFO sitting on the end with the oldham coupler, unless you are not concerned about maintaining linearity synchronization of the disc and the core. Otherwise the disc can fall off of it's shaft mounting and lose gear positioning. If you are going to lift the disc (with the adjusting screws in it) up, and want to maintain linearity synchronization, you will need to put a pencil mark on the frame and the disc in a line before that happens. Once the disc is up off the gears, you must also be very careful that the tuning shaft is not turned at all. If it is, synchronization is lost. So, before you remove the disc, you should also put a pencil mark on the frame next to the oldham coupler spring connection pin, so you can get positioning back. As you can see, it is not easy to retain linearity synchronization when you take it apart, but it can be done.

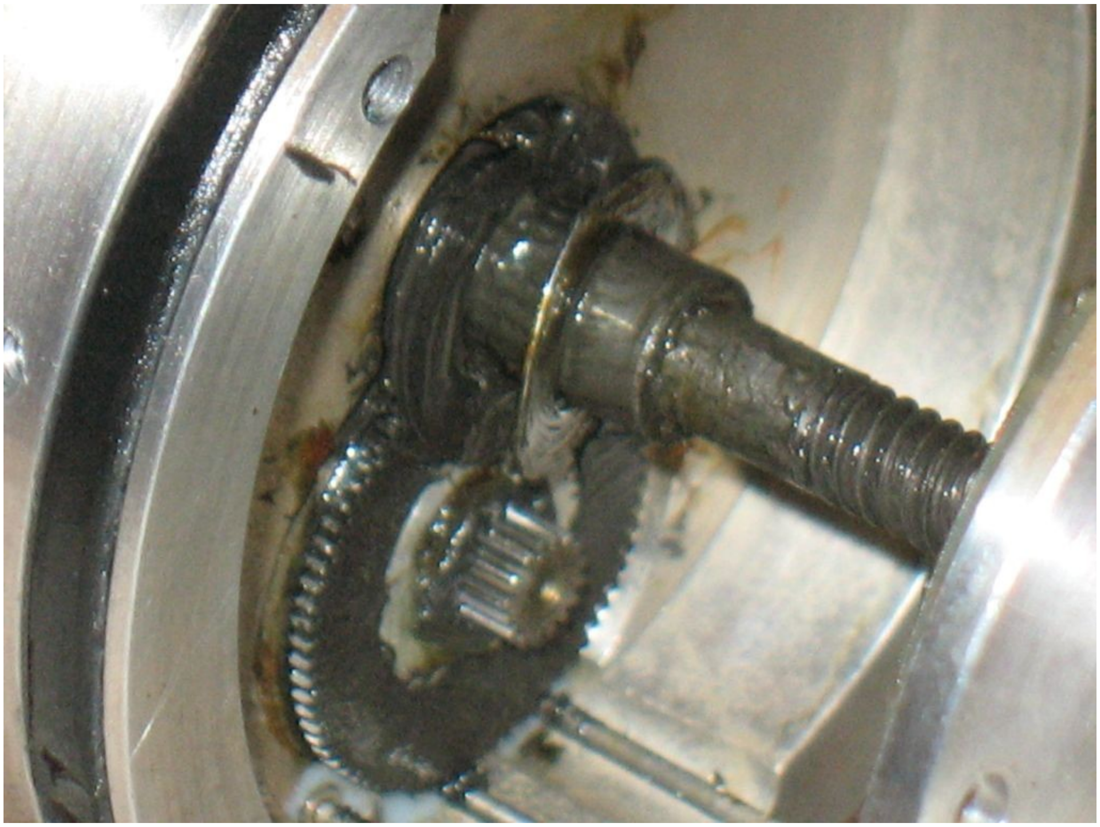
The problem is that this mechanism does need lubricating periodically, and it must be taken apart to do it (it should be lubed at least the first time you are going to go into it). However, the gears and the disc/bronze bushing should not require lubrication again, until you notice that the KC knob requires more torque than normal. The amount of time between lubes (2 to 4 years) will vary depending on the condition of the disc and bronze bushing surfaces and the oil used (but still oil sparingly). Don't forget to use the Super Lube on the core split nut and the main tuning screw, also.



