

# **Instructions for assembling UV-C lighting and electrical enclosure for UV crop disease treatment attachment**

Lighting Research Center  
Rensselaer Polytechnic Institute  
&  
Ward's Berry Farm

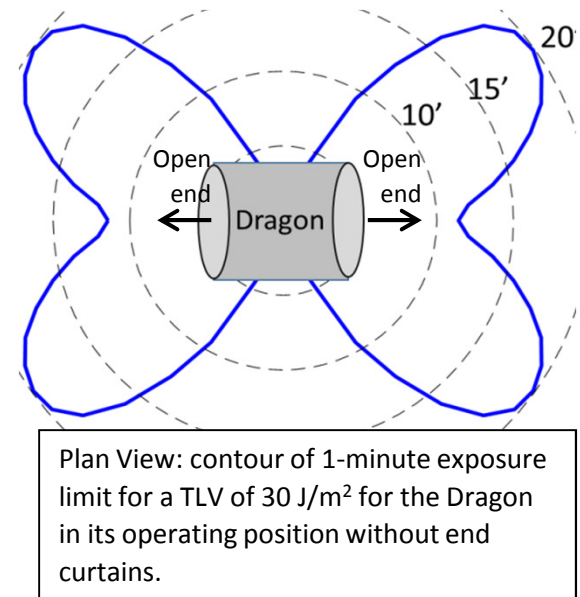
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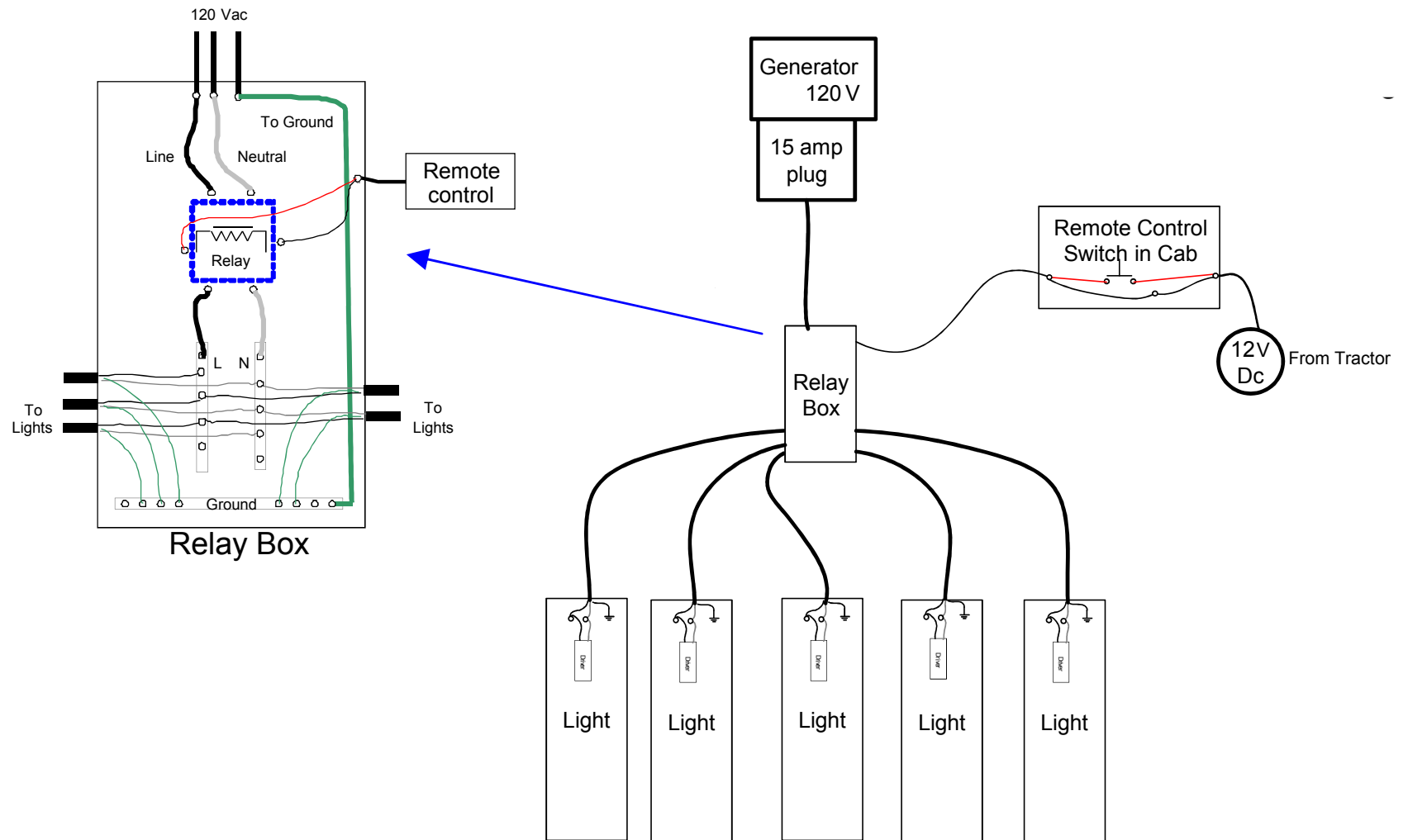
**Award Number: LNE19-388R-33243**

# Safety considerations

- Treat UV treatments as you would pesticide applications – proceed with caution.
- Direct exposure to UV radiation is extremely harmful to skin and eyes. **1/3 of one second of exposure inside the Dragon exceeds the threshold limit value (TLV) of 30 J/m<sup>2</sup> for skin and eye exposure.**
  - You must wear full personal protective equipment (PPE) (UV-rated face shield, full Tyvek® suit with adjustable hood, gloves) if you are less than 20 feet away from the dragon (without curtains) for more than one minute (see graphic to the right).
  - The safe distance from the Dragon in its operating position without curtains, without PPE, and no time limit is 425 feet.
  - **Only operate the light fixtures with the layer of reflective curtains and the sheet metal covering in place AND wear full PPE at all times.**
- All personnel should:
  - make sure the 120 V cord and the cigarette lighter (or quick-disconnect fuse holder) powering the remote switch is disconnected before starting the generator, and
  - **wear full PPE during operation.**
- If you have to inspect the unit while it is on, **wear full PPE.**



# Representative electrical schematic



# Prepare UV fixtures

- LaMar Lighting has created a custom 4-lamp fixture that includes ballasts to operate 4, 75-W UV-C lamps at the correct power level. The custom part number is: MO4LT8AUUV-R87-AL.
- Lift out the reflector from the fixture by twisting the connecting bars (Fig. 1a).
- Remove a knockout from the back knockout panel from each fixture (Fig. 1b).
- Attach a clamp-type cable connector for strain relief to the knockout panel in each fixture (Fig. 1c).

