1200 MOUNT GEAR ADJUSTMENTS

Procedures to Remove Worm Gear Backlash and to Minimize Gear Play

A telescope mount is a precision piece of equipment that allows a telescope to be pointed and to track with sub arc-second accuracy. To be able to do so requires that the gear mesh be periodically checked and adjustments occasionally performed. This becomes more important if the mount is frequently jostled around in a vehicle while transported to observing sites, than if the mount remains fixed in an observatory.

Accurate meshing of the worm gear to the worm wheel is important for peak performance of your mount. A gear mesh that is too loose will result in backlash, which can be problematic, especially where accurate declination reversal is required for excellent guiding. Gear mesh that is too tight can add unnecessary stress to the motors and can result in R.A. tracking that is not smooth, or Dec. guider movements that are not precise.

Definitions:

Backlash (as defined by Astro-Physics):

Backlash is the result of a gap between the worm gear teeth and the worm wheel teeth. For clarity of communication, we restrict the term backlash to ONLY apply to this worm gear to worm wheel mating. If movement can not be felt or seen in the eyepiece when making the tests that follow, then the adjustments described here will not be needed. Please note that other issues can give the false appearance of backlash when guiding or making fine adjustments with the direction buttons. However, only the tests below will truly identify backlash as we define it.

Play (as defined by Astro-Physics):

The movement in an axis where there was none before. It can be felt as a back and forth movement of any gearing setup or seen as an image shift in the eyepiece where there should be none. All backlash is evidenced by play, but not all play is necessarily backlash in the way that we define it. By necessity, there will always be some small amount of play in any spur gear system. This play is required in order for the gears to be able to move. There are five principal sources of play that occur in gear systems:

1. Backlash - (true worm wheel / worm gear backlash): The result of a gap between the worm screw gear and the worm wheel. This can be felt as a slight play in the axis when moved back and forth as if to rotate it.

2. Worm gear / worm spur gear: The play caused by a loose set screw or similar mating issue between the worm gear's shaft and the spur gear to which it is mated. This is easily remedied and should be zero in normal operation.

3. Reduction spur gear-set play: The cumulative play that occurs between the motor drive shaft's first spur gear and the spur gear that is on the worm shaft.

4. Spur gear cluster separation: Although extremely rare, this can occur when one member of a two-gear cluster breaks free from its paired partner. This has only been seen in the Delrin / brass cluster that is the next set after the motor in some of our mounts. When this happens, the smaller brass spur gear is able to turn without the larger Delrin gear also turning.

5. Worm gear tangential end play: A motion of the worm gear that is tangential to the worm wheel. It generally occurs because of inadequate pressure or preload on the bearings that hold the worm screw gear in place.

Part 1 - Backlash: Gear Mesh Issues

Factors contributing to gear mesh problems from greater to lesser:

1. **Transporting mounts.** Carrying or shipping mounts to local and distant observing sites causes mounts to experience vibration and jostling which can put pressure on the gear boxes and change meshing.

2. **Seasonal temperature changes.** Mounts located in geographical areas that experience extreme temperature differences between summers and winters will change gear mesh. A mount with proper gear mesh in the summer may show a loose meshing in the winter and vice-versa.

3. **Time and wear.** Over time, gear wear will cause a small change in the gear mesh.

Test for Right Ascension (R.A.) and Declination (Dec.) Backlash and Correction

Proper gear mesh is when no looseness is felt in the worm gear / worm wheel mesh and the spur gears turn freely without binding. This two-step process is discussed below.

The 1200 mount should be firmly attached to its pier, powered off and with clutch knobs engaged. The mount / telescope should be put into a Park 3 position so that proper centering and meshing of the gears will take place without undue stress or pressure.

R.A. Axis:

The R.A. test is done with the counterweight shaft pointing down in the Park 3 position. Place your hand near the end of the counterweight shaft and move the shaft back and forth as if to rotate the R.A. axis. This test can be done with the mount alone on its pier or with the telescope and counterweights attached. The play you are looking for is rather subtle. You will have a better sense of feel if you hold the counterweight shaft with your fingertips. Be sure that the counterweight shaft is not loose and wiggling.

