Lens Coupling and Installation Procedures For The Keck LRIS Blue Camera

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This document lists the procedures for installing the Keck LRIS Blue Camera lenses into their respective cells and filling the cells with optical couplant fluid. Additional fixtures and equipment required to accomplish this task are described in detail and are also listed in Appendix A. The procedures are divided into two major sections: Pre-Assembly Procedures, and Cell Assembly Procedures. Pre-assembly lists the tasks that must be completed well in advance of assembling and filling each cell. The Cell Assembly Procedures then describe the steps required for assembling and filling each of the cells.

I. Pre-Assembly Procedures.

A. Cell Preparation.

1. Clean each of the cell components to remove any contaminants that may be left from the machining process- oils, metal chips, etc.
2. Install all of the dowels in each cell. They should all have a snug fit such that they don't move during the machining process to match each lens diameter. Make sure that the special "grooved" dowels are installed in their respective fill/vent port locations (refer to the cell assembly drawings for further details- Appendix B).
3. For each cell, measure each lens diameter and machine each of the respective dowel sets in place in the cell to match the measured lens diameter.
4. Clean each of the cells of the plastic debris from machining the dowels.
5. Install the three O-rings per cell (refer to cell assembly drawings in Appendix B for sizes and locations). Check to see that all of the O-rings fit properly in their respective grooves. Make sure that the retainer O-rings stay in place when the retainer is inverted. If any don't stay in place, use plastic folder tabs to hold the O-rings in the groove during the retainer installation portion of the Cell Assembly Procedures.
6. Place the appropriate Kapton axial spacer shim in each cell- per the cell assembly drawings in Appendix B. Check the fit and the stability of the shim during handling of the cell. The Kapton material tends to cling to objects, and should stay in place during cell assembly. Adhere the shims with a very small amount of silicone cement, but only if absolutely necessary. The cementing should be done at least 24 hours in advance of actual cell assembly.
7. Install two #8-32 x 2" long screws into the blind-tapped holes in the retainer for cell #3 (part #3C5) to be used as grips for lowering the retainer into place during the assembly phase.

B. Lens Preparation.

1. All of the lenses should have been cleaned for delivery by the various vendors prior to delivery. Care has been taken to use clean nitrile/latex gloves when examining the lenses upon delivery. When the lens diameters are measured for radial dowel machining, inspect all of the lens surfaces for fingerprints or other contaminants. Clean "smudged" surfaces as necessary with acetone.
2. Store the prepared lenses in a clean and safe environment.

C. Pumping Equipment Preparation.

1. Set up a fill station for pumping couplant into the assembled cells. The station should consist of:

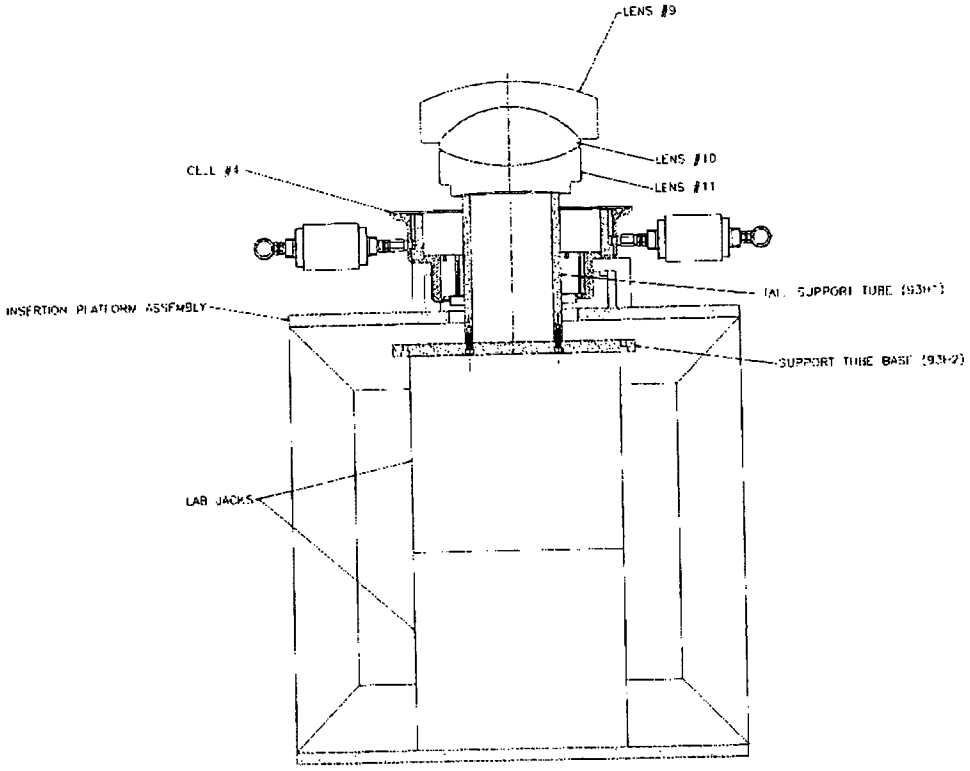
   - Cell stand with adapter rings for each cell (see figures 4, 5, 9, 10, 14, and 15)
   - Tubing pump with controller
   - Coupling fluid fill reservoir
   - Fluid overflow tank
   - Tubing of appropriate size.