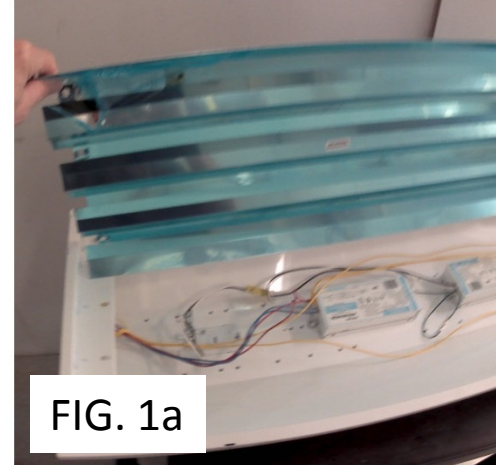


FIG. 1a

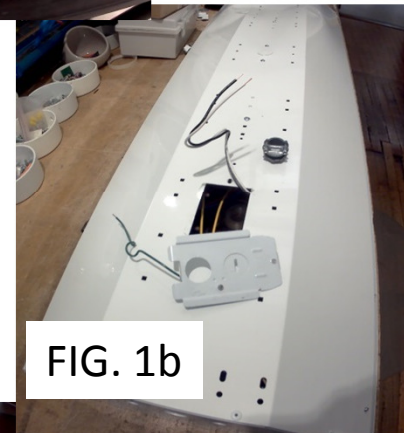


FIG. 1b

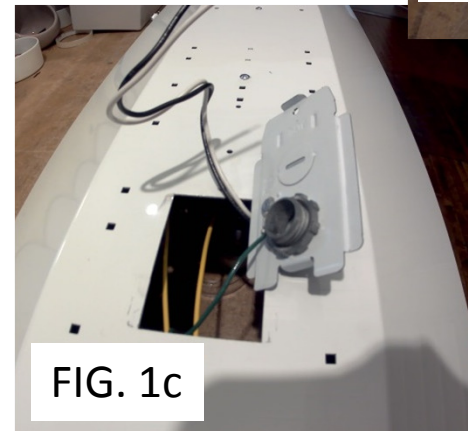
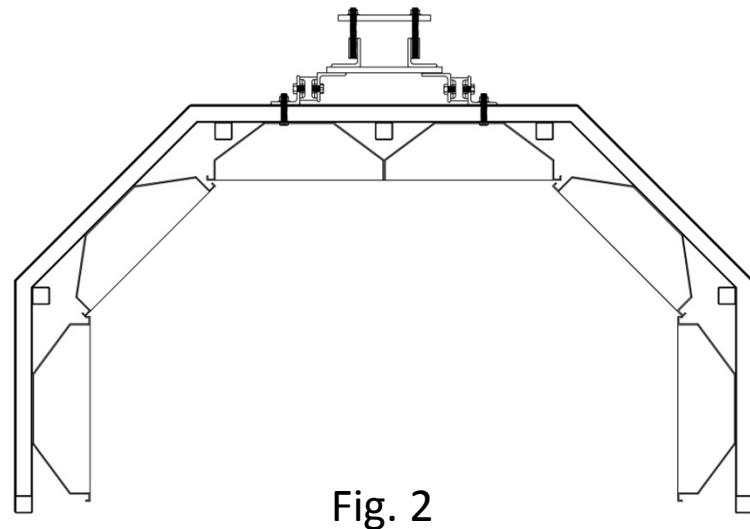
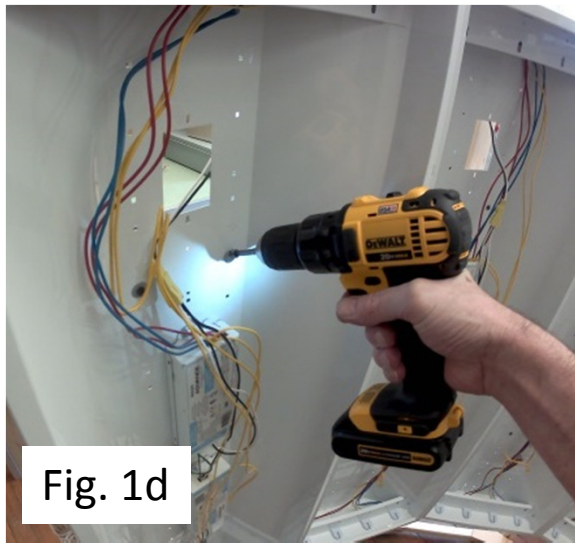


FIG. 1c

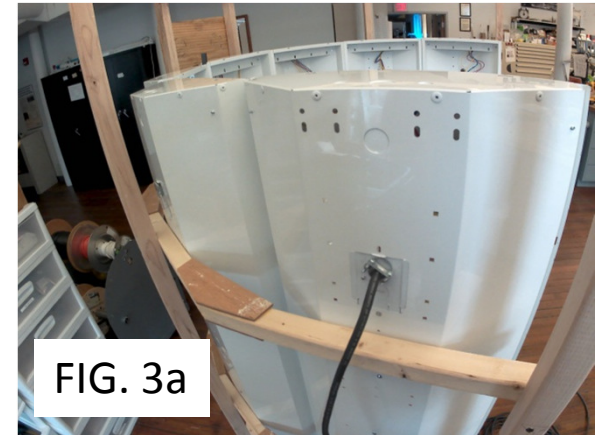
# Attach light fixtures to steel enclosure

- Attach each fixture to the steel frame in at least 4 pre-drilled locations (2 in each steel hoop) using self-drilling metal screws (Fig. 1d). It is advisable to attach the fixtures while the frame is standing up on its end.
- The top fixture should be attached to the steel frame in the center of the top of the steel hoop (Fig. 2). The sheet metal “lip” will have to be trimmed off one side of the top to fixtures. The mounting bolts for the anti-vibration mount will pass through the upper fixture housings once they have been installed, holes will need to be drilled to accomplish this.
- The remaining four light fixtures are attached to their respective sides as shown (Fig. 2).