If no play is felt, then you do not have an R.A. backlash problem.

If play is felt when attempting to rotate the shaft back and forth, proceed with the adjustment as described below.

(900 mount shown in photo)

Dec. Axis:

(900 mount shown in photo)

The Dec. test is done with the telescope pointing towards the Pole in the Park 3 position. Place your hand near the end of the telescope focuser, or at the end of the cradle plate, if the telescope is off the mount. Be sure that whatever you are using is itself solid and flex-free. Move the telescope or plate back and forth as if to rotate the Dec. axis. This test must be done with the assembled mount on its pier. Again, the play you are looking for is rather subtle. You may want to grab the scope or plate at each end and use two hands. Again, fingertips will tend to give the most accurate sense of feel.

If no play is felt, then you do not have a Dec. backlash problem.

If play is felt, proceed with the adjustment as described below.

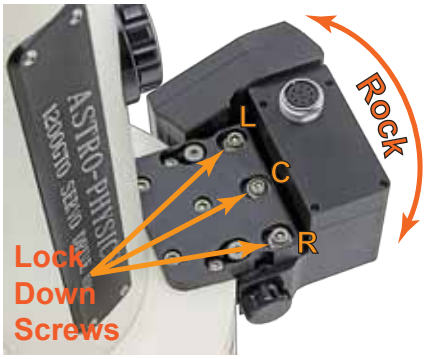
Adjustments - Apply the Following Steps to Both the Dec. and R.A. Axes

Tools needed:

- 5/32” hex key
- 1/8” hex key
- 5/64” hex key
- Paper towel for greasy fingers

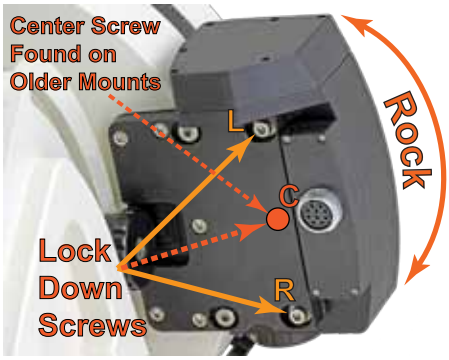
Procedure to Tighten Gear Mesh

1. **Put the mount into Park 3 position.** This is very important to ensure that there is not uneven pressure on the gears due to an out of balance load when gear meshing.



2. **Loosen the gearbox lock-down screws.** Using a 5/32” (and/or 1/8”) hex key, loosen both socket head cap screws shown in the photo. Loosen the screws sufficiently to be able to rock the motor / gearbox, but not so much that it floats around. *See photos below of Dec axis at left and RA axis at right*

3. **Properly seat the worm gear.** Gently rock the motor / gearbox from side to side while applying a gentle



pressure to be sure that the worm is fully seated in the gears of the worm wheel. The trick is to feel the "center-point" where the teeth of the gears are fully engaged. This action moves the worm gear closer to the worm wheel, which removes the gap that you felt earlier. Removing the space between the gears is a delicate adjustment. Use only a gentle pressure, such as the weight of your hand resting on a table.

4. **Re-tighten the lock-down screws.** Snug the LEFT screw first. It is critical for proper worm mesh to snug the LEFT screw first. As you snug, wiggle the box slightly so that it finds its center as the screw is gradually tightened (remember the gentle hand pressure). It is best to hold the hex key by the short end when doing the first tightening. Next, snug the right screw (and center screw if present). Alternate tightening the screws with the short end of the hex key until all screws are tight. Repeat the left-to-right tightening procedure, this time using the longer end of the hex key.

5. **Re-check for looseness.** Repeat your earlier test to see if the backlash has been removed. If you still feel backlash, then repeat the re-meshing procedure described in Steps 2-5. Repeat until correct mesh is achieved.

NOTE: These screws are not the lug nuts that hold the wheel onto your car. If you are unsure how tight to make the attachment screws, I would suggest that you err on the side of caution and don't risk over tightening. It is easier to do this whole process over making everything a bit tighter the second time around than it is to undue the damage from too heavy a hand on the hex key. We have found that a good practice is to have the long end of the hex key in the hole, so that you only have the short end for leverage. Make it as tight as you can with this short lever, and then reverse the hex key and tweak the tightness by no more than 5-10 additional degrees.

