How To Build A Kerosene Fired 180 Egg Incubator

With 12V Air Circulation

Wayne Niles
International Ministries
Cap Haitian, Haiti
Introduction

Although this document will tell you how to build a particular incubator that I have used for several years, the ideas presented here should assist in building an incubator of any capacity. The orientation here is toward solving the problems in building a kerosene fired incubator in general. Furthermore, artificial egg incubation requires three pieces of equipment: the incubator, a hatcher, and a brooder. This document only covers the incubator I use, the bottom part of which could be used as a hatcher but ideally a separate hatcher should be used. Once hatched, the chicks need to be kept warm at 32°C (90°F) for two weeks or more in a brooder. Presumably the reader is already familiar with the brooding phase of chick raising as that is where most folks begin: with day old chicks from a hatchery.

Before investing too much time and effort in construction you need to know this incubator requires good carpentry skills, preferably a table saw, and battery powered drill / screw driver. You will have to have access to acetylene welding equipment or someone who can fabricate for you the fuel tank and chimney. There are a number of items that may be hard to get other than from the sources I used in USA cited at the end. Building this incubator takes me a month. Finally, my hatches run 40 – 60%, below the 70 - 80% a good incubator should produce but comparable to my hens’ performance.

Trays

The trays and entire hatcher are based on the size of an egg. This tray will hold 50 to 60 eggs. You will need 3. It is composed of 4 mm (1/8”) hard board. The external dimensions are 365 x 312 x 50 mm (14 3/16 x 12 3/16 x 2”). The base is 355 x 305 mm (14 x 12”). Cut four holes in the bottom for ventilation 125 x 100 mm (5 x 4”) leaving a 20 mm (7/8”) web between them and a 40 mm (1 ½”) boarder around them. Glue all together with good quality wood glue. When dry apply two coats of varnish allowing each coat to dry. The varnish prevents warping in the high humidity of the incubator and allows washing the trays with disinfectant. Renew the varnish whenever it deteriorates. Staple or nail wire cloth to the bottom.

Tray supports

The trays sit in tray supports which are fixed in the incubator so the trays can be removed. The tray supports are composed of a wood frame with hardboard strips glued outside hold the trays. The overall dimensions are 370 x 315 x 40 mm (14 ½ x 1 3/8 x 1 ½”). Glue the frame together and varnish before adding the hardboard panels. Varnish the frames and hard board panels before attaching the panels so they are completely sealed in varnish.

<table>
<thead>
<tr>
<th>Qty</th>
<th>Length</th>
<th>Depth</th>
<th>Width</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>370 mm</td>
<td>19</td>
<td>19</td>
<td>Side</td>
</tr>
<tr>
<td></td>
<td>14 ½”</td>
<td>¼</td>
<td>¼</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>272 mm</td>
<td>19</td>
<td>19</td>
<td>End</td>
</tr>
<tr>
<td></td>
<td>10 5/8”</td>
<td>¾</td>
<td>¾</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>272 mm</td>
<td>4</td>
<td>40</td>
<td>End panel</td>
</tr>
<tr>
<td></td>
<td>10 5/8”</td>
<td>1/8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>355 mm</td>
<td>4</td>
<td>40</td>
<td>Side panel</td>
</tr>
<tr>
<td></td>
<td>14”</td>
<td>1/8</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
How to Build a Kerosene Incubator

The Case

The case is made of 19 mm (¾”) plywood. Apply two coats of varnish to each piece before assembling the box. That way even the hidden ends are sealed against humidity and infiltration of disease organisms. Use wood screws to assemble it so it can be disassembled if needed. When the unit is finished fill gaps with silicone glue or other appropriate filler. Use 40 mm (2”) hinges mounted flush so the door leaves no gap for air to escape when closed. A tight fit is not critical as the door insulation creates an effective seal against air escape. Low kerosene consumption and good temperature control depends on preventing unwanted air leakage from the unit.

Rear Tray Support Mount And Thermostat Mount

The tray supports are mounted in a T shaped frame at the rear of the unit. This frame must be located forward 65 mm (2 ½”) from the rear edge to clear the heating hallway mounted in the back panel. Drill 3 mm (1/8”) holes in the vertical arm of the support mount at 190, 320 mm (7 ½, 12 ½”) from the top end. Drill a similar hole 265 mm (10 ½”) from one end of the horizontal support mount. These are for the rods that the supports rock on. Cut a strip of galvanized roof sheet to connect the tray supports. Drill 3 mm holes at 12, 150, 265 mm (½, 6, 10 ½”) from one end.