# Electrical wiring process for light fixtures (Part 1)

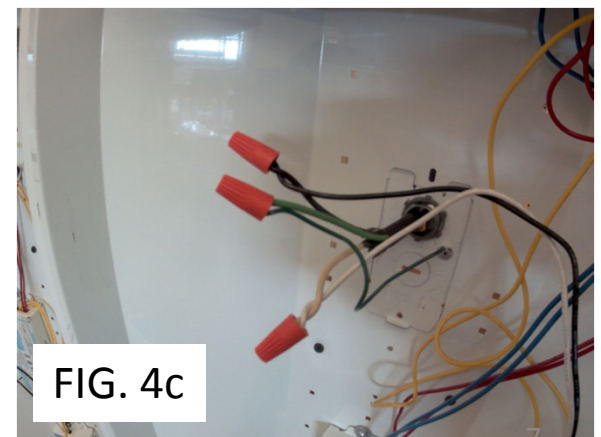
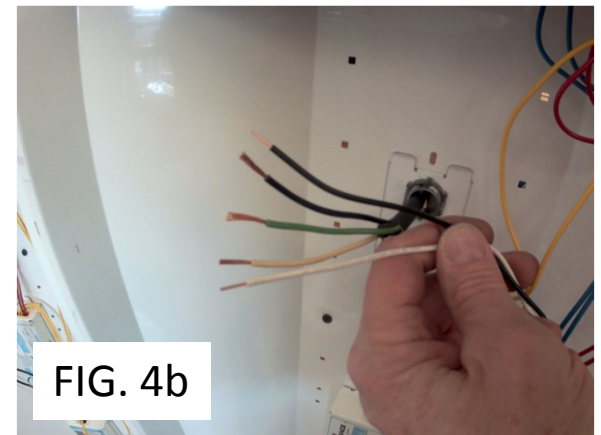
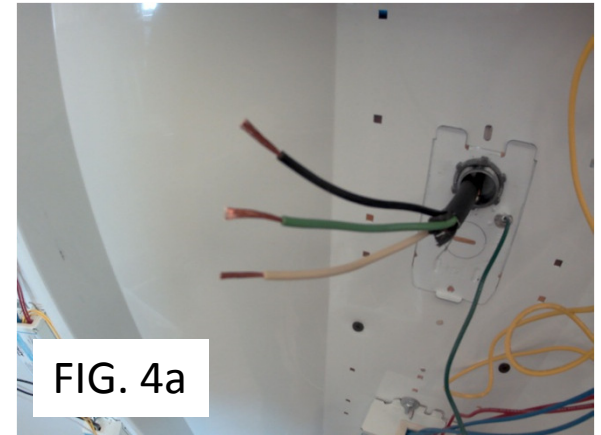
- After all 6 fixtures are attached to the frame, loosen the cable connector clamp screws and insert the SJ00 power cord wiring through the opening (Fig. 3a).
- For each fixture, leave 6 – 8" of power cord on the inside (Fig. 3b) and as much as needed on the outside to reach the control box at the top of the enclosure (3 – 7' each depending on fixture position).
- Tighten cable clamp screws (Fig. 3c).
- Repeat steps 3a – 3c for all fixtures.





# Electrical wiring process for light fixtures (Part 2)

- Strip 5" of black sheathing from power cable to reveal the wires. Strip ½" of insulation from the wires (black, white, and green/ground) (Fig. 4a).
- Locate stripped white and black ballast wires in fixture (Fig. 4b). Connect white and black power cable wires to ballast wires with wire nuts (white to white, black to black).
- Locate green fixture grounding wire attached to knockout panel. Strip end ½" and attach to green grounding wire of power cable (Fig. 4c).



## Prepare the generator cord for panel attachment

- The generator cord comes with a NEMA 5-15P plug (125 V, 15A grounded plug) on one end (Fig. 5) and is stripped on the other side.
- Strip an additional 9" of the cable sheathing to reveal the white, black and green wires inside.



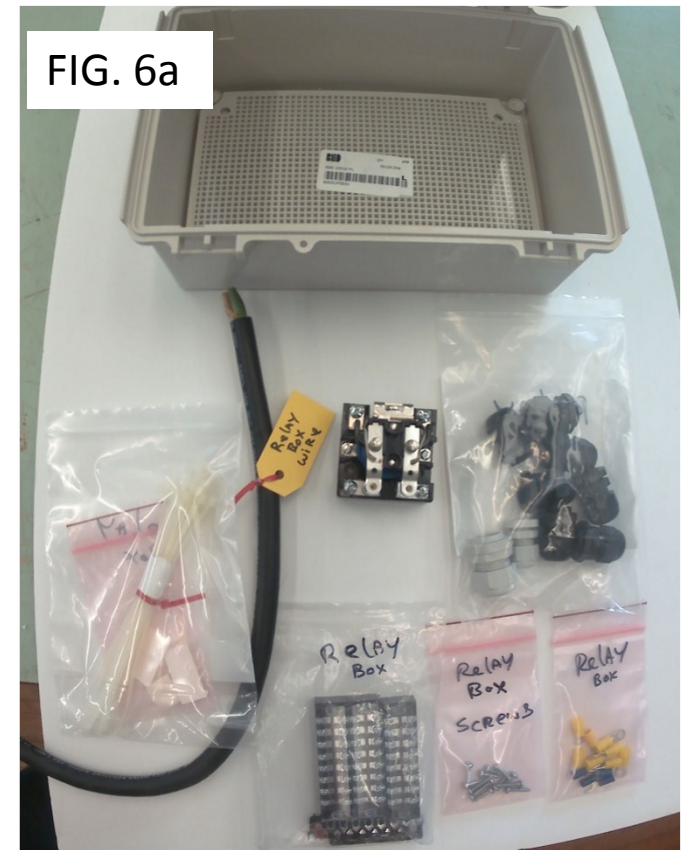
FIG. 5



# Prepare relay box

Relay box components (Fig. 6a):

- One BUD industries waterproof box with inner panel
- 12 PG13.5 (0.24 – 0.43") black waterproof cord grips for fixture wires. 6 for the box, 6 to pass through the metal cover of the light enclosure
- One PG13.5 (0.24 – 0.43") black cord grip for generator cable
- One PG9 (2.5 – 8 mm) gray waterproof cord grip for remote switch
- One 30A, 12 V double-pole, single-throw relay (DPST)
- Three 8-pole Power Bus Bars with insulated terminal barrier strips
- Two 6" 14 AWG wires
- Four blue M5 ring terminals
- Sheet metal screws



# Prepare relay box

- Determine 7 cord grip locations on waterproof box (e.g., 3 PG13.5 grips on one long side, 3 PG13.5 grips on the other long side, 2 on short side (one PG13.5 and one PG9) (Fig 6b).
- Use a bit to drill  $13/16''$  holes for the PG13.5 cord grips (6 total) (e.g., Fig. 6c). Note: a step-type drill bit works well for this.
- Use a bit to drill a  $9/16''$  hole for the PG9 cord grip.
- Attach mounting hardware to the bottom of the waterproof box (Fig. 6d).