2. Prime the pump with optical couplant just prior to beginning to assemble the first cell.

II. Cell Assembly Procedures.

A. Assembly Procedures: Cell #4.

1. Assemble the lens installation fixture assembly shown in figures 1 & 3. Bolt the two lab jacks (Newport Model 281) together, as shown. Then attach the jacks to the base plate (#93F4). Attach the two vertical supports (#93F5) to the base plate. Clamp the base plate assembly to the assembly table.
2. Attach the tall support tube (93H1) to the support tube base (93F2) with six screws, as shown in figures 1& 3. Bolt this assembly to the previously assembled lab jacks. Bolt the cell #4 insertion platform (93H4) to the vertical supports.
3. Attach three plastic cell support legs (93H3) to the pre-assembled cell #4 equally spaced at 120 degrees, as shown in Figures 1-3. Place cell #4 down on the cell insertion platform, centering it with the hole on the platform and the protruding support tube, as shown in Figure 1.
4. Raise the support tube with the jacks until it extends above the top of cell #4 by about an inch.
5. Clean lenses 9, 10, and 11 as necessary with acetone in preparation for optical coupling. Dust the surfaces with a filtered nozzle attached to a regulated dry nitrogen tank.
6. Place lens #11 on the tall delrin support tube (#93H1) with the "notched" side down, as shown in Figure 1. Refer to Optical Layout drawing #0A in Appendix B to identify the optics and surfaces.
7. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing surface (R21) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
8. Slowly place lens #10 down onto lens #11 by gloved hand until lens #10 comes to rest on the three axial spacer pads (see figure 1).
9. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing convex surface (R19) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
10. With gloved hands, carefully place lens #9 down onto the coupled lenses #10 and #11 until it comes to rest on the three axial spacer pads (see Figure 1). Be careful to keep coupled lenses #10 and #11 together- not allowing them or the Kapton shims to shift with respect to each other during this operation. A second person should stabilize lenses #10 & #11 on the tall support tube during this operation.



SECTION VIEW

FIGURE 1: CELL #4 LENS INSTALLATION FIXTURE- SECTION

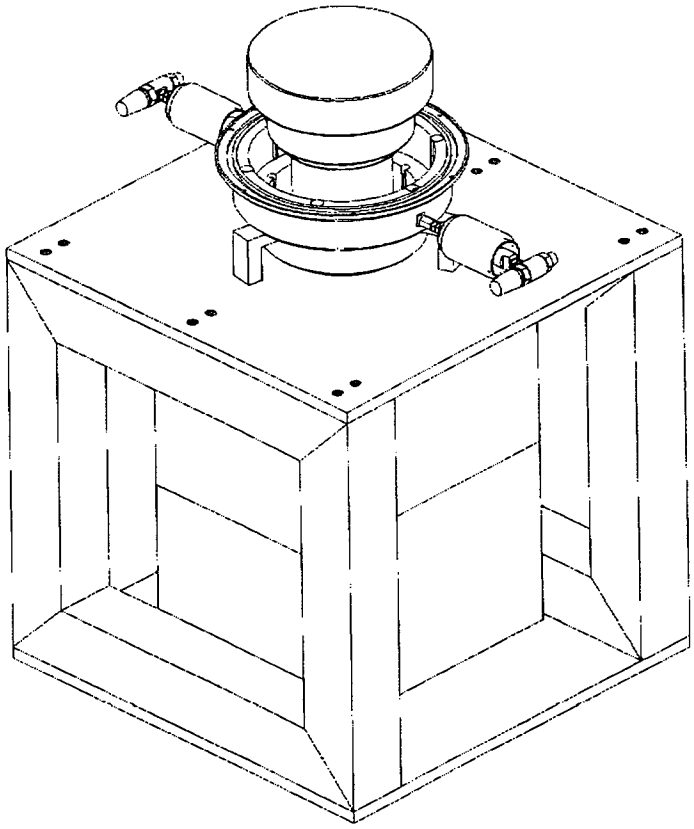


FIGURE 2: CELL #4 LENS INSTALLATION FIXTURE

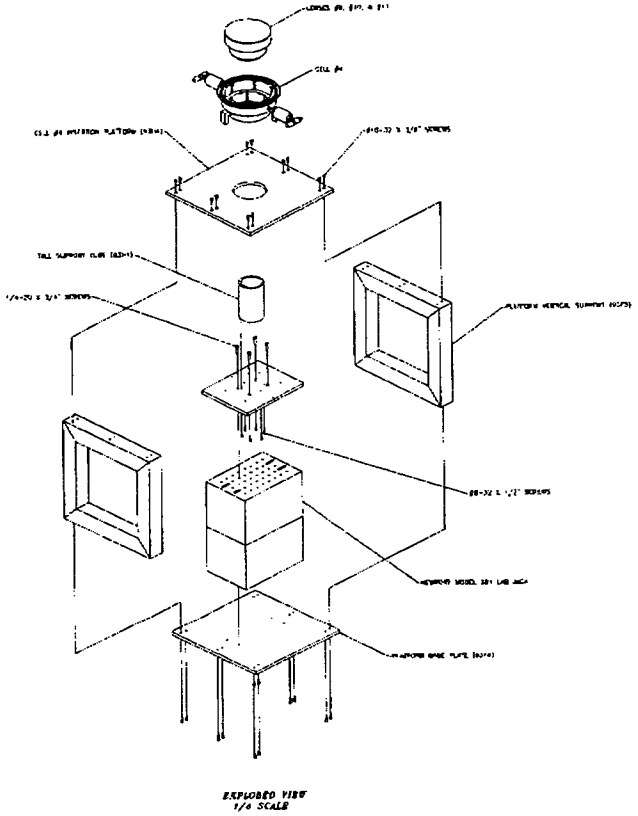


FIGURE 3: CELL #4 LENS INSTALLATION FIXTURE –EXPLODED

11. While someone presses down on the coupled lenses to stabilize them, a second person slowly lowers the lenses/support tube with the lab jacks until the radial support dowels in the cell start to contact the first lens. The cell must be adjusted/centered by feel until the lenses start to slip into place into the cell. Continue lowering the lenses until all of the lenses are seated within the cell. As the lenses are lowered, the lens stabilizing person needs to maintain downward pressure to keep the lenses coupled, compensating for the friction of the snug radial fit of the dowels.
12. Once the lenses are fully seated in the cell, continue lowering the support tube until it is clear of the cell. With the O-rings in place, install the cell retainer ring into its bore in the cell- making sure the O-rings stay in place and don't get pinched. Install the six screws and slowly tighten in an alternating "star" pattern until the retainer comes to rest on its seat, compressing the O-rings their proper amount.
13. Install the two valve assemblies into the ports on the cell. Leave the valves open. Refer to the cell assembly drawings for details- Appendix B.
14. Remove the three plastic cell support legs (93H3) from the cell. Be careful of lens #11 protruding from the cell- the cell retainer ring extends out to protect lens #9. The cell can be set on the retainer ring for this operation.
15. Bolt the sealed cell to the filling stand with the valves lined up vertically, as shown in Figures 4 and 5.
16. Attach the fill tubing to the bottom valve and the vent tubing to the upper valve. Begin slowly pumping coupling fluid into the cell using the tubing pump set at low pump rates. Cell #4 requires less than 125 ml of fluid to fill. The fluid should flow into the .001" gaps between the lenses readily. The progress can be seen through the lenses. Stop pumping as necessary to make sure the lens gaps fill without creating voids. Once bubble-free fluid flows out of the vent tube at the top, the pump is stopped, the fill valve is closed, and then the vent valve is closed.
17. The tubes are disconnected. Excess fluid is cleaned from the cell. The seals are inspected for leaks. The lenses are inspected for any visible voids/bubbles in the coupling layers.
18. The valve knobs are covered with shrink tubing to prevent accidental opening.

