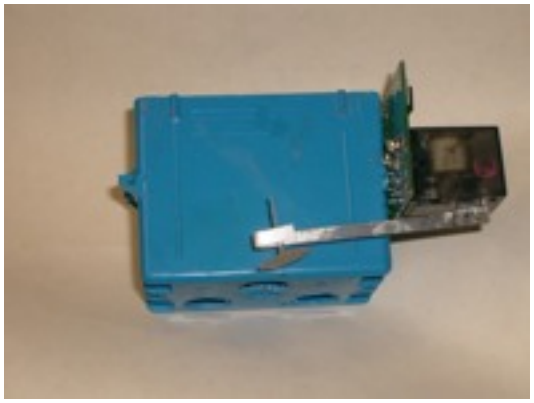
New & Improved
Fully automatic engine dryer project
--Dave Barker 587700 EAA Chapter 79

Since the first publishing of the "Do It Yourself" engine dryer kit back in the April 2007 issue of Sport Aviation, several hundred EAA members have constructed the engine dryer. This simple engine protection is some of the cheapest insurance you can build to get your engine to its rated TBO. In the intervening years several limitations of the original design have become apparent particularly in the more humid parts of the world. This has revealed itself as short service intervals for the re-drying of the Silica Gel. The resulting round trips to the kitchen oven can be a nuisance. The following design automates the entire process featuring "plug-it-in" and "forget" operation. The original design has now been outfitted with electronic humidity sensing for the moisture content of the Silica Gel. When the moisture content reaches a preset threshold, the engine air circulation pump is shut off. A purge valve for the Silcia Gel desiccant reservoir opens to the ambient environment, and an internal heat lamp turns on to warm the Silica Gel to ~ 200^{o}F. This drives the moisture out of the desiccant to the ambient air. Upon detecting dry Silica Gel, the humidity sensor turns off the heat lamp, closes the purge valve and turns the dry air circulation pump back on.

46 oz pickle bottle

Automatic Purge Engine dryer and pump

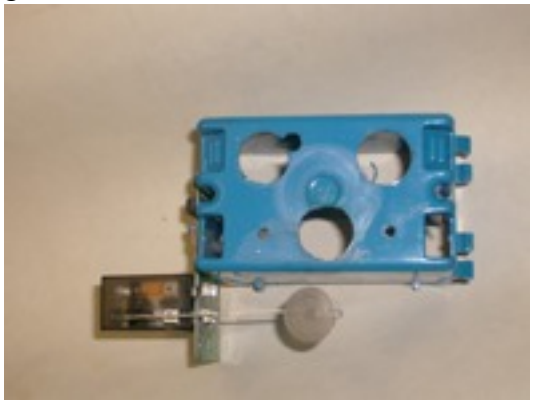

Tipped over view shows airstone, humidity sensor and lamp. The lid box carry PC board, 12V power supply, heat lamp and plumbing.

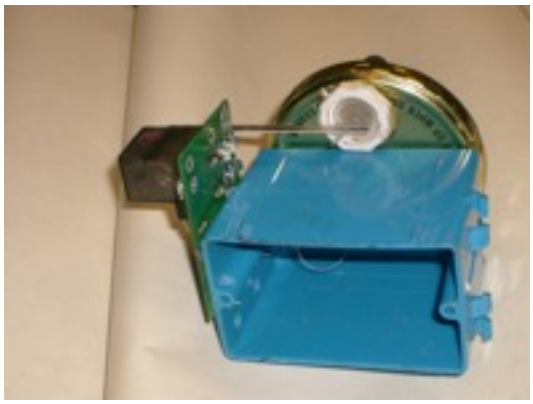

Purge valve control pc board mount on electrical outlet box

Dryer control electronics board

How the engine dryer works

The dehumidifier is connected to the engine as soon after engine shutdown as possible. (Before the engine cools) It is then run on a 24/7 basis. A small aquarium, type air pump forces ambient humid air drawn from the crankcase blow-by vent thru a Plenum bottle containing a desiccant such as Silica Gel. (This is the stuff used in shipping and storing aircraft engines and electronics.) The Silica Gel has a great affinity for moisture and literally sucks it out of the air. The dried air is filtered and injected back into the engine crankcase. Any moisture inside the engine vaporizes with the incoming dry air and is moved by the constant positive pressure from the air pump to the crankcase to the blow-by vent, back to the the Silica Gel and on to the pump.. At some point in time, the Silica Gel will absorb all the moisture it can hold. Then, the process stops and switches the dryer into the heat/purge mode of operation to get the moisture out the desiccant.