Note: Figs. 6b and 6d show 4 cord grips on one side of the waterproof box. This version should be built with 3 cord grips on one side and 3 on the other side.

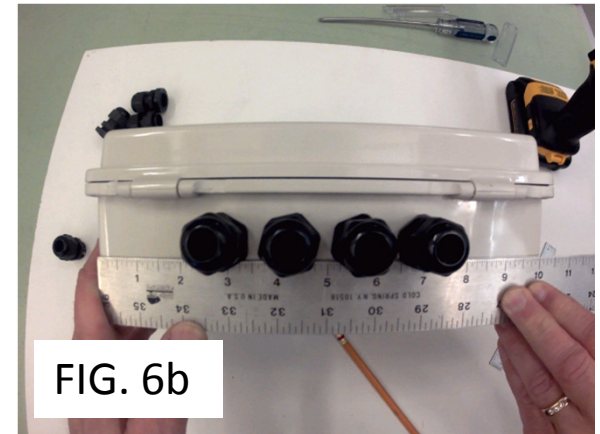


FIG. 6b

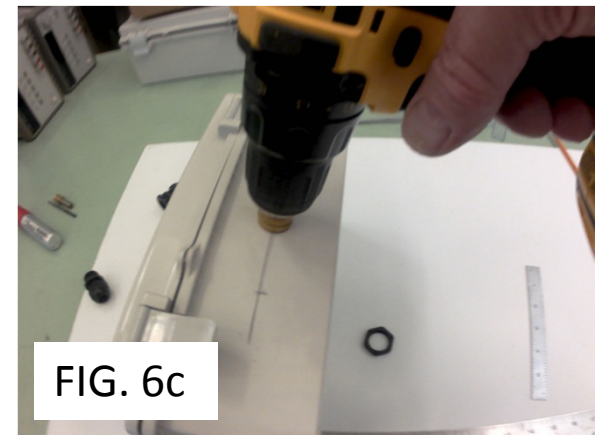


FIG. 6c

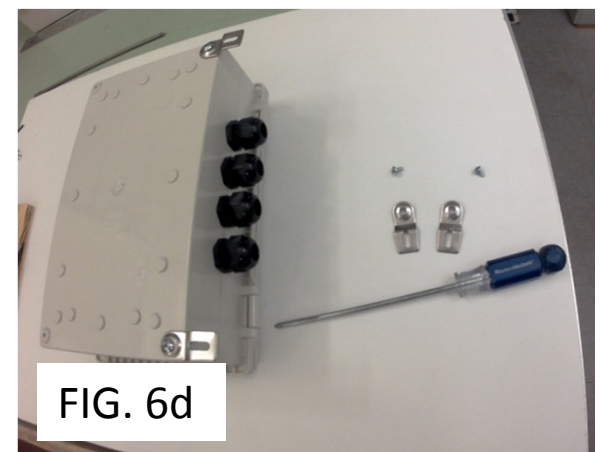


FIG. 6d

## Prepare power connection components

- Remove protective covers from power bus bars (Fig. 7a).
- Loosen screws, attach the insulated terminal jumpers under screws, then tighten, which connects them electrically (Fig. 7b). Repeat for all three terminal strips.
- Create 2 jumper cables by crimping a blue (14-16 AWG) M5 ring terminal to each end of a 6" long 14 AWG wire (Fig. 7c).