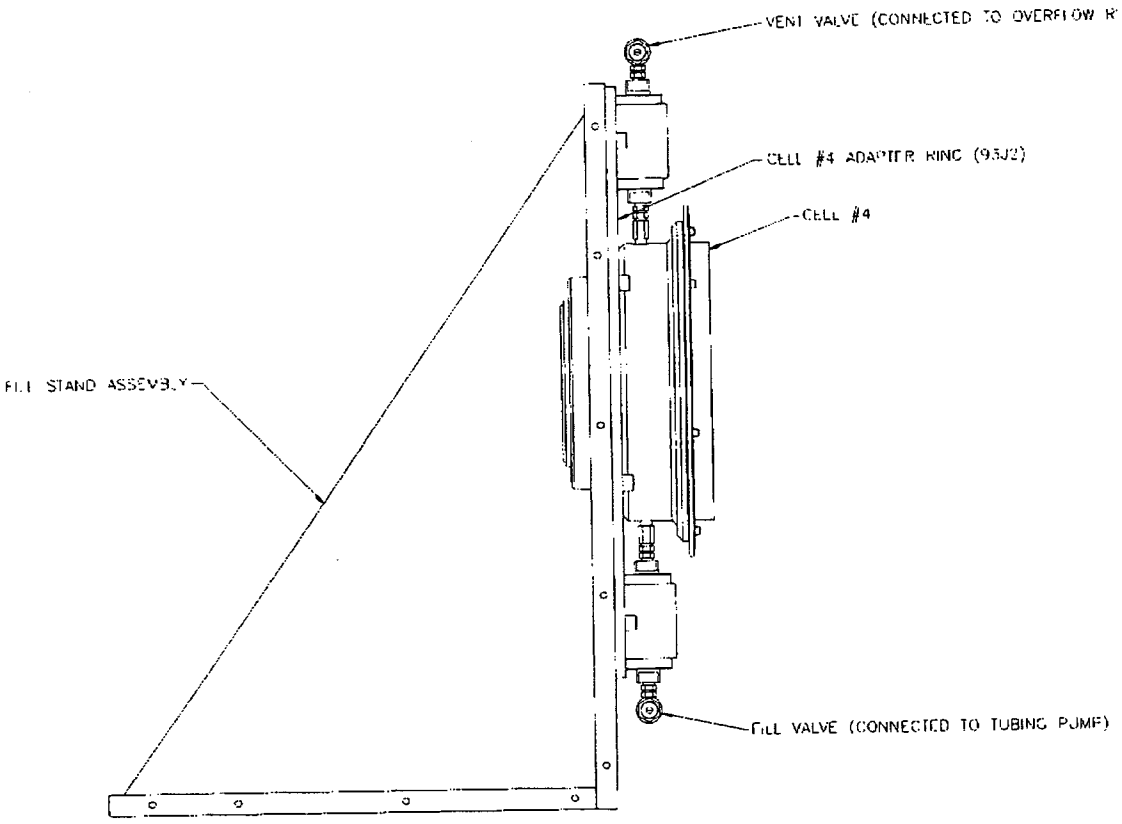


FIGURE 4: CELL #4 FILL STAND ASSEMBLY (WITH A GUSSET REMOVED FOR CLARITY)

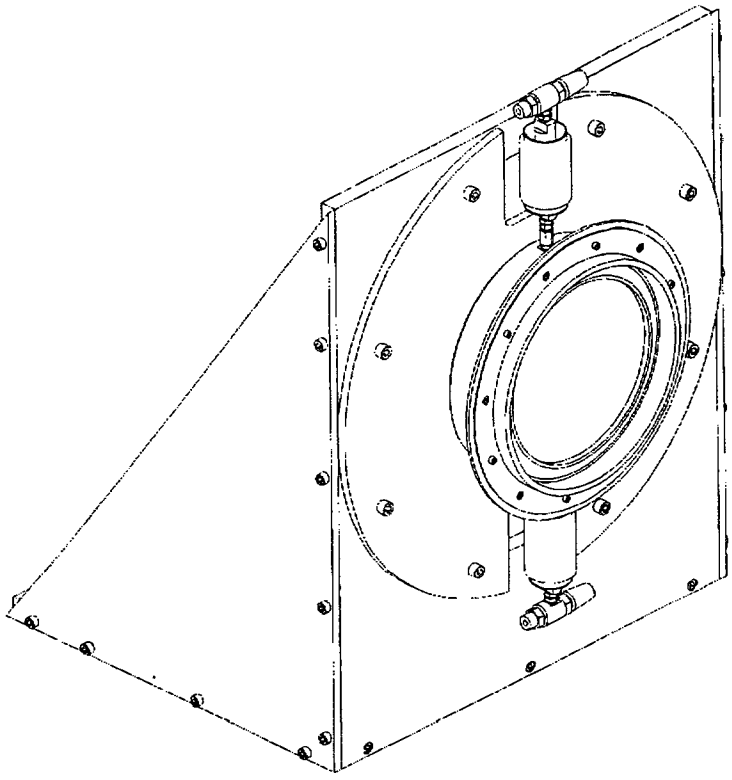
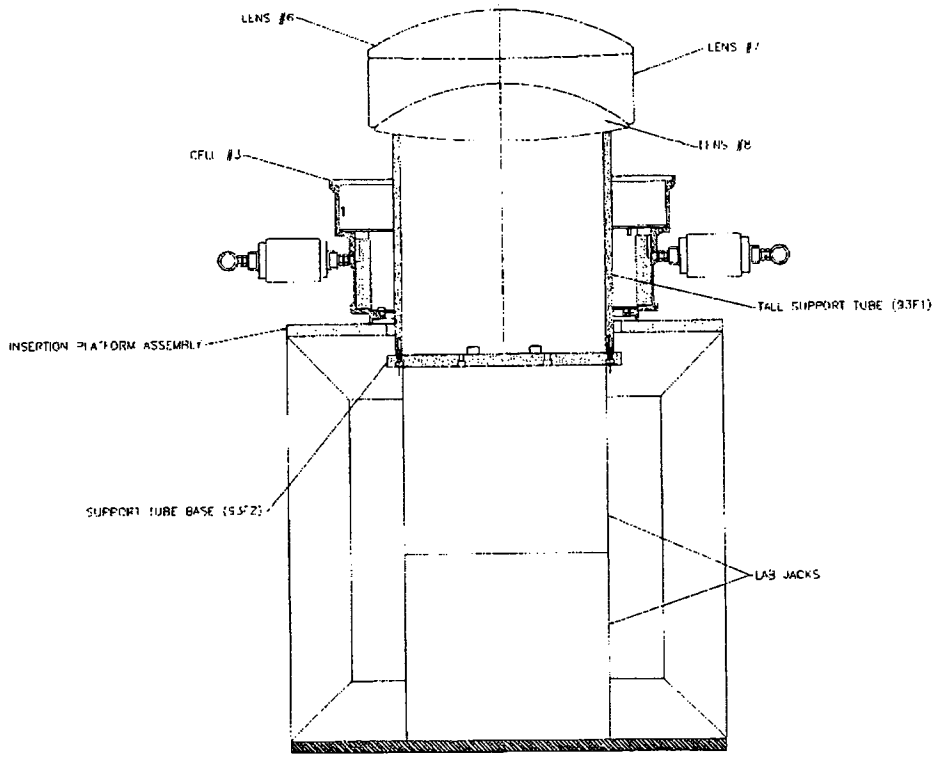