Check for Excess Tightness in the Dec. Gearbox:

1. **Put the mount into a Park 3 position.** This is very important to ensure that there is not uneven pressure on the gears due to an out of balance load when gear meshing. Be sure that the mount is powered off.

2. **Remove the Gearbox Cover.** Please see the photo at right to locate the screws to be removed. Use a 5/64" hex key.

3. **Rotate the Foremost Spur Gear.** Verify that the worm gear is not too tightly meshed by rotating the aluminum gear shown in the photo below right. The gear should turn freely with your fingers a full turn in both directions. If not, proceed to numbers 4 and 5 in these instructions. If the gear turns freely, then you are finished.

4. **If tight, loosen the gearbox lock-down screws.** *(Refer to the photo on previous page)* If the worm gear is too tight, and it is difficult to rotate the foremost spur gear, try the following solution. Holding the Gearbox in place with finger pressure only, slightly loosen the lock-down screws using a 5/32" or 1/8" hex key. With no hand pressure applied to the housing, attempt to rotate the aluminum spur gear again. The rotation of the spur gear should release the excess pressure between the worm and worm wheel. If it does, re-tighten the screws and check for backlash play. If the aluminum spur gear cannot be rotated with this action, remesh the gears as described previously. Repeat until correct mesh is achieved.

5. **Re-tighten the lock-down screws.** Snug the screws from left to right. Once all are snug, return to the left screw and finish tightening. Again rotate the spur gear in both directions to ensure that the spur gears still turn freely and also check for looseness in the mesh.

6. **Replace the Gearbox Cover.** Using the 5/64" hex key, replace the six gearbox cover screws and you are finished.

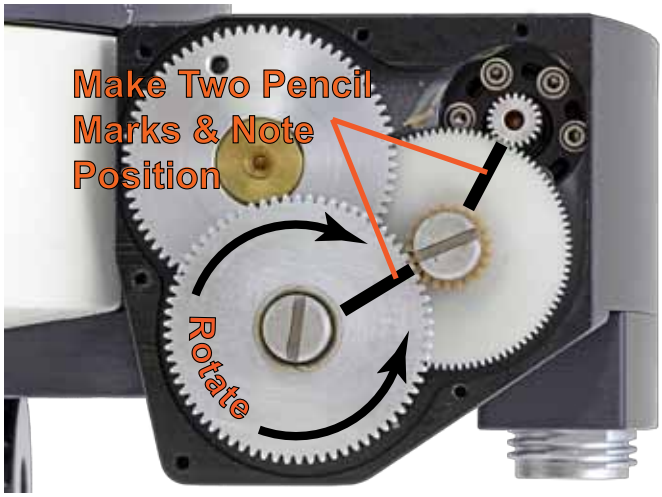
Important: ***The instructions to check for excessive tightness in the R.A. axis are similar to those for the Dec. axis with one very important exception. The spur gears need to return to the original gear angle following rotation so that the stored PE Curve is not lost. It will be necessary to mark both gears shown since the lower gear turns more rapidly and will make several complete turns while rotating the top gear a full turn in each direction. Use a pencil so that the marks can be removed for a future mesh check. If you are a visual observer or an imager who does not use the PE correction, then the PE Curve is not important and you can check both gearboxes identically without concern for gear angle. However, if the R.A. gear angle is changed, it will be necessary to turn off PE correction or, alternatively, install a new PE Curve using PEMPro™.***

Check for Excess Tightness in the R.A. Gearbox:

1. **Put the mount into a Park 3 position.** This is very important to ensure that there is not uneven pressure on the gears due to an out of balance load when gear meshing. Be sure that the mount is powered off.

2. **Remove the Gearbox Cover.** This is the cover at the left side of the gear box (as you face the Y-cable socket) and held by six socket head cap screws. Use a 5/64" hex key, being careful not to drop the tiny screws. By exposing the spur gears, you will be able to check to be sure that your gear mesh has not been made too tight. Please see the photo on the previous page to locate the screws to be removed.