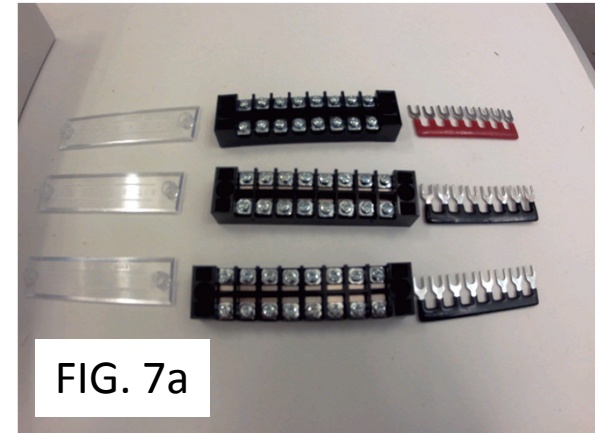


FIG. 7a

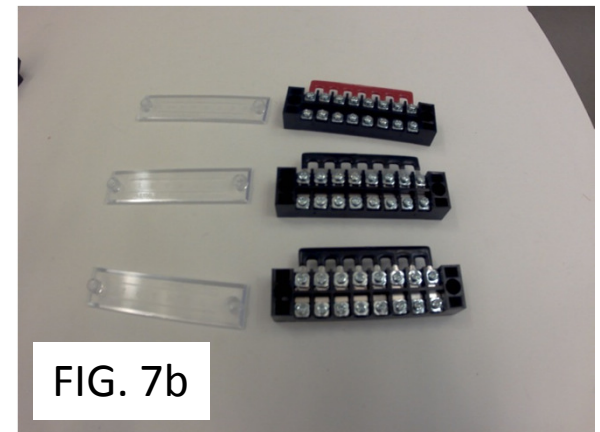


FIG. 7b

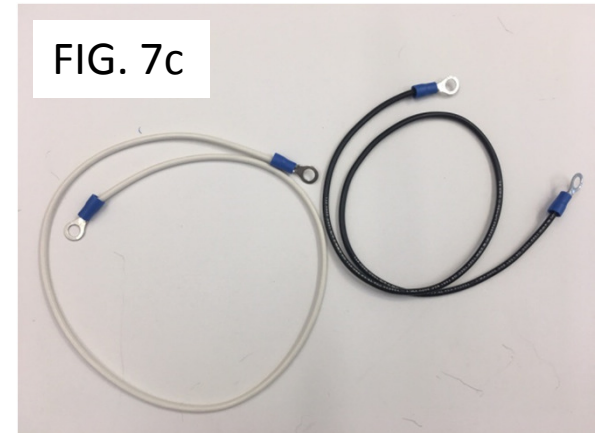
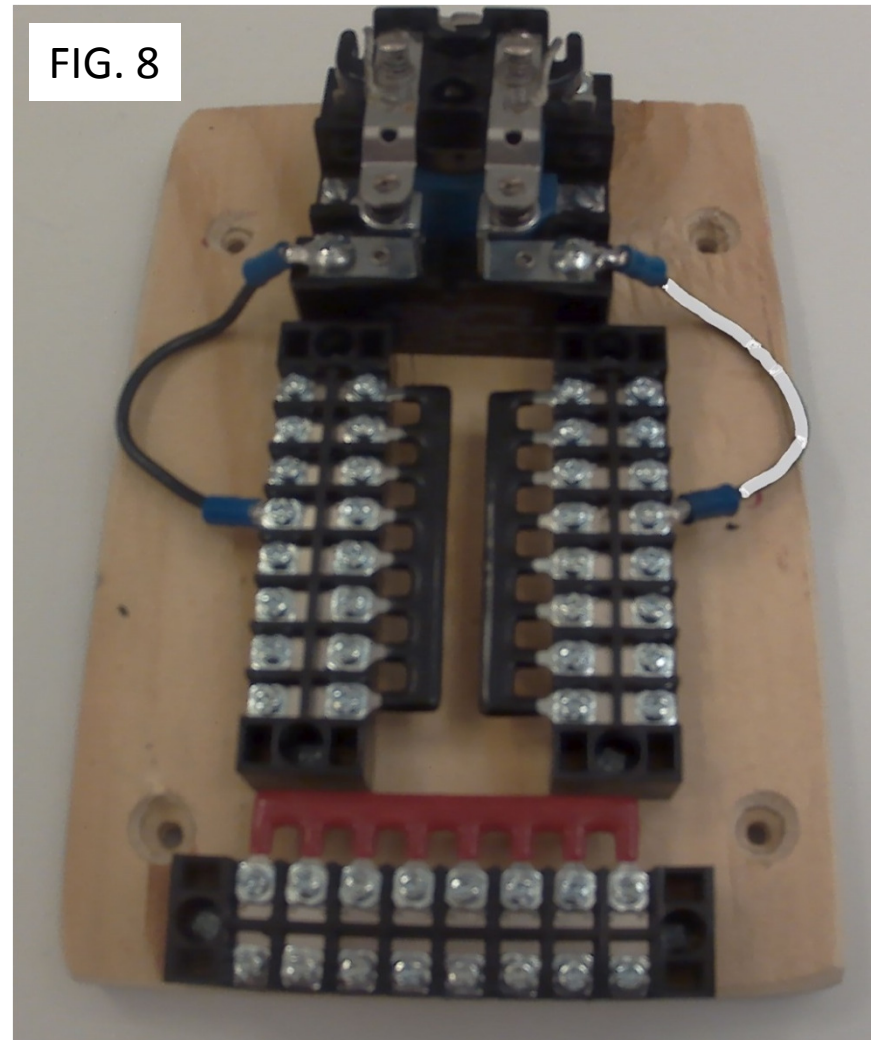


FIG. 7c

# Mount components to inner panel

- Attach 30A relay to the short edge of inner panel (Note: use the plastic inner panel included with box, not plywood panel as shown here) (Fig. 8).
- Mount bus bars to inner panels (see suggested layout).
- Attach jumper cables from output side on relay (bottom connections) to bus bars in the middle of the panel (see suggested layout).
- Bottom bus bar (shown with red jumper) is used for grounding.





# Mount relay panel in waterproof box

- Mount inner plastic panel inside waterproof box with included screws.
- Attach 6 cord grips to waterproof box (See Fig. 13 for suggested cord grip locations).
- Route cables through sheet metal covering and up to relay box (Fig. 9a).
- Insert power cord cables from light fixtures through cord grips, then strip 14" of black sheathing from each power cord (Fig. 9b).

Note: Figs. 9, 10 and 13 show cables from 7 connected UV fixtures. This dragon only has 6 connected UV fixtures.



FIG. 9a

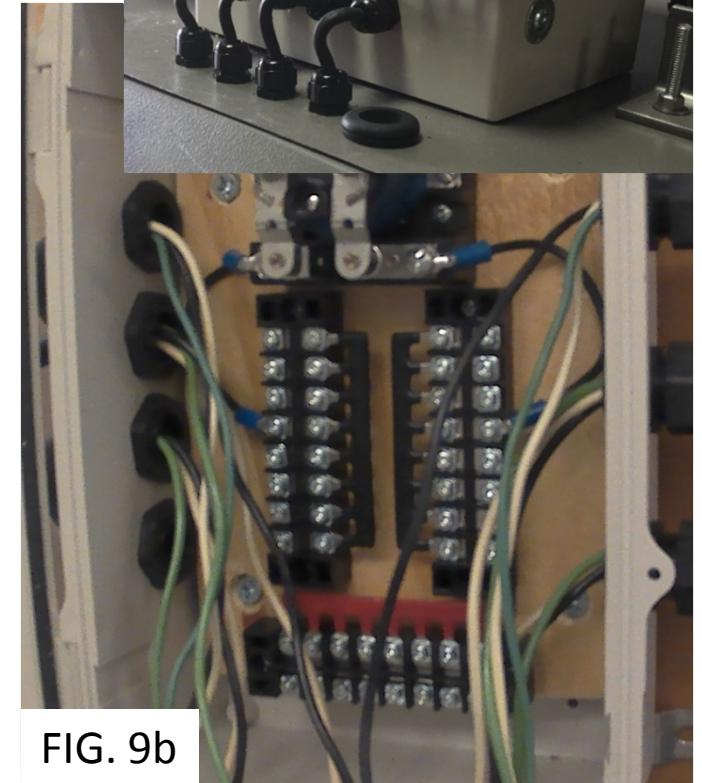
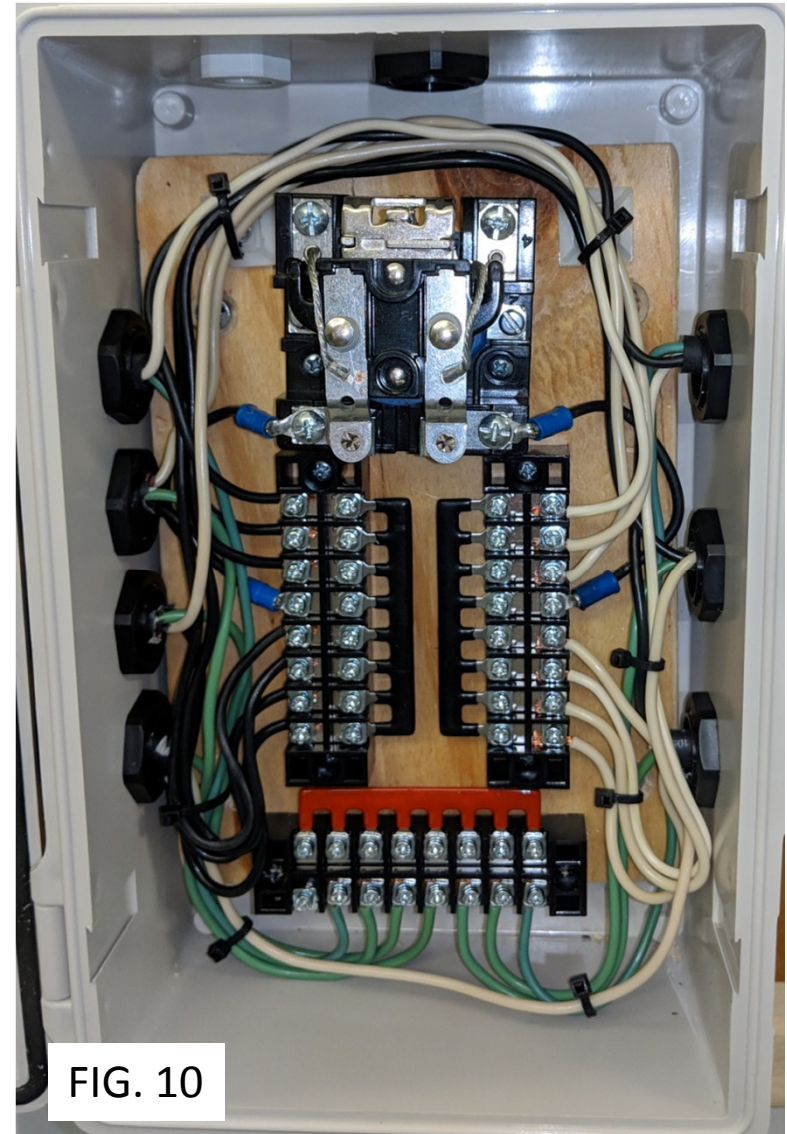