FIGURE 5: CELL #4 FILL STAND ASSEMBLY

B. Assembly Procedures: Cell #3.

1. Attach the tall support tube (93F1) to the support tube base (93F2) with six screws, as shown in figures 6 and 8. Bolt this assembly to the previously assembled lab jacks (from cell #4 assembly). Bolt the cell #2 insertion platform (93F6) to the vertical supports in place of the cell #4 insertion platform.
2. Place the pre-assembled cell #3 down on the insertion platform, with the tall tube protruding through the insertion platform centered in the center of the cell, as shown in Figure 6.
3. Raise the support tube with the jacks so that it extends out the top of the cell, as shown in figure 6.
4. Clean lenses 6, 7, and 8 as necessary with acetone in preparation for optical coupling. Dust the lenses with a filtered nozzle attached to a regulated dry nitrogen tank.
5. Place lens #8 on the tall delrin support tube (#93F1) with R16 down, as shown in Figure 6. Refer to Optical Layout drawing #0A in Appendix B to identify surface R16.
6. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing convex surface (R15) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
7. Slowly place lens #7 down onto lens #8 by gloved hand until lens #8 comes to rest on the three axial spacer pads (see figure 6).



SECTION VIEW

FIGURE 6: CELL #3 LENS INSTALLATION FIXTURE- SECTION VIEW

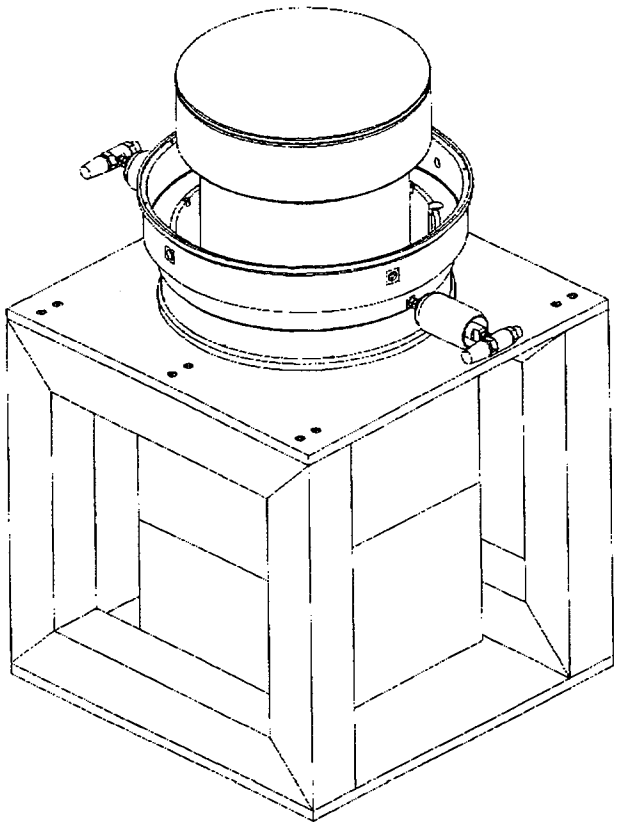


FIGURE 7: CELL #3 LENS INSTALLATION FIXTURE

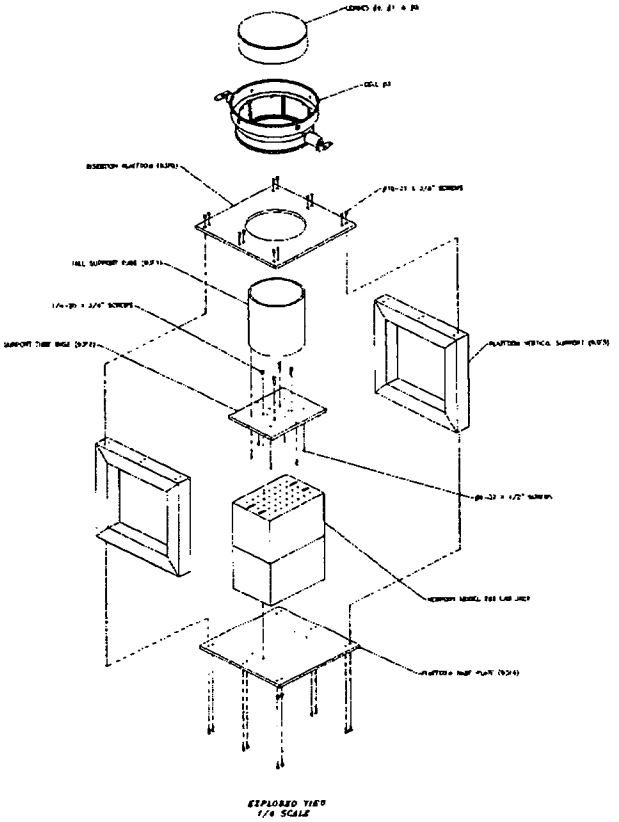


FIGURE 8: CELL #3 LENS INSTALLATION FIXTURE - EXPLODED

8. Clean the upward facing concave surface R13 of lens #7 as necessary with acetone and/or dry nitrogen dusting in preparation for coupling, being careful not to separate the lenses.
9. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing surface (R13) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
10. Slowly place lens #6 down onto lens #7 by gloved hand with R12 down until lens #6 comes to rest on the three axial spacer pads (see Figure 6). Be careful to keep coupled lenses #7 and #8 together- not allowing them or the Kapton shims to shift with respect to each other during this operation. A second person should stabilize lenses #7 & #8 on the tall support tube during this operation.