The other part to keeping the linearity synchronization is the main tuning core positioning. If you remove the core and want to maintain synchronization, it must go back on the shaft in the exact same position as it was before removal. You will need to count the turns it took to remove it and the position it was on the shaft. It can go on it in two positions 180 degrees apart. In order to inspect, clean and lube the inners, you do not need to remove the core. But, if you can not successfully clean it up so that the shaft rotates easily, the core may need to be removed, or the problem is the main shaft bearings or the linearity gear drive. When you put it back together, the linearity disc is pushed against a bronze bushing that must be free of any sticky material. It should be oiled vary sparingly with a good medium viscosity synthetic oil with PTFE in it (such as Super Lube). It's shown next (the 1/8” thick brass colored ring above my screw driver tip (above the red painted screw)):



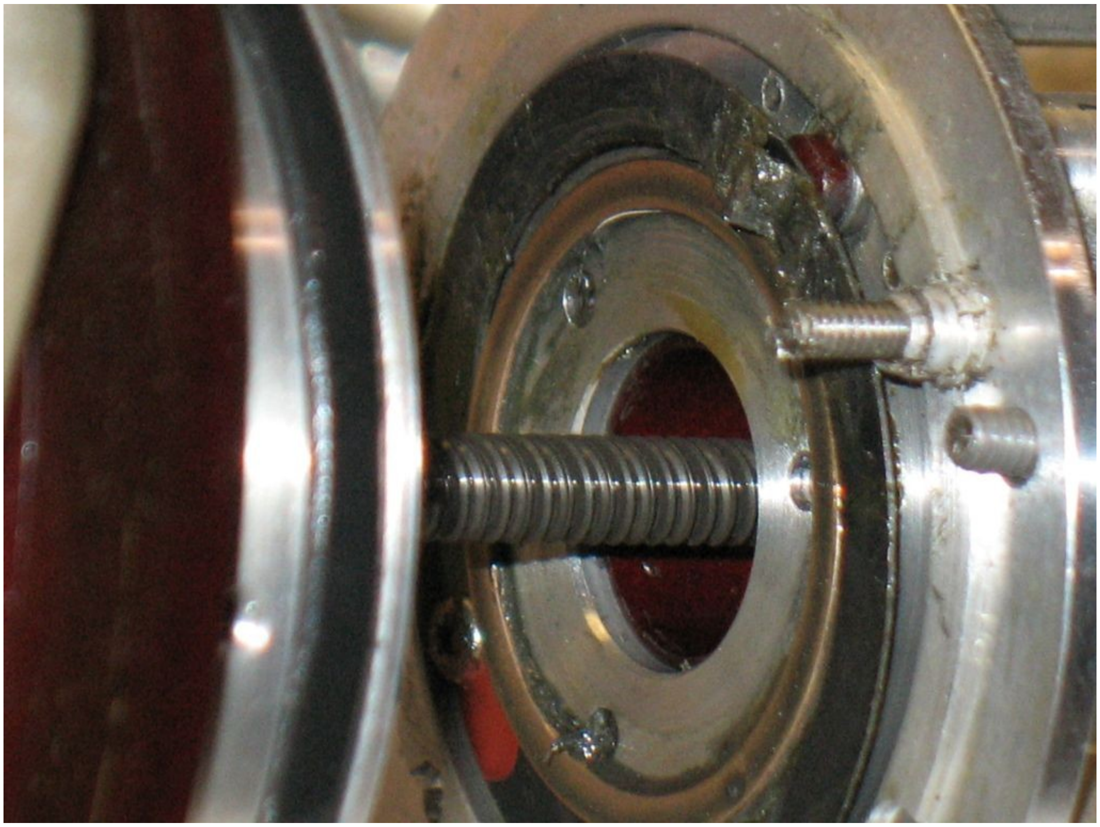
The disc with the linearity adjusting screws in it is pushed against it by a wavy spring washer shown in the next picture:



The gears should be lubed vary sparingly with a good medium viscosity synthetic oil with PTFE in it (such as Super Lube). The wavy and flat washers should be lubed with a heavier grease. The number and thickness of the washers there determines how hard the disc is pressed against the bronze bushing. It must be enough to maintain correct operation of the linearity cam, but not too much as to impair rotation of the shaft. This next picture shows the gears, C clip and washers better:

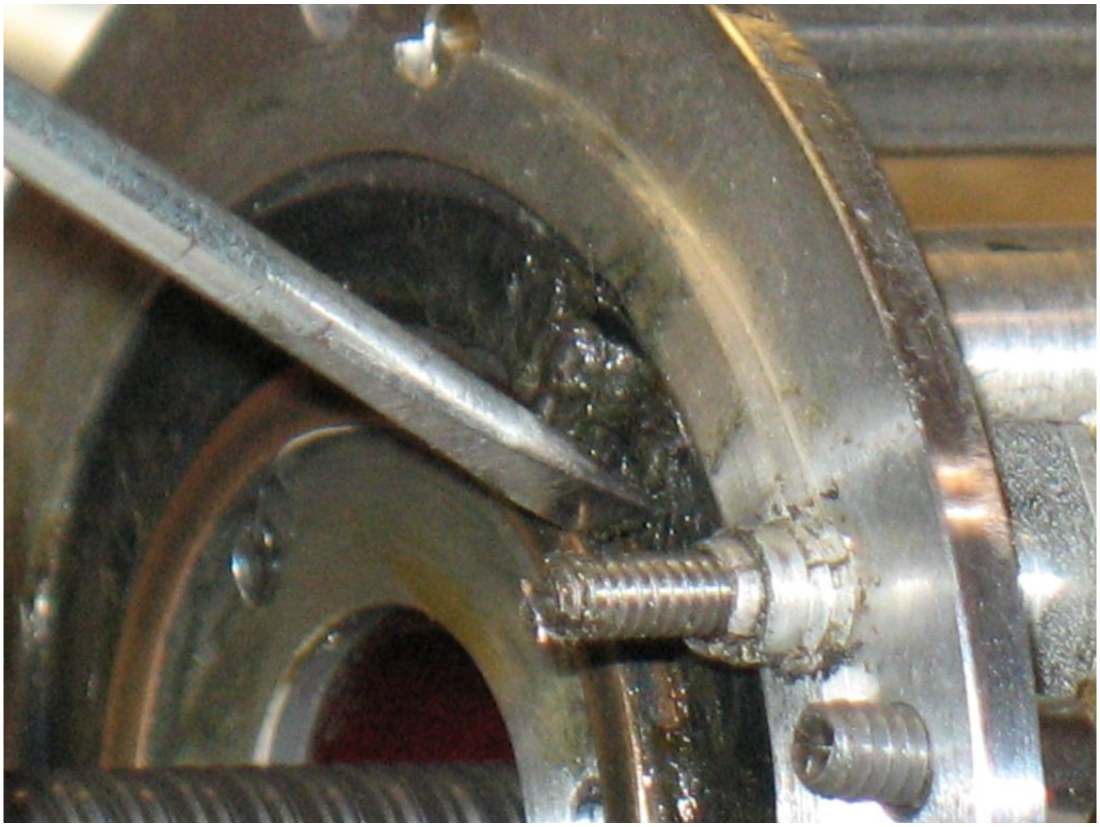
In the above, the shaft has been pulled out a little in order to get a better view. The position of the small reduction gear is not important.

Shown next is the large circular flat spring (about 1.5” in diameter) with the cam on it that operates the linearity inductor core (the cam is just above and left of the EP adjusting screw):



