

# **Procedure for maintenance to filter wheels #1 and #2 in a Mk IV Brewer spectrophotometer**

**National Ultra Violet Monitoring Center  
Department of Physics and Astronomy  
University of Georgia  
Athens, GA 30602**



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**Prepared by M.G. Kimlin and T.E. Taylor  
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## **Introduction**

Brewer Mk IV spectrophotometers are equipped with several rotating filter wheels which allow selection of different filters for various instrument scans. On occasion the mechanical components of the filter wheels encounter difficulties and maintenance work must be performed to correct these problems.

There are many symptoms of filter wheel problems. FW#2 contains neutral density filters, and therefore incorrect positioning will result in step changes in diagnostic lamp intensities. This will cause erratic behavior in the R5 and R6 ratios which are recorded in the instrument's Sloavg file. Another indicator of FW problems is failed HG calibration scans.

## **Equipment**

Mk IV Brewer spectrophotometer  
Hex wrench set (English sizes)  
Spare AC power cable (optional)  
Spare data cable (optional)

## **Purpose**

This Standard Operating Procedure (SOP) outlines the NUVMC technique for correcting the operation of filter wheels #1 and #2 in a Mk IV Brewer.

## **Procedure**

1. If the Brewer is still running in schedule exit the schedule by pressing the Home key when the message "Press Home to abort schedule" appears on the computer screen.
2. Run three 50W lamps to use as a reference for any change that may take place to the instrument's sensitivity due to the removal of the foreoptics tube. Follow the procedure in the document "Procedure for 50W lamp calibrations" available from the NUVMC.
3. Power off the Brewer by pressing the push button located on the edge of the instrument near the zenith prism window.
4. Place a protective cover on the quartz dome on the top of the Brewer outer cover.
5. Remove the circular connectors for the zenith drive, power and data cables which are connected from the tracker into the side of the Brewer.
6. Remove the 4 hex bolts connecting the Brewer feet to the tracker unit.

7. Lift the Brewer off the tracker and move it indoors to a clean working environment.
8. Connect the AC power and data cables to the Brewer and initialize communication between the Brewer and computer. If the cables that are normally used to control the instrument cannot be easily rerouted to the inside work space, it may be necessary to use spare cables.
9. Remove the Brewer outer cover by loosening the four latches and lifting the cover up.
10. Give the "TT" command at the Brewer Home screen to move to teletype mode. Press "Y" or "N" to respond to the printout prompt and then press the Enter key until a command prompt appears on the screen.
11. Zero FW#1 by giving the command "M,4,320" at the TT command prompt. See Table 1 for a complete description of TT commands for operating the filter wheels.
12. Test the operation of FW#1. At the command prompt type the command "M,4,0:M,4,320:A" and press Enter. This command will cause FW #1 to rotate from position zero to position five and back until interrupted by pressing the Home key.
13. While the wheel is rotating observe the movement for any indications of binding or erratic behavior. Note any unusual movements and try to determine if they are caused by mechanical binding or perhaps by bad electrical connections.
14. Press the Home key to abort the TT mode. Pressing the Home key will terminate TT mode and exit to the Brewer command line screen.
15. Reenter TT mode and zero FW#2 by giving the command "M,5,320" at the TT command prompt.
16. Test FW #2 operation by giving the command "M,5,0:M,5,320:A".
17. While the wheel is rotating observe the movement for any indications of binding or erratic behavior. Note any unusual movements and try to determine if they are caused by mechanical binding or perhaps by bad electrical connections.

18. If binding was noted for either filter wheel, rotate the FW by hand to determine the exact position of mechanical binding. If it is confirmed that there is some binding occurring during rotation then the FW assembly should be removed from the instrument for rebuilding.
19. If the FW's seem to be rotating smoothly by hand but do not rotate smoothly when using teletype mode, the problem most likely is any combination of faulty/intermittent cable/wire connections, a faulty I/O board or a faulty stepper motor.
20. Replace the appropriate electronic board which controls FW#1 and #2 in the card rack and the ribbon cables to the stepper motors and retest the operation of both FW's.
21. Gently tug on each wire connection at the stepper motor/ribbon cable connection for loose wires. Loose wires should be properly reattached and then operation of the FW retested.
22. If operation of the FW's is not remedied by the above steps, it is necessary to dismantle the FW#1 and #2 assemblies.
23. Turn off power to the Brewer by pressing the push button on the side of the instrument. Remove the AC power cable from the instrument.
24. Locate the FW#1 and #2 assembly along the foreoptics tube. Refer to Figure 1. Note the figure shows a schematic of a single electronic board instrument. The layout of a multi board instrument is similar.
25. Remove the white foreoptics face plate located above the foreoptics tube; There are three bolts securing the face plate. First loosen the 3/32" hex bolt at the zenith prism end of the foreoptics tube which secures the face plate to the foreoptics tube brace plate. Do not completely remove this bolt. Remove the two 1/16" hex bolts securing the face plate to the spectrometer housing. Lift the face plate out of the instrument and set it aside.
26. Disconnect the D-sub pin connectors to both the internal lamp and the zenith prism motor.
27. Disconnect the iris and FW#1 and #2 motor connectors from the ribbon cables. The ribbon cables are mounted to the right foreoptics sidewall plate.