3. **Make pencil marks on both spur gears.** Place marks on both spur gears so that they can be returned to the same gear angle following the test. *See photo at right*



4. **Rotate the Foremost Spur Gear.** The gear should turn freely with your fingers in both directions. If not, proceed to numbers 5 and 6 in these instructions. If the gear turns freely, re-establish the gear angle via the pencil marks and then you are finished.

5. **If tight, loosen the gearbox lock-down screws.** Refer to the photos on page 2. If the worm gear is too tight, and it is difficult to rotate the foremost spur gear, try the following solution. Holding the Gearbox in place with finger pressure only, slightly loosen the screws again. With no hand pressure applied to the housing, attempt to rotate the aluminum spur gear again. The rotation of the spur gear should release the excess pressure between the worm and worm wheel. If it does, re-tighten the screws and check for backlash play. If the aluminum spur gear cannot be rotated with this action, remesh the gears as described previously. Repeat until correct mesh is achieved. Re-establish the gear angle so that the stored PE curve is not lost.

6. **Re-tighten the lock-down screws.** Snug the screws from left to right. Once all are snug, return to the left screw and finish tightening. Again rotate the spur gear in both directions to ensure that the spur gears still turn freely. Re-establish the gear angle via the pencil marks. Make a quick check for gear mesh looseness, as described on the previous page, and you are done.

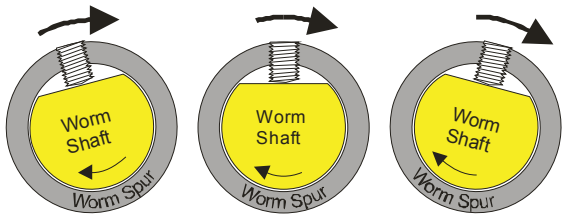
7. **Replace the Gearbox Cover.** Using the 5/64" hex key, replace the six gearbox cover screws and you are finished.

Remember: ***If the R.A. gear angle is changed, it will be necessary to turn off PE correction or, alternatively, install a new PE Curve using PEMPro™.***

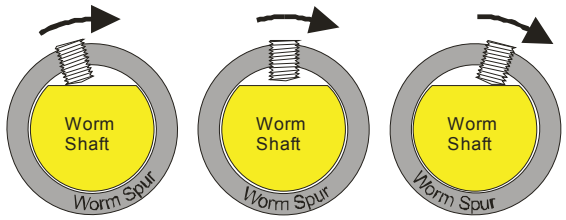
Part 2 - Loose Spur Gear Set Screw

Symptoms

If you are experiencing long delays in direction reversal, but you are confident that your worm gear to worm wheel mesh is good, then the problem is most likely a loose Spur Gear on the worm gear shaft. First be sure that your gear mesh is correct for your mount. The Spur Gear becomes suspect when you cannot feel backlash in the system, but you experience delays in direction reversal when moving with the direction buttons at slow speed like 1X or in autoguiding. A loose Spur Gear will not cause a perpendicular motion, but since that problem may require the removal of the Spur Gear, it is suggested that you read on and not skip ahead. The illustration shows what happens when the set screw is loose or is not centered on the flat surface on the worm shaft. This is a relatively easy thing to both diagnose and repair. *See illustration at right.*



Correct - Tight Set Screw Causes Worm to Turn with Spur Gear



Loose Spur Gear Set Screw Causing Slop in Gear Train

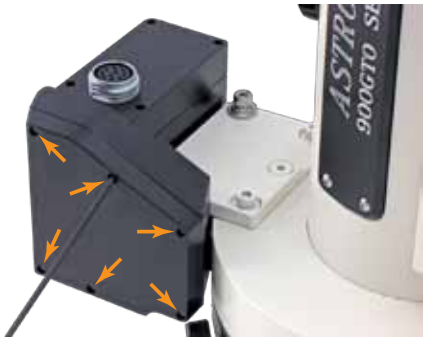
<u>Important Note</u>: *Removing the top spur gear, as required by this procedure, will result in the loss of your stored PEM curve. You will need to use PEMPro™ to create a new curve.*