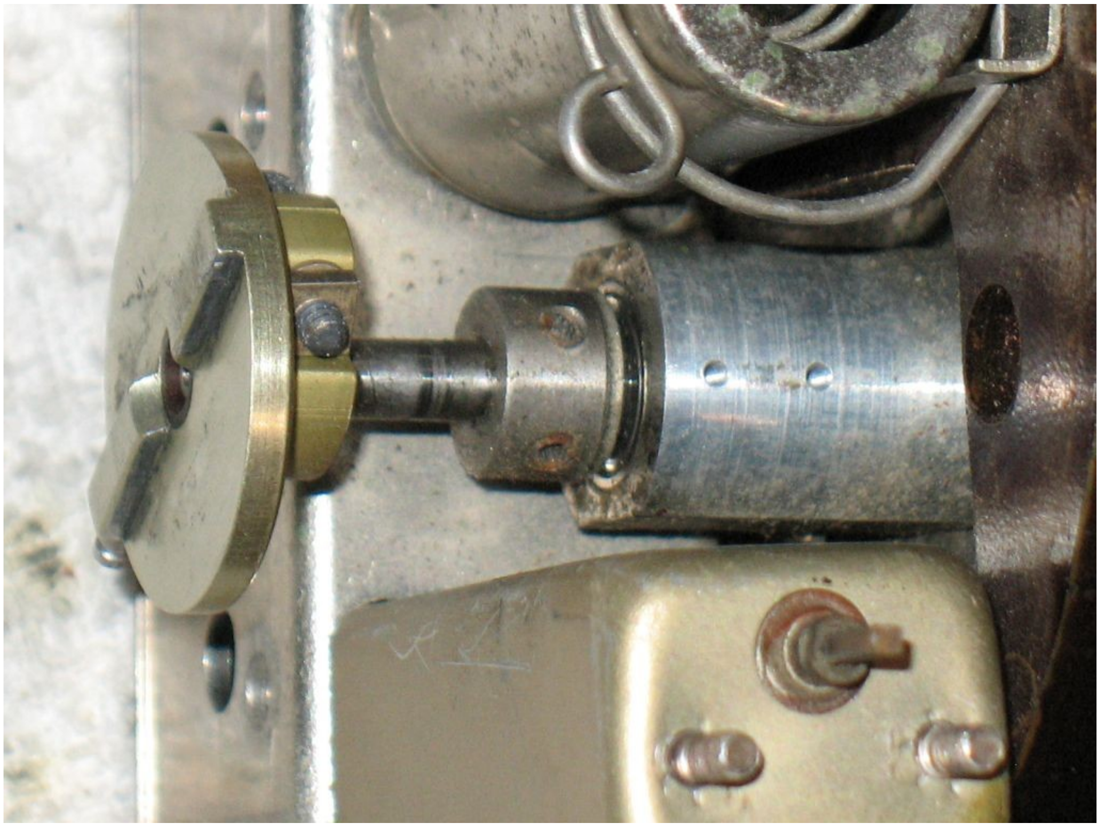
Underneath the flat spring with the cam on it (in the picture above), you can see the red phenolic button that is part of the linearity inductor core. It is spring loaded and must move freely.

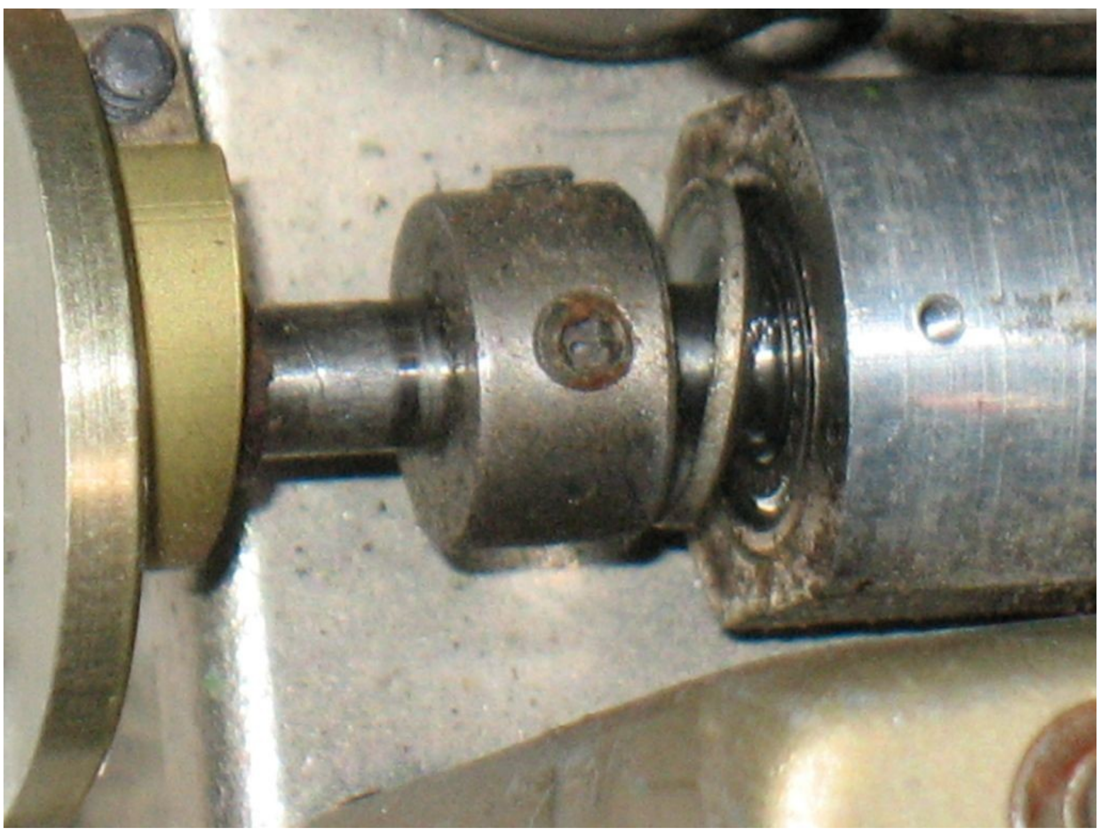
In the next picture you can see my screw driver tip pushing on the cam spring to ensure that it moves easily and is not obstructed by anything (this is an important part of the mechanism):