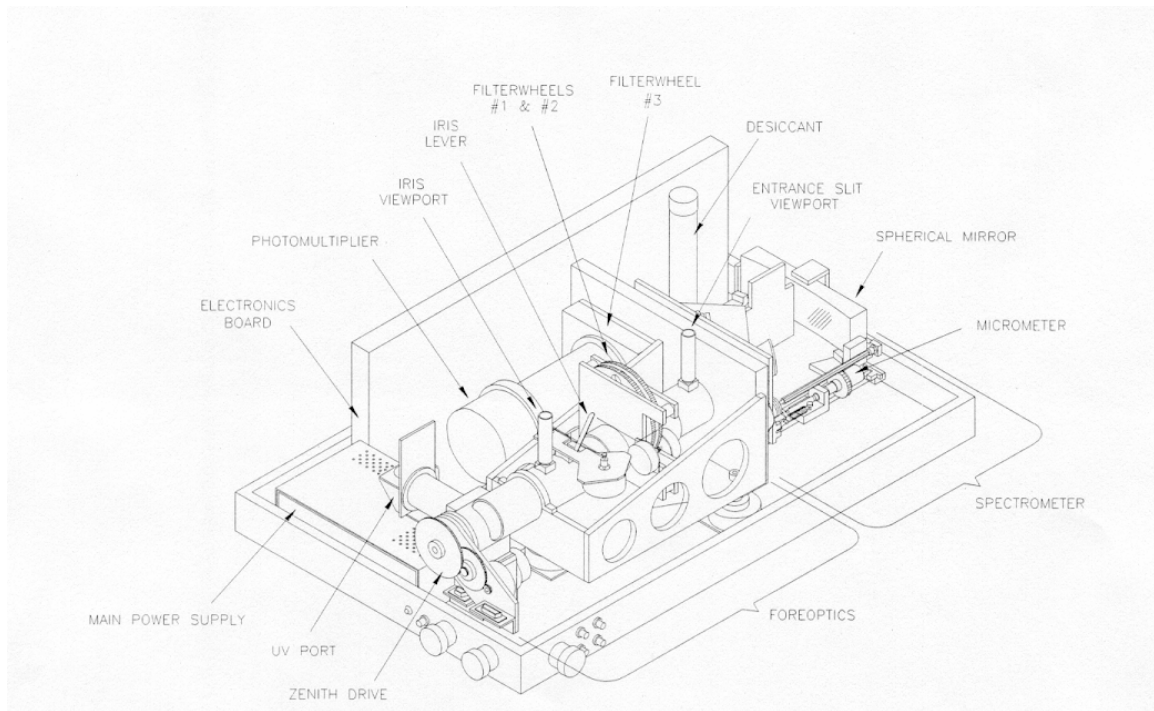
28. Remove the four 7/64" hex bolts which secure the foreoptics tube brace plate to the foreoptics tube left and right sidewall plates. The sidewall plates can be identified as the ones with a series of three holes bored out of them.
29. Grasp the foreoptics tube with one hand near the spectrometer box and the other hand near the zenith prism and gently slide the tube in the direction of the zenith prism-away from the spectrometer. The end of the tube near the spectrometer should come free of the spectrometer wall and the entire foreoptics tube should be able to be lifted out of the instrument.
30. Locate the FW mounting plates which sandwich FW #1 and #2. Remove the four 5/64" hex bolts that secure the plates together. The bolts run thru sleeves to keep the plate separated at a constant distance.
31. Once the four bolts holding the plates together have been removed the two halves of the foreoptics tube are mated together by a steel shaft on which the FW's rotate. To separate the foreoptics tube into two halves, firmly grasp the tube with one hand at the spectrometer end and the other hand at the zenith prism end. Gently pull the tube along its length until the halves separate. Watch for any washers which may fall off the shaft once the separation takes place.
32. FW #1 is now free to come off the steel shaft. There is a washer located between FW #1 and its mounting plate, a washer between FW #1 and FW #2 and a third washer between FW #2 and its mounting plate. There is a pin extruding from each of the FW mounting plates and a groove cut into one side of each FW in which the pin runs. This ensures that the assembly goes together in only one way.
33. Once both FW's are removed from the steel shaft, inspect the shaft for scarring. Inspect the hole in the FW's for any signs of abnormal wear. Usually if the FW's have been sticking the dismantling process fixes the problem. Check for any damage to the nylon washers and replace them if necessary. Use only non-outgassing lubricants such as Krytox inside of the Brewer to avoid deposits on the filters.
34. Reassemble the FW unit. The order of components is; mounting plate, washer, FW #2, washer, FW #1, washer, mounting plate.
35. Mate the steel shaft into the FW #1 mounting plate to join the two halves of the foreoptics tube back together. Be sure that when joining the two halves of the foreoptics tube assembly that the mounting plates are