Blue box wiring and PC board mount

Fabrication /Electronics

The New / Improved Engine dryer is constructed on top of a ~2 quart wide mouth glass pickle jar. All electronics mount over

and under the lid. The lamp (heater) is suspended below the lid in the desiccant as well as a custom designed humidity sensing capacitor. After a number of failures for commercially available humidity sensors,

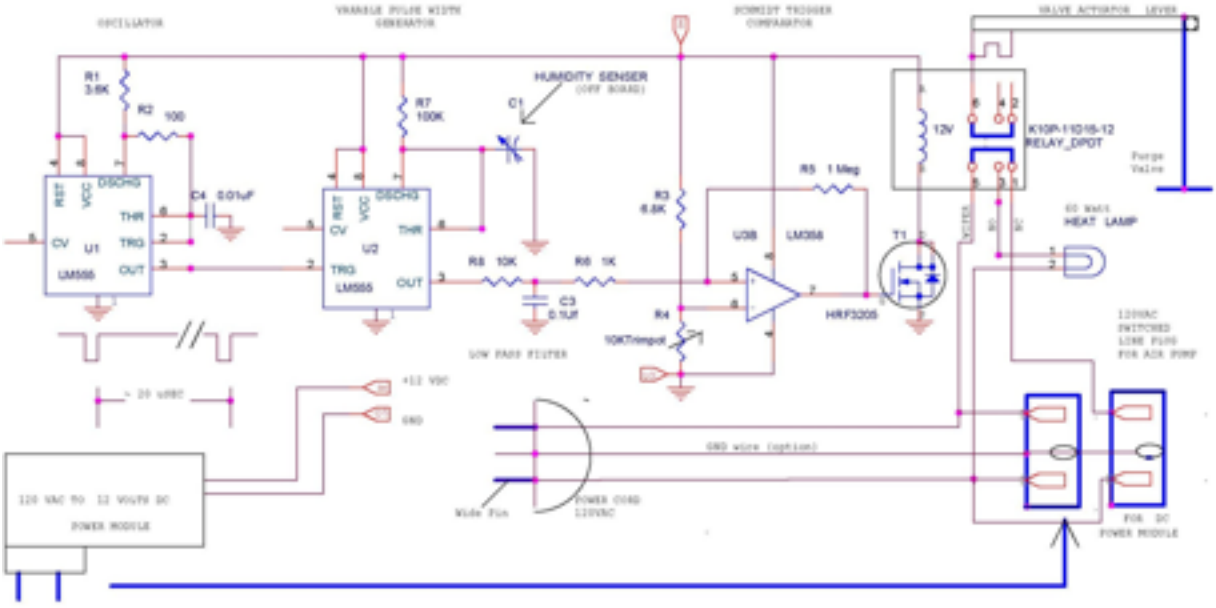
(And many, many dollars spent on several different types) necessity resulted in my own sensor design for this project. By using a $CaSO_4$ desiccant material as the capacitor dielectric, the failure modes of the

commercial thin film sensors have been circumvented. This sensor changes capacitance proportional to relative humidity. It is incorporated into a variable pulse width circuit. The pulse train output then changes pulse width (duty cycle) with relative humidity. The pulses train is low-pass filtered yielding a DC voltage proportional to pulse width. An LM 358 operational amplifier is configured as a Schmidt trigger comparator and buffered by the FET transistor T1 to operate a relay that switches off the air pump turns on the heat lamp and opens the purge valve. diaphragm. Lamp heat drives out the adsorbed moisture. When the desiccant moisture content drops the humidity sensor will switch it back into the engine dryer mode. The air pump injects dry air into the engine crankcase via a standpipe mounted in the engine oil fill cap. Air venting from the crankcase blow by vent is recovered and returned to the Silica Gel for subsequent re-drying.

A modified wall plug socket plastic electrical box is used to support the PC board and valve. and the socket terminal lugs are used for the 120VAC power cord, connections to the pump power plug, lamp, and power supply. A cut in the interconnecting tang on the line side isolates the two outlets. This is done to provide a switched power outlet for the air pump and continuous power for the 120VAC to +12 VDC power supply module used to run the electronics.