Tools needed:

- 1/16” hex key (older 900/1200)
- 5/64” hex key (all mounts)
- Flat head screwdriver (for 900/1200)
- 3/8” nutdriver (for Mach1GTO)
- Paper towel for greasy fingers

Appying the Fix (900/1200/Mach1GTO mounts - appearances may differ)

1. Start by removing the gearbox cover from the motor / gearbox on the axis in question. To remove the cover, simply remove the socket head cap screws indicated by the arrows (number of screws may differ by mount). Be careful not to lose the screws! *See photo at right*



2. Remove the cover to expose the clustered spur gears beneath. The worm’s spur is hidden underneath the large spur gear that is on top of the cluster. This top cluster gear must be removed.

3. Use a standard flat head screwdriver (900GTO & 1200GTO) or 3/8” socket (Mach1GTO) to undo the spur gear bolt that holds the gear in place and then remove the gear. *See bottom right photo on following page*

4. Take hold of the worm’s spur gear and turn it back and forth. If the set screw is loose, you will feel some slop between the spur and the worm shaft. The spur gear should feel as if it were welded to the worm. If the spur can turn without subsequently turning the worm, you have found the source of the problem. *See photo above left*

5. The set screw is on the collar on the side of the spur gear. You will probably have to turn the spur and worm to get clear access to the screw. On older 900/1200 mounts, the set screw probably takes a 1/16” hex key. Newer mounts including all Mach1s will have larger set screws requiring a 5/64” hex key. *See photo at right*

6. Be careful to fully seat the hex key into the socket of the set screw so that you don’t wallow out the socket hole. The Bondhus™ hex key set, included with your mount, has a ball end on the long leg of each hex key that will be helpful.

7. Before tightening the set screw, you need to properly position the spur gear on the worm shaft. There are two parts to this. The spur gear must be positioned laterally along the shaft to properly engage the next gear, and it must have the set screw centered radially over the flat spot on the worm shaft.

8. For the lateral positioning on the 900/1200 mounts, start by making sure that the spur is roughly flush with the end of the worm shaft. With some mounts, you may need to push the spur gear on a tiny bit further to prevent contact with the gearbox housing. For the Mach-1GTO, fully seat the spur gear until it stops. *See photo at left*

9. To align the set screw with the worm shaft's flat spot, turn the spur back and forth and position it in the center of its free play. Turn the set screw just until it makes contact, and then test the centering of the spur over the worm shaft's flat spot by turning it back and forth again. It is very important that the set screw is dead-centered over the worm shaft's flat spot.

10. If you are unsure where the center of the flat spot is, remove the spur gear completely and make a small mark on the end of the worm shaft with a Sharpie marker to mark the spot so that you can see it when the spur gear is re-installed.

11. Tighten the set screw, and give the spur gear one final test by turning it back and forth. The spur gear and worm should feel like they are made from one piece of material, and should have NO play or slop whatsoever between them. (Of course, you must distinguish any play between the spur and worm from any play caused by the mesh between the worm gear and worm wheel.)

12. If you wish to re-grease the spur gears while the gearbox is open, clean them with a soft cloth and then use a good quality lithium grease rated for the temperatures that the mount is likely to encounter. It will not generate significant additional heat in operation, so a high temp grease is unnecessary. You should probably be more concerned about the cold end of the grease's temperature rating. Astro-Physics uses "AeroShell 33", but this is certainly not a requirement.

13. As important as lubricating the gears themselves, is to place some lubricant onto the spur gear bolt shafts that serve as the axles for each reduction spur gear. In ALL applications of lubricant, only a very light greasing is recommended. Do not pack in extra grease!

14. Replace the top spur gear that connects the worm spur to the motor side of the reduction gear train and tighten the spur gear bolt. DO NOT OVERTIGHTEN! This is especially true with the MACH1GTO where you will have the leverage of a 3/8" wrench on the bolt (it is better to use a nutdriver instead of a wrench to minimize risk of damage). *See photo at right*

15. Replace the gearbox cover and you are finished.