- oriented properly with respect to one another, i.e, the entrance slit view port tube and the iris view port tube should be in the same position and the FW motor gears should sit flush on the FW's. Also, be sure the mounting plate pins are inserted in the FW grooves so that the wheels hit the mechanical end stop.
36. Reinsert the sleeves between the FW mounting plates.
  37. Insert and tighten the 5/64" hex bolts to secure the plates together.
  38. Rotate the FW's by hand to be sure the system has been put back together properly. The FW's will normally have some room to wiggle on the shaft slightly. The rotation of the wheels should feel smooth with no binding until they hit the mechanical end stop.
  39. Place the foreoptics tube back in the instrument between the tube sidewall plates. Avoid pinching wires or connectors when placing the foreoptics tube.
  40. Reinsert and tighten the four 7/64" hex bolts securing the tube brace plate to the left and right sidewall plates.
  41. Reconnect the iris and FW #1 and #2 motor connectors to the ribbon cable connectors on the right sidewall plate. Check the wire connections for signs of deterioration and looseness. A poor connection can cause the FW's to move erratically.
  42. Reconnect the internal lamp and the zenith drive cables to the connectors near the zenith drive end of the foreoptics tube.
  43. Replace the white foreoptics tube face plate and tighten all three hex bolts.
  44. Restore power to the Brewer and reinitialize communication between the Brewer and computer.
  45. After the motors have initialized and the Brewer command line screen is visible, move to the Teletype mode by giving the TT command.
  46. Use the commands as before to test operation of FW#1 and #2. Observe if the FW's move smoothly and do not bind. There should be a rhythm to the rotation that will be interrupted intermittently if there is a binding problem. Abort the command by pressing the "Home" key.

47. If it is determined that the FW's are operating properly, replace the Brewer outer cover and secure the four latches, ensuring that the outer cover is mounted evenly all the way around the Brewer case.
48. Disconnect the cables and move the Brewer back to its position outside.
49. Remove the quartz dome protector.
50. Reconnect the power and data cables and reinitialize communication with the computer.
51. Perform lamp scans on the same 50W lamps that were run prior to moving the Brewer.
52. Perform a tracker steps per revolution (SR) test followed by a sun sighting (SI) per the procedure in the Operators SOP. This will ensure that the Brewer optical path is reoriented properly if the zenith prism was realigned. The date and time on the computer should be verified to be correct for this step.
53. Enter an electronic comment (CM or CO command) describing briefly if the zenith prism was adjusted and any other observations made. Also enter a brief entry in the paper station log form.
54. Place the Brewer back into schedule by giving the command "skc" at the command line. When prompted for schedule, enter the name of the current network schedule (epa96d for the US EPA/UGA network as of December 2002).

<b>Table 1: Brewer Motor Positions and Control Commands</b>				
<b>Motor # and Name</b>	<b>Step #</b>	<b>Filter</b>	<b>FW Position</b>	<b>Command String</b>
Filter wheel #1	320	0:film polarizer (horizontal)	O	M,4,320
	256	1:quartz diffuser (translucent)	I	M,4,256
	192	2:blocked aperture (opaque)	II	M,4,192
	128	3:clear aperture	III	M,4,128
	64	4:quartz diffuser; ND of f=2.0 (translucent)	IV	M,4,64
	0	5:film polarizer (vertical)	V	M,4,0
Filter wheel #2	0	0:f=0	O	M,5,0
	64	1:f=0.5	I	M,5,64
	128	2:f=1.0	II	M,5,128
	192	3:f=1.5	III	M,5,192
	256	4:f=2.0	IV	M,5,256
	320	5:f=2.5	V	M,5,320
Filter wheel #3	50	Clear aperture (transparent)	I	M,6,50
	114	Blocked aperture (opaque)	II	M,6,114
	178	BG-12 filter	III	M,6,178
	242	NiSO4 and UG-11 filter	IV	M,6,242





**Figure 1: Brewer components**

**For further information or advice concerning this SOP please contact the NUVMC at the University of Georgia at <http://oz.physast.uga.edu>**