Cut the output leads for the +12V power supply module to ~ 6". The wire with the white spots is the +12V line. Solder to PC board. Pads. Do not get the reversed. (Instant catastrophe!)

Seal all 120 VAC electrical relay contacts with RTV to preclude any shock hazards. Also seal the lamp socket terminals with RTV to prevent corrosion.



The box, relay, and printed circuit board mount on top of the3-1/2” diameter twist lock metal jar lid. A drill template pattern is provided to locate all holes for the purge valve, lamp mount and screws. The bottom of the lid carries the heat-lamp socket. The humidity sensor capacitor is constructed with a cylindrical geometry and mounted on the dry air delivery pipe. It resides buried in the desiccant. All electrical feed thrus, lid plumbing and mounting screws must be airtight. This is accomplished by soldering the brass air pipes to the top of the lid. Glue in the PVC valve seat body. Removal of some of the valve body flange material on one side will aid in getting it to seat squarely. RTV glue seal the wire feed thru for the lamp and humidity sensor wire’s feed thru sleeve. A Dremel tool grinder is recommended to remove the paint from the lid top around the brass air tube feed thru holes. This will allow soldering of the brass air tubes to the metal lid to make an air tight seal. Install the long dry air pickup tube / humidity sensor and its airstone (dust filter) Solder the air tubes to the lid. (A slight outboard tilt orientation in the mounting of the long dry air tube away from the lamp is recommended)

Engine air input fitting to oil filler cap Drill and tap 1/8” NPT

Air fitting for oil filler caps 1/8 NPT

Aquarium air pump modifications

Disassembled Air pump.

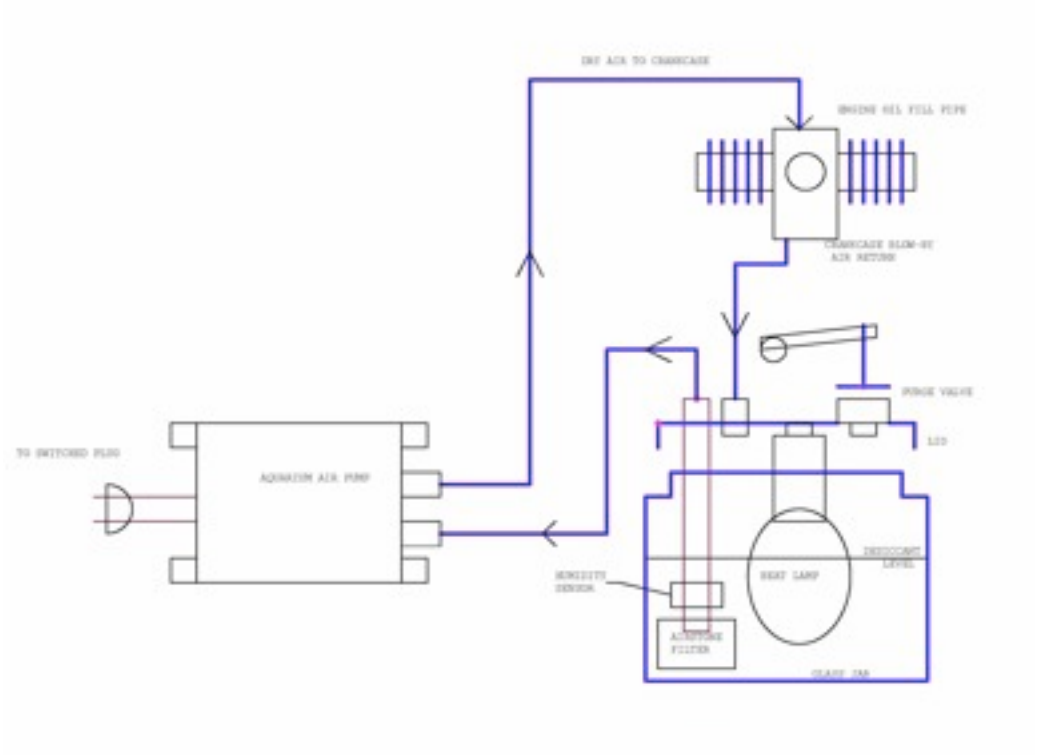
Remove felt filter in the bottom of the pump and plug hole with glue.