The thermostat mount is 65 mm (2 ½”) forward of the rear edge. Drill a 12 mm (½”) hole 125 mm (5”) in from the outside end of the thermostat mount for the button on the bottom of the thermostat to sit in. The hole helps hold the thermostat in place. As always, varnish all surfaces of the pieces with two coats before assembling. Attach them to the case with wood screws so they can be removed if needed.

Front Tray Support Mounts

Cut three front tray support mounts and drill a 3 mm (1/8”) hole in the vertical center of each 265 mm (10 ½”) from one end. Varnish all surfaces before mounting. The top edges of the mounts are located 155, 280, 425 mm (6 ½, 11 ½, 16 ¾”) from the top inside surface respectively. The front surface is 65 mm (2 ½”) in from the front of the case for insulation and

<table>
<thead>
<tr>
<th>Qty</th>
<th>Length</th>
<th>Depth</th>
<th>Width</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>560 mm</td>
<td>19</td>
<td>470</td>
<td>Top &amp; Bottom</td>
</tr>
<tr>
<td>16</td>
<td>18 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>722 mm</td>
<td>19</td>
<td>470</td>
<td>Sides</td>
</tr>
<tr>
<td>28</td>
<td>18 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>760 mm</td>
<td>19</td>
<td>565</td>
<td>Front &amp; Back</td>
</tr>
<tr>
<td>30</td>
<td>22 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qty</th>
<th>Length</th>
<th>Depth</th>
<th>Width</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>425 mm</td>
<td>19</td>
<td>40 mm</td>
<td>Vertical rear support mount</td>
</tr>
<tr>
<td>16</td>
<td>1 ½”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>528 mm</td>
<td>19</td>
<td>40 mm</td>
<td>Horizontal rear support mount</td>
</tr>
<tr>
<td>20</td>
<td>1 ½”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>177 mm</td>
<td>19</td>
<td>40 mm</td>
<td>Horizontal thermostat mount</td>
</tr>
<tr>
<td>7</td>
<td>1 ½”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>60 mm</td>
<td>19</td>
<td>40 mm</td>
<td>Vertical thermostat mount</td>
</tr>
<tr>
<td>2 3/8”</td>
<td>3/4</td>
<td>1 ½”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>280 mm</td>
<td>21</td>
<td>7/8”</td>
<td>Sheet metal strap, support connecting</td>
</tr>
<tr>
<td>11”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How to Build a Kerosene Incubator

Air Clearance.

Heating System

The heating system involves two circulations an internal and external one. A still air incubator without internal circulation is simpler to build but limits you to one layer of eggs and a different rotation method since the heated chamber must be as shallow as possible.

The external circulation begins at the kerosene flame. Air enters the base of the burner thru small holes in the base. A small cap guides a portion of the air close to the wick to promote an even flow that spreads the flame out and aids full combustion. The hot air passes into a short vertical pipe, makes an abrupt 90° bend which is wrapped with high temperature insulation, and passes into an S – shaped 40 mm (1 ½”) stainless steel flexible pipe in which it winds its way to the top and out. The S bends promote heat transfer and extend the length of the pipe. Any steel pipe will probably do but condensates in the exhaust will burn holes in the pipe in a couple months making stainless steel worth the cost.

The internal circulation is driven by a 12V fan which requires a 12V battery. I use a fan that draws less than 0.7 amp. A typical 55 Amp Hour fully charged battery can run this unit the 3 ½ days without charge. It is better however to recharge the battery everyday with a solar panel or generator. My unit receives a charge for 3 hours each day. The same battery has served me continuously year round three years in a row. There are smaller 12V fans from computer power supplies that draw much less that I considered but don’t blow enough air for this size unit. They might be suitable for smaller units.

The internal circulation is in the opposite direction from the external one. Warm air is drawn in from the top (passing the thermostat) and drawn down over the S shaped pipe where it passes over its increasingly hotter surface before being expelled into the cabinet by the fan at the bottom. A small amount of air enters the system at the bottom where the hottest gases pass into the S pipe. This cool the pipe to reduce the danger of burning the cabinet wood.