FIG. 9b

# Connect light fixture wiring to panel

- Attach all white wires from fixture power cords to one connected bus bar (on right in Fig. 10), all black wires to the second connected bus bar (on left in Fig. 10), all green wires to the unconnected bus bar (at bottom in Fig. 10).
- The picture on the right (Fig. 10) shows the connected wires; these wires were cut to length to minimize excess wiring in the panel box.
- Tie wraps should be used to neaten and secure the wiring.





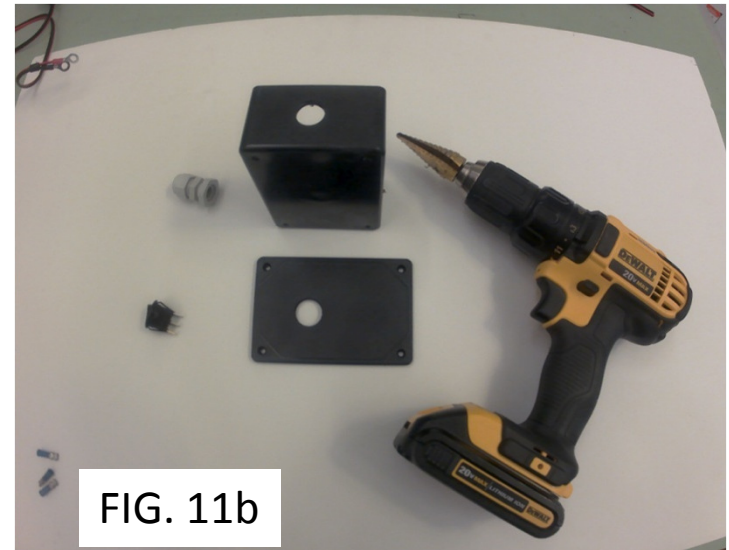
# Fabricate remote switch (Part 1)

- Remote switch components (Fig. 11a):
  - 12VDC power supply (not shown) & fuse holder
  - 4.5" x 3" x 2" plastic box
  - PG9 2.5 – 8.0 mm cord grip
  - Illuminated switch
  - 25 – 40' of 16 AWG black/red wire
  - 3 blue flag terminals (14-16 AWG)
  - 2 blue M4 ring terminals for relay panel
  - 6" 14 AWG black pigtail
  - Note: Lighter power adaptor is shown, but not used with this design.



## Fabricate remote switch (Part 2)

- Unscrew box to separate top panel from box body.
- Drill 9/16" hole in short side of plastic box for waterproof connector (Fig. 11b).
- Drill 1/2" hole in the removable panel for remote switch (Fig. 11b).
- Sticker on switch indicates pinout, make note of this information before installing switch (it may be helpful to note it on the cover, as shown Fig. 11c).
- Insert switch inside top panel, secure with provided nut.



## Fabricate remote switch (Part 3)

- Utilize the power adapter and cord provided. Cut the cord in half lengthwise. Insert both red/black cables through waterproof cord grip. Be sure the two cables are labeled, one is a power source and the other powers the relay in the control box. Note: Fig. 12a shows a cigarette lighter plug: this is not used in this design.
- Strip all wires (leave 3/8" exposed).
- Twist both black wires with a black pigtail and connect with an orange wire nut (Fig. 12b).
- Crimp each red wire and black pigtail to a blue flag terminal (see Fig. 12c).
- Attach blue flag terminal from black pigtail to ground(earth) spade on the switch (Fig.).
- Attach the blue flag terminal from the power plug to outer spade opposite the ground and the remaining terminal to the center load spade – this wire will go to the control box (Fig. 12c). Note: Your switch may look different.
- Close box with screws and tighten cord grip.

FIG. 12a

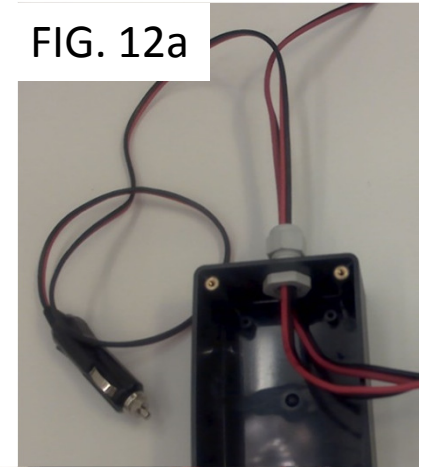


FIG. 12b

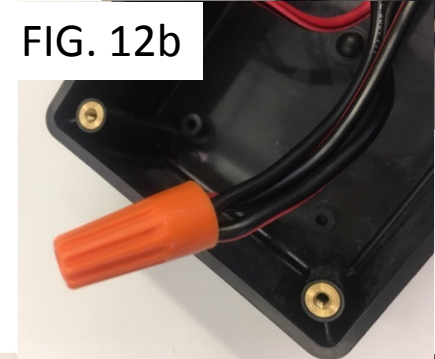


FIG. 12c





## Connect remote switch cable and generator cord to panel box

- Insert the remote switch cable through the P9 cord grip (one red/black wire).
  - Split wire and crimp an M4 blue ring terminal (14-16 AWG) onto each end.
  - Connect each blue terminal from the remote box to the middle connection on the 30A relay (red arrows in Fig. 13).
- Insert the black generator cord into the PG13.5 cord grip.
  - Crimp blue ring terminals (14-16 AWG) onto white, black and green wires.
  - Connect white and black terminal ends onto input side of 30A relay (yellow arrows in picture).
  - Connect green terminal end to the ground bus bar (bottom yellow arrow in Fig. 13).
- Replace plastic bus covers.
- Tighten all cord grips.
- Close relay panel box.