Use RTV silicon aquarium cement around entire case seam and all four sides of the power cord strain relief.

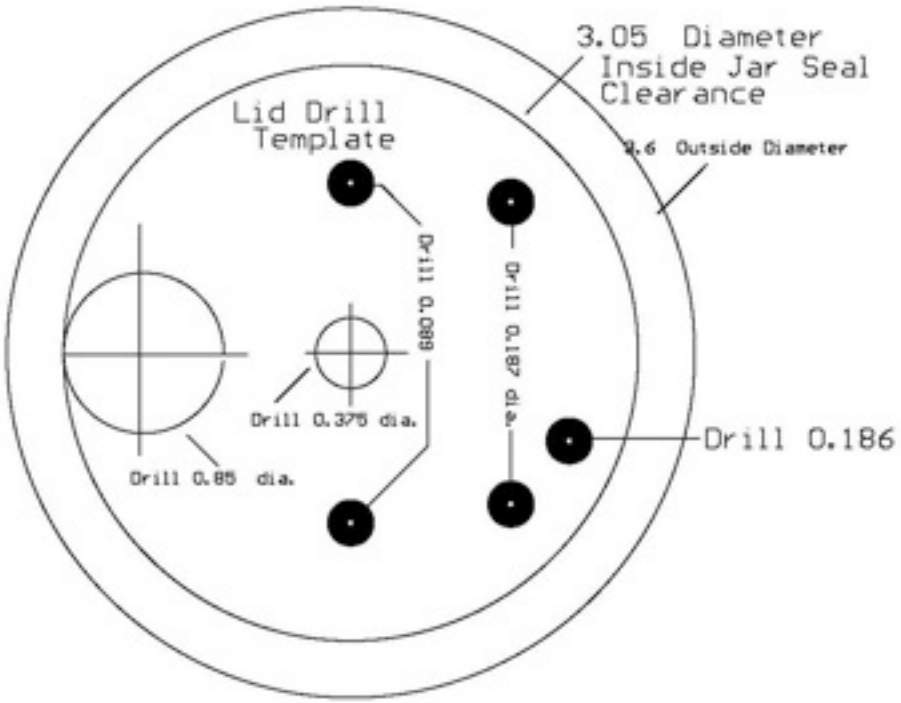
Pump with air return installed
Return air input tube adapter fitting
Drill 3/16” hole ~ ¼” deep and ~ ½” to the left of the output port into pump case. Insert brass stub and secure airtight with glue. This will become the air input line.

Pump return line in Blow-by port
(Mooney 231 illustrated)

Blow-by return rubber fitting



Mount the lamp socket to the lid and secure with the hollow mounting bolt.
Route the lamp wires up thru the bolt and solder to the appropriate neutral plug and switched relay terminals as shown in the wiring diagram. Seal the lead feed thrus with RTV Silicon glue.
Route the thin white humidity sensor lead up thru the lid Delrin feed thru sleeve and out thru the hole drilled in the side of the blue box . Solder the wire to the humidity sensor input pad on the PC board. Secure to blue box to the lid via the two #4 sheet metal screws. Solder a ground wire to the lid next to one of the brass air tubes and route out of the blue box to the back of the PC board ground pad. Solder the other end \to the power ground pad on the PC board.
Slide the silicon rubber diaphragm valve stem into the U shaped end of the relay lever and position it so that the valve face seats flat with a very slight downward pressure on the PCV valve face. Check for actuation and clearance by lifting upward on the valve lever. When satisfied that the valve is sealing repeatedly, then gently crimp the valve lever U structure slightly and add a small blob of cement.
Seal the lamp wires feed thrus and all holes with RTV Silicon glue.