Building The Warm Air Duct

Lay the flexible pipe on the back panel and form it into an S shape entering on the lower right and exiting the upper left. Run the centerline of the pipe 65 mm (2 ½”) from the bottom edge and 45 mm (1 ¾”) of the outlet section from the top edge. Trim the pipe so that 75 mm (3”) overhangs the side at the top and 25 mm (1”) overhangs at the bottom of the back. Trace around it with a pencil for future reference. Cut 2.5 m (10’) of 19 mm (¾”) or 12 mm (½”) wood strips 50 mm (2”) wide. Lay out a wood hallway around the pipe by cutting and fitting sections of the wood strip. Always maintain a 12 mm (½”) space between the pipe and wood hallways for air circulation. The fan is located in the lower left corner where the pipe makes its first turn up. Leave ample room in the walls of the hallway to exceed the diameter of the fan by at least 12 mm (½”).

Cut and place the strips on the back with the S shaped pipe in place. At the inlet (bottom left) begin 25 mm (1”) inside slightly more than the thickness of the case wood. At the top, the lower part of the hallway runs to the inside right edge of the case, the upper part of the hall terminates 215 mm (8 ½”) back from the right edge. Trace the positions of the pieces on the back then remove them and drill two holes for each piece for attaching screws to pass. Drill two holes on either side of the flexible pipe near the top and midway to the bottom. Thru these you will pass galvanized wire to hold the pipe in place. Tie the wire off on the outside of the back. Mount the hallway pieces, use nails if you don’t have a battery powered drill. If all looks well, seal the joints
between pieces with silicone glue. Wire the flexible pipe in place.

Cover the hallway with galvanized roof sheet or tin can sheets. Overlap the pieces at least 12 mm (½”) to minimize air leakage. Silicone glue is handy for filling all air leaks. Do not cover the final 150 mm (6”) at the top right for the air inlet. The idea here is to guide the entering air over the thermostat so it knows if to raise or lower the flame.

**Mounting The Fan**

The fan I use must be disassembled to remove unneeded parts. There is a two speed switch and resistor I throw away and solder the wires from the battery directly to the wires going to the fan motor. Prepare a flat piece of sheet metal to fit the hole in the hallway left for it. Center the fan on it and trace around it. Before cutting, draw in two or three tongues that you will bend up for mounting the fan. Cut the hole for the fan avoiding cutting the tongues. Drill holes in the tongues then bend them up and adjust to fit the fan. Be sure the blade spins freely. Use 8 mm (1/4”) sheet metal screws to mount it. Again see that the blade does not hit screws and turns freely. Mount the fan as close to the sheet as possible to reduce air leaks. Any large gaps can be closed with duct tape. The fan blade should be held at least 8 mm (¼”) from the flexible pipe so it will not melt if the pipe runs too hot for some reason.

When attaching the wires don’t forget to pass them thru the back panel first. Alligator clips ease attaching and removing the wires from the battery. Be sure the fan blows in to the cabinet. If not, reverse the wires on the battery.

These cheap little fans survive 9 months at most. You need to keep an extra one on hand as you have no incubator when the fan dies and you lose 180 eggs. The bearings dry and slow their rotation over time. I keep a can of WD 40 spray on hand and just spray the motor with it every few weeks. The motor usually gives a few days warning before failing completely. Should the fan stop, the temperature of the flexible pipe rises and eventually causes the thermostat to turn the flame off. A flame out suggests fan problems.

**Burner Preparation**

I purchase burners in the main market in Cap Haitian for under US$5. Anyone interested in a kerosene incubator obviously lives under circumstances similar to mine where electricity is almost nonexistent and kerosene lighting is common. Finding a way to attach a lever arm to the burner so the thermostat can control it is crucial to the success of the incubator project. Not knowing what kind of burners are available elsewhere, it is up to you to figure out the best way to do this. I use a relatively heavy piece of sheet metal that I clamp around the burner adjusting knob with a piece of inner tube rubber added for friction.