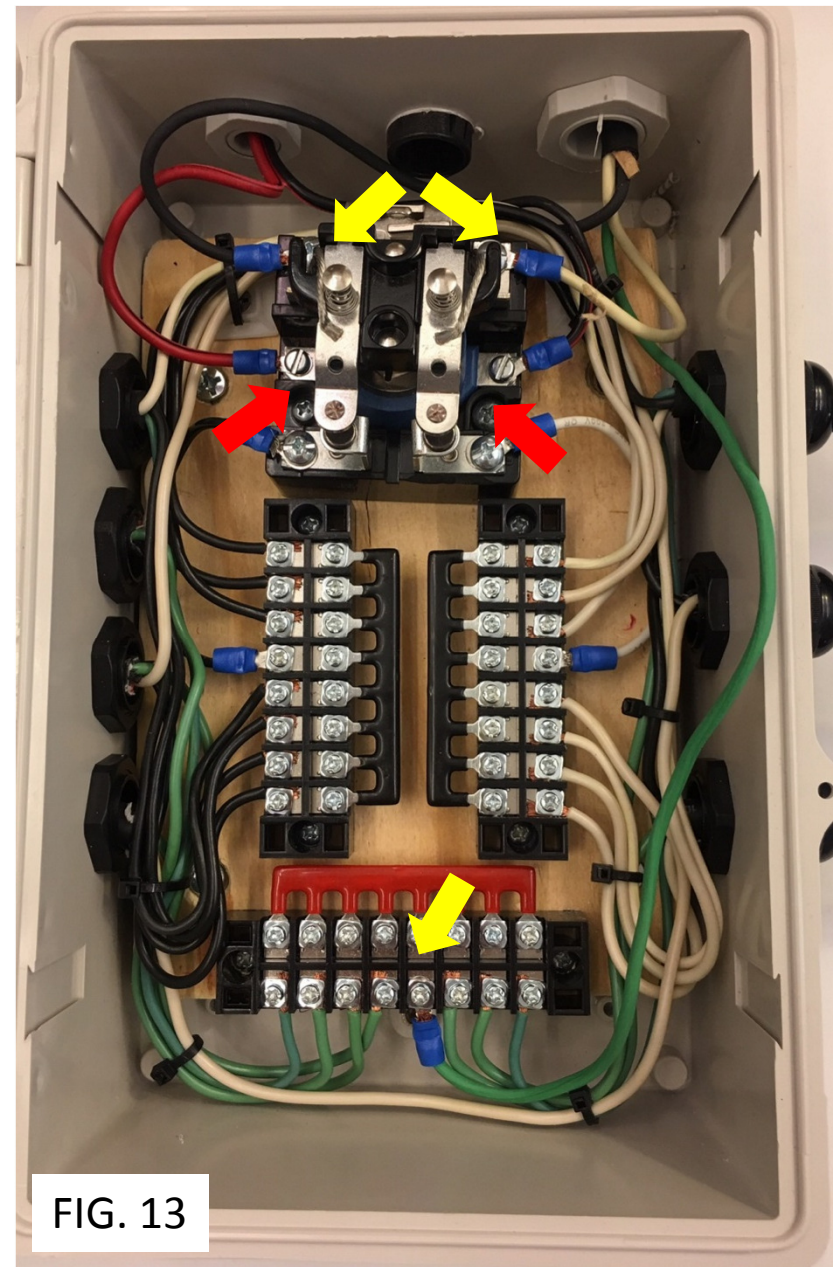


FIG. 13

# Reflective curtains

- Pages 15 - 16 of the “Light Enclosure” construction drawings show how to cut, locate and attach the curtains.
- Once the curtains are cut in the shapes shown in the construction drawings, aluminum foil HVAC tape is applied to create a surface that reflects UV-C.
- Lay the first row of reflective tape so it aligns with the left side of the plastic (Fig. 14a). Make reference marks  $\frac{1}{2}$ ” from the edge of the tape to align the next row of reflective tape.
- TIP: Peel only an inch or so of the backing paper to begin. Peel the rest as you work your way down the strip. The foil need not be perfectly smooth to be effective.
- Align the next row of tape with the marks made in the previous step (Fig. 14b).
- Align the final row with the right side of the plastic, and this should provide  $\frac{1}{2}$ ” overlap with the center row of foil tape for an 8” wide strip.
- **The curtains should be attached with the shiny aluminized side facing in, toward the UV light fixtures.**



Fig. 14a

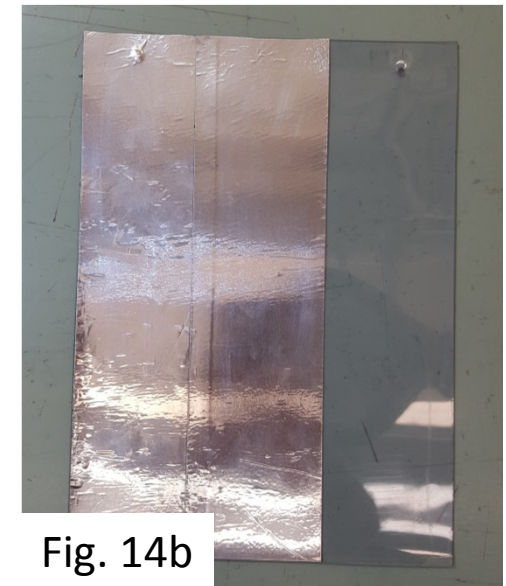


Fig. 14b

# Applying FEP coating to the UV-C lamps

## to prevent breakage

- Fluorinated ethylene propylene (FEP) sleeves must be applied to the UV-C lamps to contain glass fragments if lamps break.
- The FEP sleeves transmit UV-C; other protectant “food-safe” lamp sleeves will not transmit UV-C.
- Cut the FEP sleeve so it extends past the metal endcaps (4' – 1.25"; the entire glass tube and endcaps must be covered).
- The FEP must be heat-shrunk to the lamp to function properly.
- A forced-air heater works well for this task. It is important to keep the lamps and shrink tubing free from oils from your hands, so use **clean, new** cotton gloves when handling them. This will also protect your hands from the heat (Fig. 15).
  - Example: Master Propane Forced Air Torpedo Heater, 60,000 BTU, MH-60V-GFA
- After heat-shrinking, trim excess FEP material from ends of lamp that may interfere with sockets using a **sharp** utility knife (X-ACTO®-type).