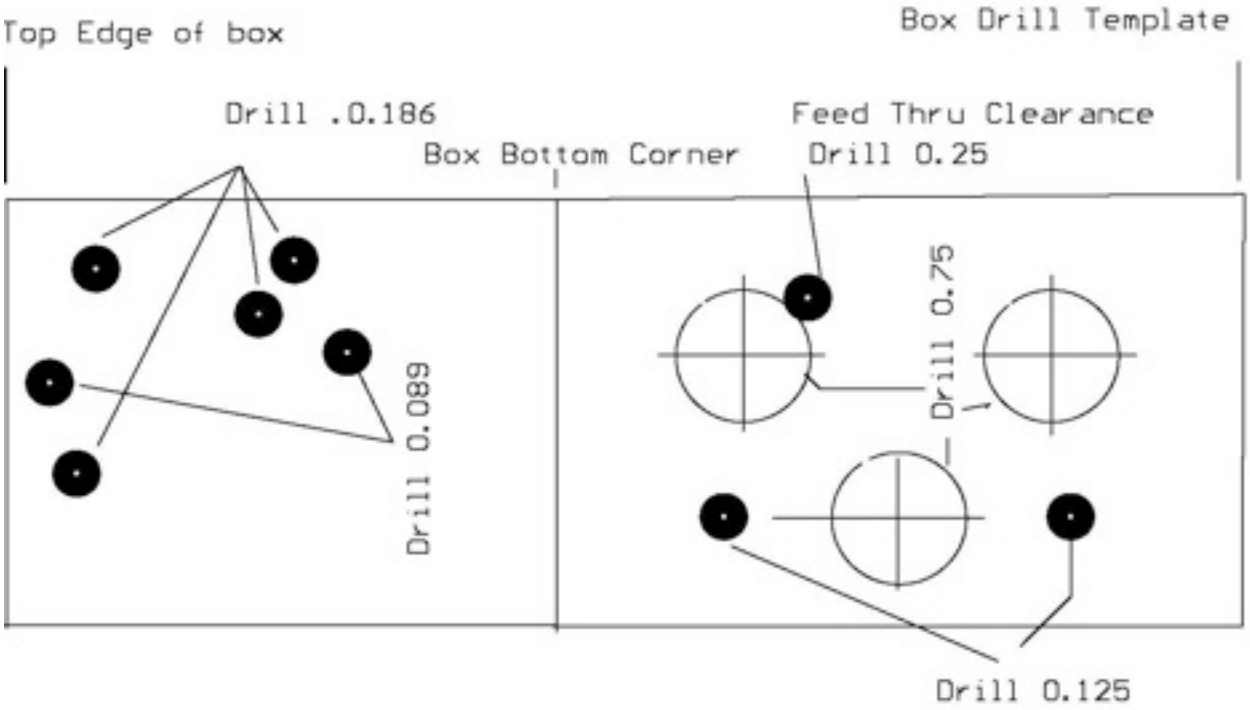
Lid Drill Template

Lid Drill Template.
Print out full size and cut out template.
Spray glues the template to the lid top.
Support the lid interior on a wood block and center punch each hole location.
Drill 3ea. 3/16" (0.187") dia. holes and drill 2 ea 0.089" (#43) for the blue box mounting holes.
Use a 0.850"diameter spade bit to drill the purge valve body hole. Use a sacrificial wood block and clamps when drilling this hole to avoid tearing up the thin lid metal.
Drill a 3/8" (0.375") hole for the lamp mount.
Remove the paper template.
De-burr holes and grind away paint on the lid top lid surface around two of the 3/16" used for the brass tube air feed thru holes.
Press fit the Delrin humidity lead feed thru connector in the remaining 3/16" hole and glue (no lid grinding required here).