The lever arm is 45 mm (1 ¾”) long with holes drilled 8 and 12 mm (¼, ½”) from the burner adjusting shaft. A hole for the burner adjusting shaft to pass thru is crucial for keeping the lever arm in place. The lever needs to have a good grip on the adjusting arm and yet be able to slip so the level of the wick can be adjusted relative to position of the thermostat. The adjustment is made by holding the adjusting arm shaft fast with pliers and forcing the arm up or down as needed. You adjust every time you trim the wick.
The wick must move relatively freely through the burner so that it can be raised with only the weight of the control arms between the burner and the thermostat. Most burners I purchase are fairly stiff. They can be freed up by twisting the adjusting arm up and down several times so the part that raises the wick ‘settles’ in. Really tight burners can be ‘opened up’ a small amount by running a small screwdriver up the tube the wick follows.

**Tank And Chimney**

The tank and chimney must be fabricated by someone with acetylene welding equipment. I used a Christmas cookie tin with two holes in the lid for a tank for the first year but that’s not ideal. I had to add kerosene every six days. This tank will last a month or more. A small collar is necessary for holding the base of the burner. It should be a snug fit. The filling hole needs to be accessible for filling without turning off the incubator. The outside dimensions of the tank are 265 by 265 by 75 mm (10 ½ x 10 ½ x 3”).

The chimney is composed of two parts: the elbow pipe and sight glass. The elbow pipe turns the heat of the flame into the incubator. The sight glass is not essential to the functioning of the unit but required to know how the flame is doing. Otherwise you could use a metal can. I use a peanut butter jar for the sight glass. Cutting the jar is an art and probably the greatest challenge to building the incubator. I destroy half a dozen jars before succeeding. I use a diamond file to groove the glass and then try to break it along the groove. You need a large stock of jars with a mouth that is as large as the base of the burner unit.

The elbow pipe must be tapered where it fits into the flexible pipe so it sticks. It must descend into the burner unit to within 12 mm (½”) of the flame. I flatten the pipe slightly for it to be widest where the flame is widest. There is no need for a good seal between the glass and the elbow pipe. The presence of the glass is crucial however for the burner to work. Normally the burner comes with a tall chimney. I have discovered that the aerodynamics of the burner and chimney are not trivial. The wide bulge of the chimney causes the flame to expand and give abundant light. The tapered top help speed up the exhaust column to pump more fresh air into the burner below.

If you cannot find jars the right size or have destroyed all you have you can always purchase a proper tall chimney glass and insert an extended elbow piece into it. This adds about 200 mm (8”) to the height of the incubator, a minor inconvenience for overcoming the impasse of trying to cut glass. The tube that extends into the glass chimney must reach to within 12 mm (½”) of the flame to capture all the exhaust gasses. Otherwise the chimney will run very hot and crack.

The chimney must be easy to remove and install to facilitate lighting the flame. The insulation makes this possible when the unit is in use otherwise you burn your hands. The insulation also reduces heat lost to the outside of the incubator. You could get the greatest efficiency by putting the flame under the incubator so the first turn is in part of the hallway of the internal circulation. This entails lots of inconveniences when lighting the burner or trimming the wick so I have not done that. The insulation I use has no obvious way of attachment other than wrapping and clamping with galvanized wire.
Thermostat and Control Linkage

Temperature is controlled by the thermostat which expands as the air around gets hotter and shrinks as the temperature drops. Incubator thermostats are optimized to be most sensitive around 38 °C (99 °F) which is what the eggs need to hatch. There are about four designs of incubator thermostats depending on the threads they have for attachment to the control linkage. I use two to double the ‘throw’ and increase sensitivity of the unit. In reality I have no idea how these units actually work. I would like to see a temperature vs. expansion curve for these units based on loading. You would think they would be most sensitive with the smallest load but that is not my experience. The thermostats can take a tremendous load and are rather powerful, you will see that from the linkage I use. That said, using a data logger monitoring temperatures read every 3 minutes in these units, I never got anything close to a horizontal line. When it is hot outside the incubator, it runs hotter, when it’s cold outside the incubator, it runs colder. Aiming for 38 °C (99 °F) I get between 37 and 39 °C (98 and 102 °F) over a 24 hour period if the outside temperature varies considerably. I take comfort from University web sites that instruct you to ‘keep incubators away from outside walls and floors’ to avoid temperature fluctuations and to place the incubator in a room with as little temperature change as possible. To that end my incubators are located in the down wind side of a building that is under a spreading Ficus tree.