11. While someone presses down on the coupled lenses to stabilize them, a second person slowly lowers the lenses with the jacks until the radial support dowels in the cell start to contact the first lens. The cell must be adjusted/centered by feel until the lenses start to slip into place into the cell. Continue lowering the lenses until they are all seated within the cell. As the lenses are lowered, the lens stabilizing person needs to maintain downward pressure to keep the lenses coupled and the shims in place, compensating for the friction of the snug radial fit of the dowels.
12. Once the lenses are fully seated in the cell, the support tube should be lowered further until it is clear of the cell. With the O-rings in place, install the cell retainer ring into its bore in the cell- making sure the O-rings stay in place and don't get pinched. Install the six screws and slowly tighten in an alternating "star" pattern until the retainer comes to rest on its seat, compressing the O-rings their proper amount.
13. Install the two valve assemblies into the ports on the cell. Leave the valves open. Refer to the cell assembly drawings for details- Appendix B.
14. Bolt the sealed cell to the filling stand with the valves lined up vertically, as shown in Figures 9 and 10.
15. Attach the fill tubing to the bottom valve and the vent tubing to the upper valve. Begin slowly pumping coupling fluid into the cell using the tubing pump set at low pump rates. Cell #3 requires approximately 125 ml of fluid to fill. The fluid should flow into the .001" gaps between the lenses readily. The progress can be seen through the lenses. Stop pumping as necessary to make sure the lens gaps fill without creating voids. Once bubble-free fluid flows out of the vent tube at the top, the pump is stopped, the fill valve is closed, and then the vent valve is closed.
16. The tubes are disconnected. Excess fluid is cleaned from the cell. The seals are inspected for leaks. The lenses are inspected for any visible voids/bubbles in the coupling layers.
17. The valve knobs are covered with shrink tubing to prevent accidental opening.

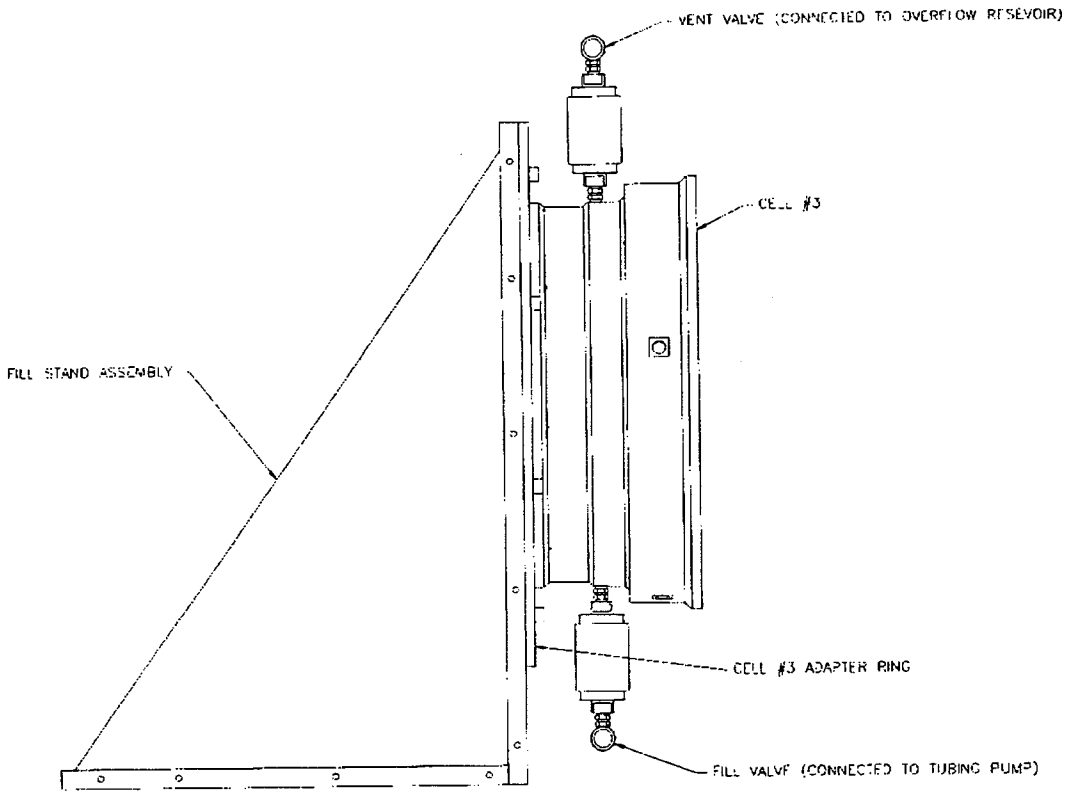


FIGURE 9: CELL #3 FILL STAND ASSEMBLY (WITH A GUSSET REMOVED FOR CLARITY)