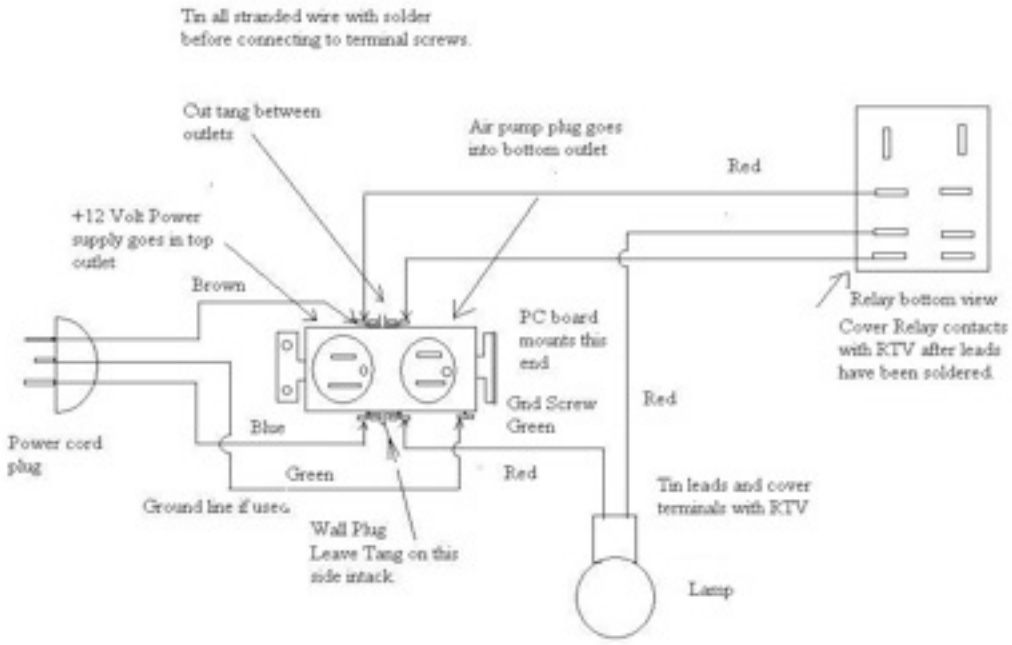
Orient the serpentine brass tube so that the sensor is as far away from the lamp as possible.

Solder the brass air in/out tubes to the top of the lid. Solder a black ground wire to the lid at the exit surface of one of the air tubes.
Mount all hardware to the lid.
Seal all screws feed thru(s) power contact terminals and all exposed raw metal fittings on the underside of the lid with Locktite. paint or RTV aquarium cement. This will preclude any corrosion. (The interior environment will get very wet during early portion of the purge cycle.) Route the thin white humidity sense wire thru the lid and blue box to the PC board humidity sense pad and solder.
Slide the silicone rubber diaphram valve into the U shape end of the relay lever and position it so that the valve face seats flat with a very slight downward pressure on the PVC valve seat.

Drilled lid with paint removed at brass tube solder locations



Blue box drill template cut off the box nail mount tabs fold template around box



Note: Power cord wire color change. Blue is now white. Brown is now black

The silicone valve diaphragm valve and stem mount vertically on the valve body and is connected to the lever fixed to the relay armature. Some care must be observed in position the mounting of the silicon valve. Check orientation of lever sensor board to assure free and smooth motion of the valve lever mechanism. The valve seals when the relay armature is in its normally closed (power-off) position. Reduced internal air pressure will help seal the valve during dryer phase of operation.
When confident that motion & seal are OK, fix the position on the valve stem with a drop of crazy glue. (add RTV latter) Test mounts the lid assembly on the jar. Connect all the Tygon engine hook-up tubing via the holes next to the PC board on the blue box and on to the air in/out ports. For leak testing, plug all but one hose to test for system pressure leaks by holding valve shut and suck the hose. The system must be completely airtight.

RTV lamp terminals and plug wire feed thru

Cover All active relay lugs with RTV for insulation (red wires) to preclude shock hazard. Mount PC board to the blue box using 2 ea. #4 sheet metal screws and a two high stack of washers between the PC board and the blue box.

Complete dryer system

System chek out and calibration
Place the Silical Gel on a cookie sheet and heat in a 270 degree oven for 1 hour. Rremove the hot silica gel and quickly transfer it to the pickle jar.
Add marbles or 1/2 sphere decorative glass beads if needed to cover the heat lamp to ~ 3/4 of its height. Work the lamp and humidity sensor down into the Silica Gel by tilting and rolling the bottle . The humidity sense tube should be bent slightly to keep it ~ 1" away from the surface of the lamp. While the

Silica Gel is still hot, power up the dryer and adjust the trimpot so that the lamp trigger just turns off.

Normal function

Upon power up the unit will circulate dry air thru the engine crankcase. At ~ 30% R.H. the sensor will:

Switch off the pump.
Turn on the lamp.
Open the purge valve.

The heated desiccant then outgases its moisture content. This can occasionally be observed as a temporary condensation near the top of the jar. With additional heating, the humidity in the jar will continue to rise and then start to fall as the moisture is driven out of the desiccant to the atmosphere.