In my case, I was lucky. The hard rotation was caused by a sticky substance on the bronze bushing and the disc plate that pushes on it. After I cleaned them up and lubed them vary sparingly with Super Lube, the shaft rotation was smooth and easy. Operation is back to normal.

If that were not the problem, the next place to check would be the main shaft bearings and the small linearity disc reduction gear driven by the main tuning shaft. I'd check the drive reduction gear, first. There is a little slack in this gear system, but a little is OK. You will need to pull the main tuning shaft out a little in order to do this. This next picture shows the collar on the shaft next to the oldham coupler. The external shaft grounding contact that is normally screwed to the top of the bearing housing has been temporarily removed. The collar has two set screws holding it in place. Loosen them to slide the collar towards the oldham coupler allowing the shaft to be pushed in towards the main tuning coil. The set screws may have burred the shaft, so the burrs may need to be removed in order to move it. This will disconnect the reduction gear for testing. Remember to mark the position of the oldham coupler on the frame. If the gear does not rotate freely, clean and lube it with super lube. The position of the reduction gear is not important. If it was already easy to turn, check the bearings. This also exposes the bearing on the inside next to the linearity gears. If the bearings are the problem, before replacing them, try a little bit of the 'super lube' oil on them. I know that oiling bearings is a no-no, but if it's frozen or hard to turn, well...





The next picture shows the bearing on the inside:

When reassembling the shaft, make sure that the gears are lined up and the drive gear on the shaft is pushing against the bearing inner racing. Then while holding the shaft against it, press the collar against the other bearing by the outside housing and tighten up the set screws. There should be no end play and the bearings and shaft should still be very easy to turn.

Don't forget to reinstall the main shaft grounding contact on the bearing housing next to the oldham coupler. Check for correct contact pressure, while your at it. This is also a good opportunity to clean the shaft and contact. Do not oil this contact point. Deoxit very sparingly is OK. This is very important for warble free tuning.

When reassembling the linearity unit, you will notice that at about 1/16” before it is completely together, you will feel spring resistance. This is normal and is from the wavy spring washer. It should be enough to allow for the correct operation of the linearity disc, but not so much as to cause bad shaft rotational drag. Manually hold it together and rotate the shaft. The rotational effort should be only slightly more than when it is still 1/8” apart. If it is more than that, check the bronze bushing and disc plate that pushes on it. The problem should not be the wavy spring washer or the shim washers, but you never know who's been in there before and done what to it.

Disclaimer: I don't know anyone connected to Super Lube and am not receiving any benefit from anyone for mentioning it.

Have fun. Regards, Larry
Revision 1C end.