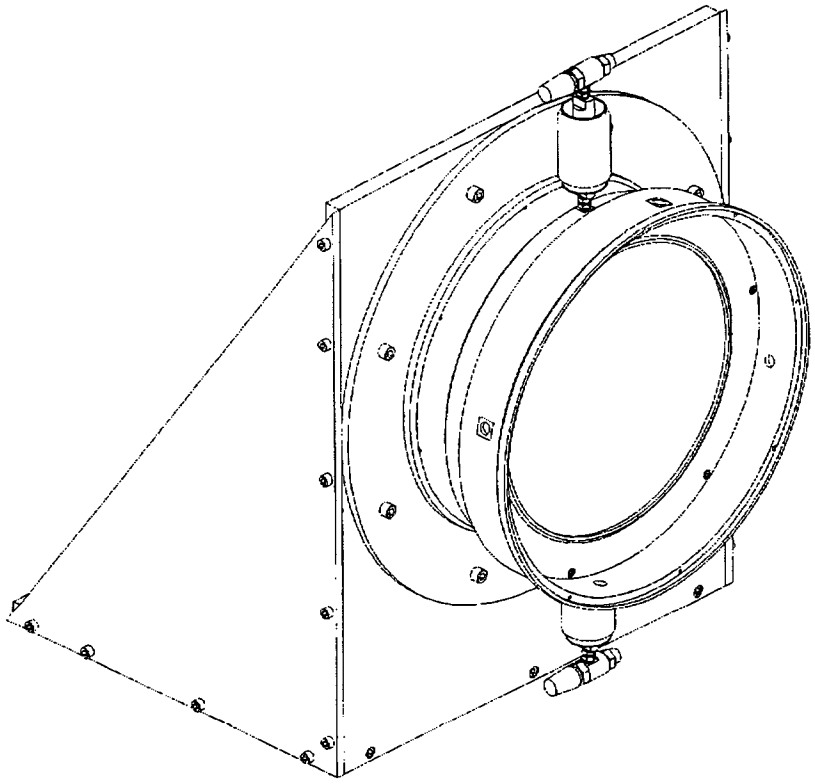
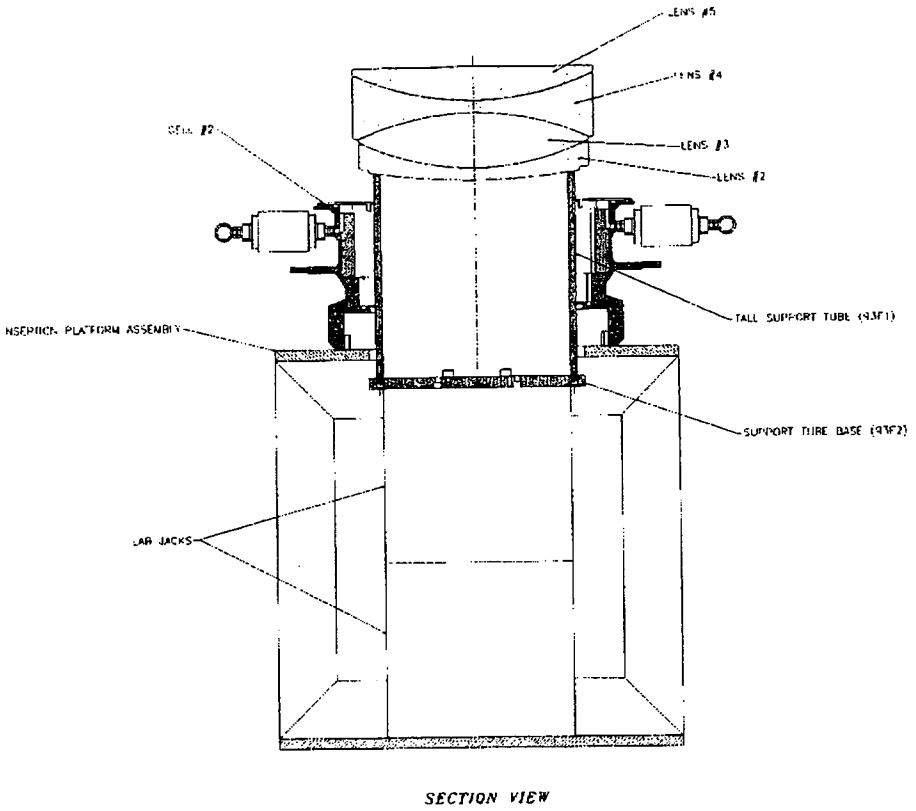


FIGURE 10: CELL #3 FILL STAND ASSEMBLY

C. Assembly Procedures: Cell #2.

1. Continue using the tall support tube (93F1) attached to the support tube base (93F2) with six screws, as shown in figures 11 & 13. This assembly is bolted to the previously assembled lab jacks (from cell #4 assembly). Bolt the cell #2 insertion platform (93F6) to the vertical supports, as was used for the cell #3 assembly.
2. Place the pre-assembled cell #2 down on the insertion platform, with the tall tube protruding through the insertion platform centered in the center of the cell, as shown in Figure 11.
3. Raise the support tube with the jacks so that it extends out the top of the cell, as shown in figure 11.
4. Clean lenses 2, 3, 4, and 5 as necessary with acetone in preparation for optical coupling. Dust the lenses with a filtered nozzle attached to a regulated dry nitrogen tank.
5. Place lens #2 on the tall delrin support tube (#93F1) with R4 up, as shown in Figure 11. Refer to Optical Layout drawing #0A in Appendix B to identify surface R4.
6. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing surface (R4) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
7. Slowly place lens #3 down onto lens #2 by gloved hand until lens #3 comes to rest on the three axial spacer pads (see figure 11). Make certain that R5 is down towards R4.
8. Clean the upward facing convex surface R6 of lens #3 as necessary with acetone and/or dry nitrogen dusting in preparation for coupling, being careful not to separate the lenses.
9. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing convex surface (R6) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
10. Slowly lower lens #4, with surface R7 facing down, onto lens #3 until lens #4 comes to rest on the three axial spacer pads (see figure 11). A second person should stabilize lenses #2 & #3 on the tube as lens #4 is lowered into place. Refer to Optical Layout drawing #0A in Appendix B to identify surface R7.
11. Clean the upward facing concave surface R8 of lens #4 as necessary with acetone and/or dry nitrogen dusting in preparation for coupling, being careful not to separate the lenses.
12. Place three Kapton spacer shims (3/16" x 3/16" x .001" thick) at the edges of the upward facing surface (R8) equally spaced about the perimeter (120 degrees apart). The thin Kapton film clings to the glass surface.
13. Slowly place lens #5 down onto lens #4 by gloved hand until lens #5 comes to rest on the three axial spacer pads (see figure 11). The previously coupled lenses should be stabilized on the tube while lens #5 is lowered.
14. While someone presses down on the coupled lenses to stabilize them, a second person slowly lowers the lenses by hand until the radial support dowels in the cell start to contact the first lens. The cell must be adjusted/centered by feel until the lenses start to slip into place into the cell. Continue lowering the lenses until all of the lenses are seated within the cell. As the lenses are lowered, the lens stabilizing person needs to maintain downward pressure to keep the lenses coupled and the shims in place, compensating for the friction of the snug radial fit of the dowels.
15. Once the lenses are fully seated in the cell, the support tube should be lowered further until it is clear of the cell. With the O-rings in place, install the cell retainer ring into its bore in the cell- making sure the O-rings stay in place and don't get pinched. Install the six screws and slowly tighten in an alternating "star" pattern until the retainer comes to rest on its seat, compressing the O-rings their proper amount.
16. Install the two valve assemblies into the ports on the cell. Leave the valves open. Refer to the cell assembly drawings for details- Appendix B.