When the humidity falls below < 20%:

The lamp will shut off.
The purge valve closes.
The air pump turns on

Typical purge time will run 2-4 hours. This may occur every couple of days in really wet environments. Or vary rarely after initial drying in a tightly closed engine and dryer system. (Exhaust and intake ports blocked)

Note: A thermal insulating blanket surrounding the jar (not shown) will greatly reduce the purge process time. (And in fact be mandatory in cold climates to get the temperature high enough to drive out the moisture)

Additional Construction addendum and notes (please read)

1**. Production Unit Changes since prototyping**

2. **Bottle eliminated from kit.** Empty new bottle costs plus the inbound and outbound shipping runs ~ 4X the purchase price of a pickle jar from your local grocery. And as a bonus you get the pickles!

3) Make a thermal insulation blanket (fiberglass insulation mats or hot pad materials) to contain the major portion of the jar. ~ 80% of the jar surface. The top 10- 20% is left uncovered.

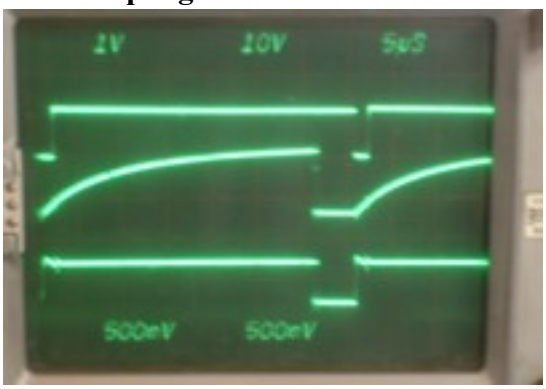
4) U3 LM358 this is a part change for the LF 353 number screened on the annotation.

5) **Simple operational testing**

Cantilever the humidity sensor over the edge of a table and hold a wet sponge 1-2” below the sensor. Touch a sponge with a hot soldering iron. This will create a steam column and switch the dryer to purge mode. (Light ON and pump OFF) The reverse condition can be accomplished by warming the humidity sensor with a heat gun or hair dryer.