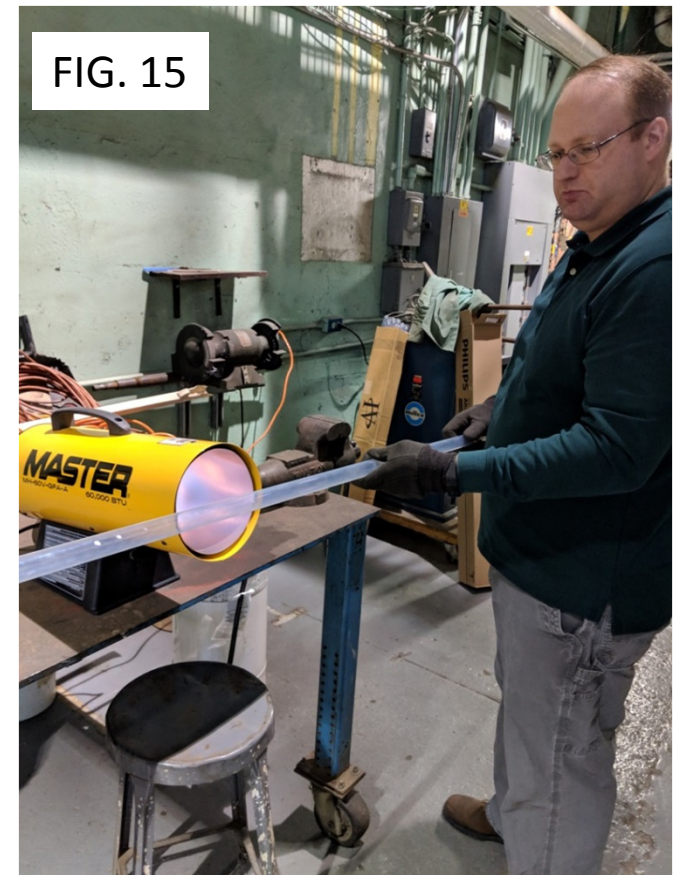


FIG. 15



# Insert reflector and covered lamps into UV light fixtures

- Reflector and FEP-covered UV-C lamps (bulbs) need to be inserted into UV light fixtures (Fig. 16a). Wear clean cotton gloves to perform these steps.
- Insert reflector into fixture and twist the metal bars into the horizontal positions to lock the reflector in (Fig. 16b).
- Insert lamp into fixture (may have to insert it diagonally) (Fig. 16c).
- Place lamp ends into lamp holders and twist lamp 90° to lock lamp pins into position (Fig. 16d). The lamps should fit snugly in the lamp holders.

\*\*It works best to load the outer lamps loosely without socketing them before loading and socketing the inner lamps.

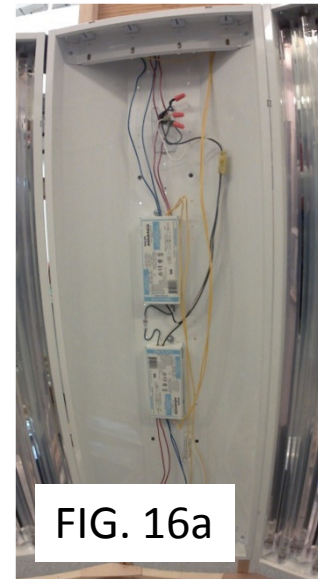


FIG. 16a

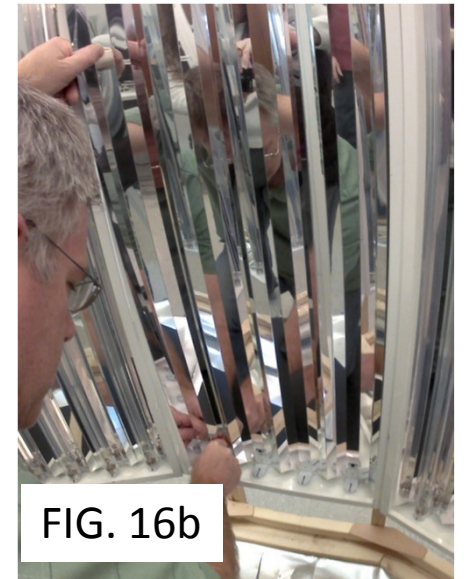


FIG. 16b



FIG. 16c



FIG. 16d

# Operation instructions

- Wear safety glasses at all times.
  - Wear full safety equipment (PPE) during operation.
- While stationary, system should not be left on over an area with plants.
- System check: With the 120 V cord unplugged, plug in 12 V cigarette lighter and turn the remote box switch on. If the generator is used to supply 12 V, it will need to be running. Relay will engage (listen for audible click, it can be felt also), switch indicator will illuminate but lamps will not energize. Turn switch off.
- Start generator, if it hasn't been already. Make sure the remote switch is off and plug in 120 V cord.
- Turn on the remote box switch to energize the system and produce UV (wear appropriate PPE).
- When the dosing is complete, turn off the remote switch to de-energize the system.
- To store the attachment: Disconnect the 12 V power source and unplug cord from generator.
- See following page for Troubleshooting Guide.

# Maintenance / Troubleshooting Guide

If the system-ready indicator fails to illuminate green follow these steps:

- **Put on all of your personal protective equipment (PPE).**
- Power on the unit and look for lamps that are non-functional.

If all lamps are functioning:

1. Power off the unit and clean the lamps and fixtures.
  - Clean dust from the unit with compressed air.
  - Clean mud or dirt with a microfiber cloth. Clean only the affected area and minimize contact with the polished reflectors. Attempt to clean the dirt off dry first, if that fails then use high purity Isopropyl (rubbing) alcohol as a solvent.
2. If this doesn't resolve the problem, contact LRC Staff for assistance at 518-276-7100.

If lamps are observed to be off (not illuminated) when they should be on:

1. If **all four lamps in a fixture are off**, check the power source for the fixture with a multi-meter. If power is OK, replace problem unit with spare fixture and spare FEP covered lamps.
- OR –
1. If **less than 4 lamps in a fixture are off**, depower unit and replace non-functional lamps with FEP-covered spare lamps.
  2. Power the unit back up. If the spare lamps don't emit light, replace the entire fixture with spare fixture and use the replacement lamps.