SECTION VIEW

FIGURE 11: CELL #2 LENS INSTALLATION FIXTURE- SECTION

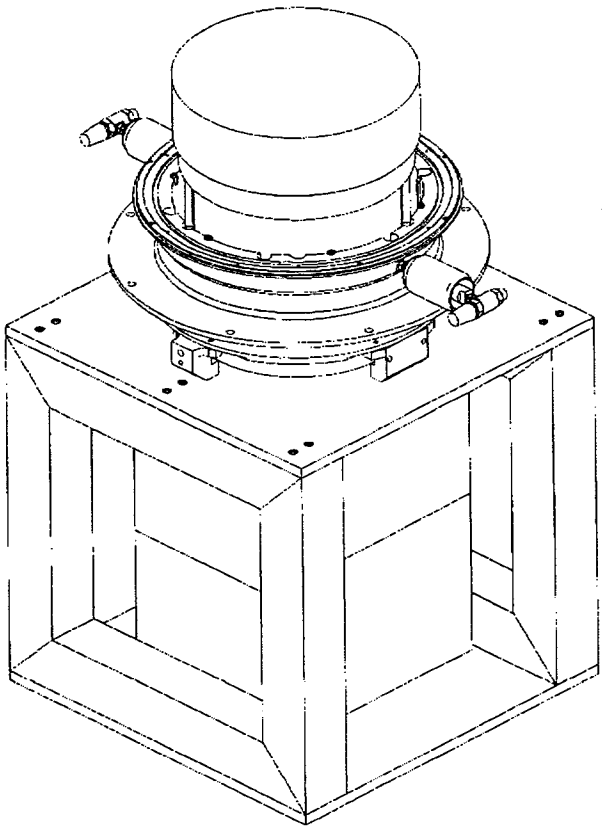


FIGURE 12: CELL #2 LENS INSTALLATION FIXTURE

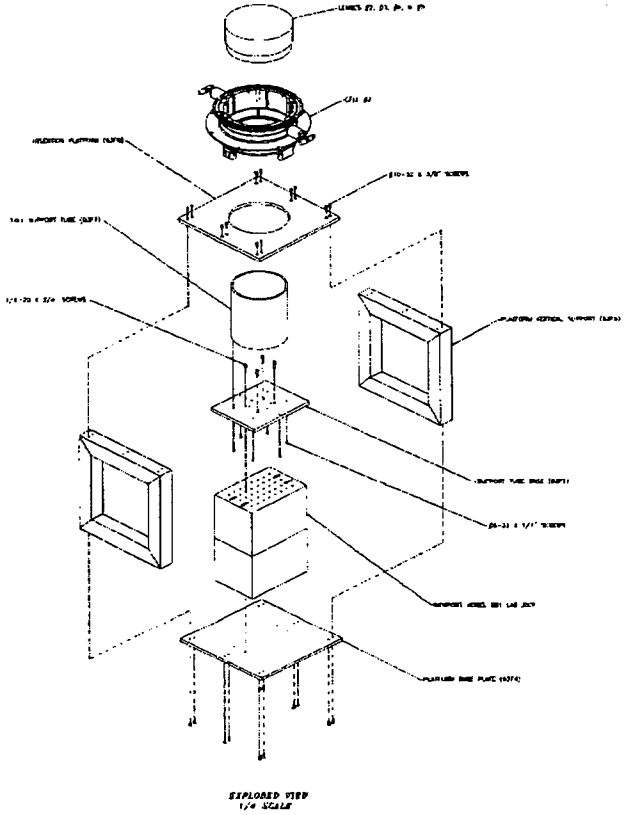


FIGURE 13: CELL #2 LENS INSTALLATION FIXTURE- EXPLODED

17. Bolt the sealed cell to the filling stand with the valves lined up vertically, as shown in Figures 14 and 15.
18. Attach the fill tubing to the bottom valve and the vent tubing to the upper valve. Begin slowly pumping coupling fluid into the cell using the tubing pump set at low pump rates. Cell #2 requires approximately 125 ml of fluid to fill. The fluid should flow into the .001" gaps between the lenses readily. The progress can be seen through the lenses. Stop pumping as necessary to make sure the lens gaps fill without creating voids. Once bubble-free fluid flows out of the vent tube at the top, the pump is stopped, the fill valve is closed, and then the vent valve is closed.
19. The tubes are disconnected. Excess fluid is cleaned from the cell and the exposed lens surfaces. The seals are inspected for leaks. The lenses are inspected for any visible voids/bubbles in the coupling layers.
20. The valve knobs are covered with shrink tubing to prevent accidental opening.