Wet Sponge Test

Wet Sponge test

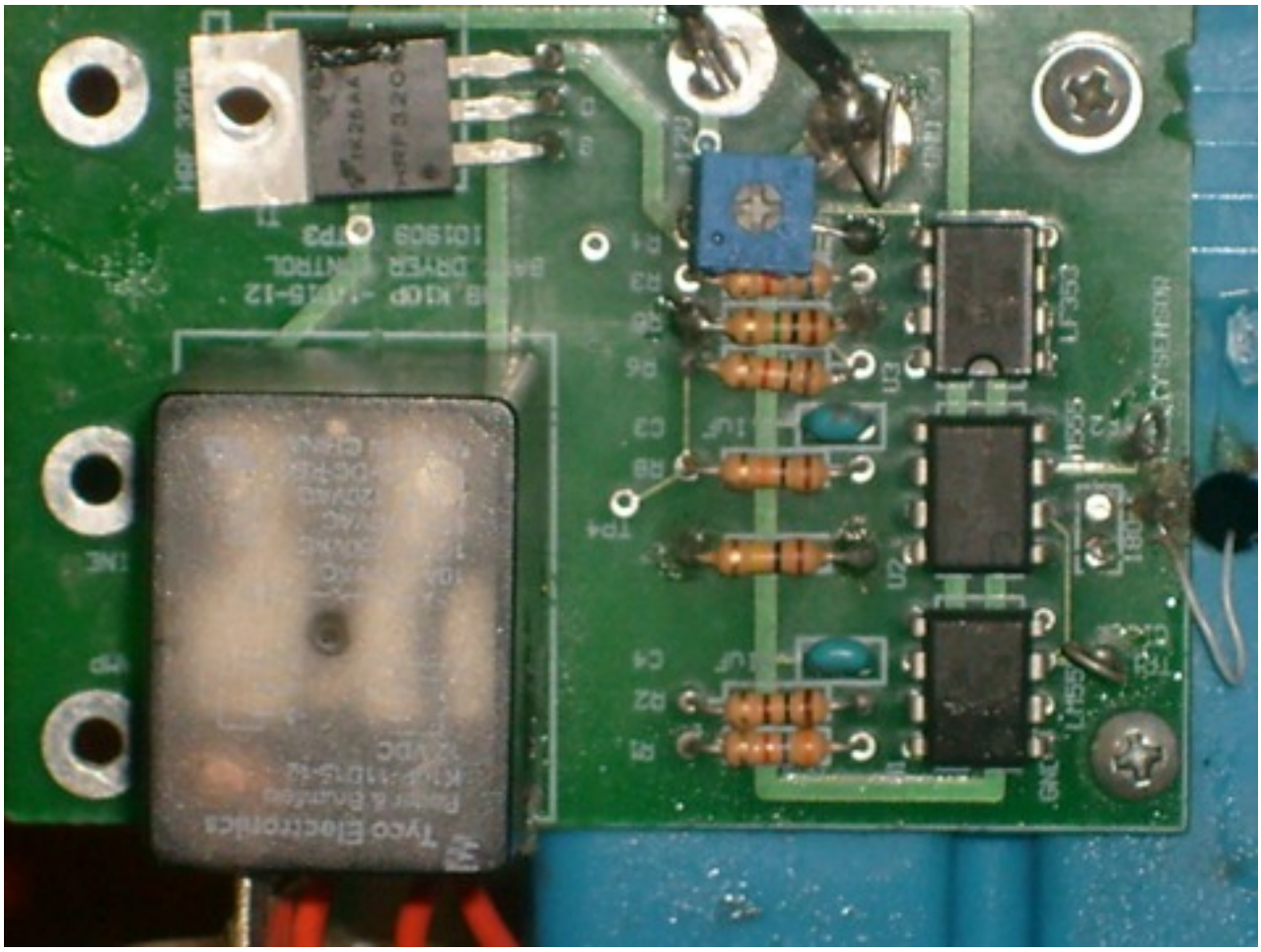


Oscilloscope Photos

Top trace TP1 clock
Middle trace Variable RC time constant (measure at end of 100K resistor R7 (near relay)
Bottom trace Variable pulse output TP2

7) Make sure the in/out air lines do not kink inside the blue box.
8) If the unit does not operate correctly,
try grounding the humidity sense white wire. This should switch the unit into the heat purge mode (lamp on & pump off.)

a) If it does not switch then check for cold solder joints and correct parts placement.
b) If the unit is staying in the heat purge mode, disconnect
c) the humidity wire from the PC board. If it switches back to dryer mode then either the sensor is wet or short circuited Try Heat with hair dryer and check with an ohmmeter.



Resistor and Capacitor locations

Kit Bill of Materials
Full kit includes:

Air pumps 10 gp
Tygon tubing 10 ft
Engine air fitting for oil cap
4013108 1/8HB x 1/8 MPT Barb
Cap for air fitting
1lb. Silica Gel desiccant
"Lid drill template BARC
Box drill template
Blue box electrical outlet box # B120A Ace SKU 30740
Purge valve housing PVC
¾" Silicone SCUBA check valve RP-27
Lamp 60W
Lamp socket MC 335/PO 01
Hollow socket bolt 1/8" NPT 120V Power 2-outlet socket (split tang)
Power cord flying lead
3/16" Brass stub (2) ~1" inlet tube K&S
3/16" x 5-1/2" Brass tubing delivery tube with humidity sensor* and attached
Air stone (dust filter) BARC

All electronic components including:

120VAC to 12VDC power supply
PC Board BARC CONTROL 1013
LM555N timers (2)
LM358N Op–Amp
HRF3205 FET transistor
DPDT relay (12V coil)
K10P-11D15-12* (Modified*)

Resistors ¼ watt 5%

Value	**(color code)**
R1 3.6K	(orange, blue, red)
R7 100K	(brown, black, yellow)
R5 1 Meg	(brown, black , green)
R8 10K	(brown, black, orange)
R3 6.8K	(blue, gray, red)
R6 1K	(brown, black, red)
R4 10K	trimpot
R2 100 ohms	(brown, black, brown)

Capacitors

C4	**0.01uF**	**(103)**
C3	0.1Uf	(104)

*Humidity sensor BARC

You also will need: (not included)
46oz wide mouth glass pickle jar with lid
Soldering iron
Solder
RTV glue or Locktight
Hand tools
Insulating blanket for the jar
Fabricate your own blow-by air return adapter.