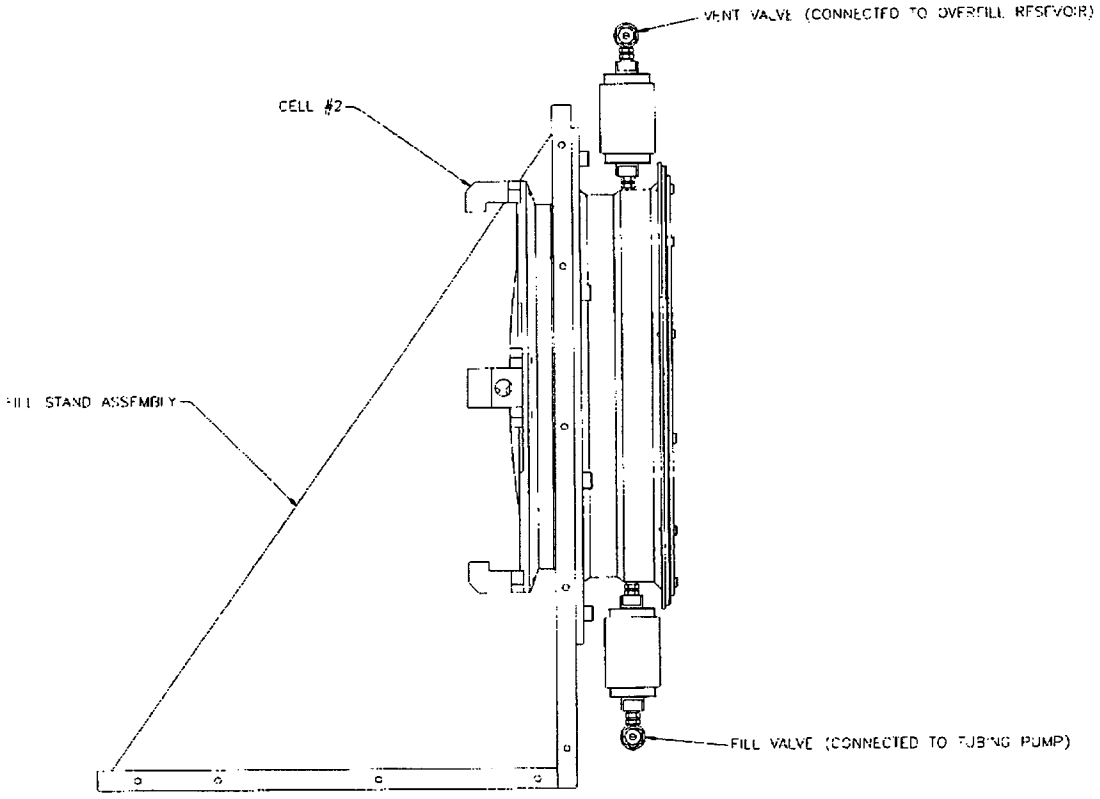


FIGURE 14: CELL #2 FILL STAND ASSEMBLY (WITH A GUSSET REMOVED FOR CLARITY)

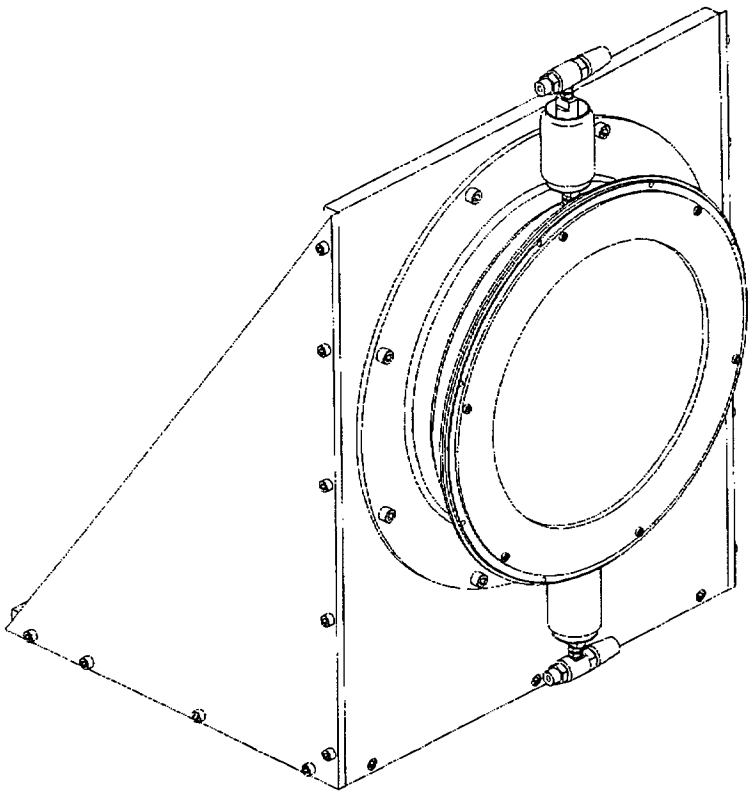


FIGURE 15: CELL #2 FILL STAND ASSEMBLY

APPENDIX A: PARTS LIST

FABRICATED PARTS

PART # OR SPECIFICATION	PART DESCRIPTION	QUANTITY
93F1	Tall Support Tube	1
93F2	Support Tube Base	1
93F4	Cell Platform Base Plate	1
93F5	Cell Platform Vertical Support	2
93F6	Cell #2 Insertion Platform	1
93H1	Tall Support Tube	1
93H3	Cell #4 Support Leg	3
93H4	Cell #4 Insertion Platform	1
93J1	Cell #3 Adapter Ring	1
93J2	Cell #4 Adapter Ring	1
93JA	Fill Stand Assembly	1

PURCHASED PARTS

PART # OR SPECIFICATION	PART DESCRIPTION	QUANTITY
Cole-Parmer E-77913-00	Masterflex L/S Modular Pump W/ head, tubing, and drive	1
Pneumadyne SBF-170V	1/4" Connector Barb X #10-32 O-ring	6
Newport Model 281	Lab Jack, 3" Range, 300 lb. Capacity	2

APPENDIX B: REFERENCE ASSEMBLY DRAWINGS

- 0A Optical Layout and Lens Specifications, 12" EFL Blue Camera
- 3B Cell Two Assembly, Blue Camera
- 3C Cell Three Assembly, Blue Camera
- 3DA Cell Four Assembly, Blue Camera