The center of the thermostat(s) is located 85 mm (3 3/8”) in from the cabinet inside back edge and 140 mm (5 ¼”) from the inside right edge. A 75 mm (3”) long piece of 3 mm (1/8”) welding rod wire extends up from the thermostat into the main lever arm. The hole the rod passes thru is 8 mm in diameter allowing plenty of room for movement without touching the cabinet.

The rod enters the main lever arm 100 mm (4”) from the fulcrum. This wood arm is drilled and threaded for a ¼ x 20 UNC thread. The rod extends up into the threaded hole and rests on the end of a screw turned into the arm. The screw is the ‘fine’ temperature adjustment.

The main lever arm is 665 long, 32 mm (1 ¼”) wide by 25 mm (1”) high at the large end tapering down to 8 mm (¼”) wide 12 mm (½”) high at the thin end. The fulcrum is located 100 mm (4”) from the large end. A sheet metal plate bent in the shape of a U forms the fulcrum support. It should hold the fulcrum 40 mm (1 ½”) above the case. It is attached to the cabinet by wood screws. A 85 mm (3 ¼”) long piece of 3 mm (1/8”) welding rod forms the axle. It is bent at one end. It is a challenge drilling the fulcrum hole absolutely perpendicular to the lever arm and drilling similarly perpendicular holes in the lever arm support. If they are not perpendicular the end of the arm does not rise and fall vertically.

The end of the lever arm has a 1.5 mm (1/16”) hole drilled 12 mm (½”) from the end for a piece of galvanized wire to pass thru. The wire extends down to the short lever on the burner. You can put bends and ‘dog legs’ in the wire as needed to clear the case and burner. A small piece of inner tube rubber pushed over the ends of the wire will keep them from slipping out of their holes at each end. Install the wire after firing up the unit the first time.

Installing the Tray Supports

The tray supports rock on 3 mm wire axles prepared from 1/8” welding rod that has had the covering knocked off. These come conveniently straight. Drill 3 mm (1/8”) holes thru the centers of the side (370 mm) panels making them perpendicular as possible. Cut the 3 mm wires to 370 mm (14 ½”) length. Mount the tray supports on their wires by
sliding the wire thru the support mounts and the tray supports. When all three have been mounted fix them together with the 21 mm (7/8”) strap with 6 mm (1/4”) sheet metal screws 40 mm (1 ½”) in from the edge of each tray support.

When properly mounted the three trays should rock together freely at least 30° in each direction from horizontal. If they don’t loosen the screws or add washers under them to keep the strap from bind with the supports.

A rocker arm attached to the right end of the top support tray extends thru the top of the case and is bent to form a handle of sorts. The bend on the handle limits tray rocking to the right, a clamp on the arm inside the case limits the travel of rockers to the left. The rocker attaches to a small metal link made from sheet metal 21 x 65 mm (3/4 x 2 ½”) with a 3 mm (1/8”) hole drilled 21 mm (7/8”) from the end. The link is bent 100 mm (4”) from the end having the hole. Fasten it to the tray supports with two sheet metal screws.

The clamp limiting movement to the left could be a hose clamp with some rubber tire for friction. I used an electrical cable clamp.

The eggs need to be rocked several times a day, essentially every time you check the unit to see that it is running ok. The units should be visited at least three times a day: morning, noon, and evening both to rock them and see that the temperature is normal and there is water in the bottle.

**Insulation**

After the trays have been installed, insulate the case with a 19 mm (¾”) thick layer of Styrofoam insulation. I use wood screws and large plastic washers to fix it in place. The plastic washers are 25 mm (1”) squares cut from plastic bottles. Use silicone sealant around the edges of the insulation to glue it to the case and to glue small pieces in corners. Cover as much of the inside as possible leaving clearance for air circulation around the fan, thermostat and the two ends of the air hallway.

Place a sheet of insulation on the inside of the door. It will have to be trimmed 19 mm (¾”) in from the edge all around to fit inside the case. Also the insulation will have to be trimmed 19 mm (¾”) from the front to accommodate the insulation on the door. The labyrinth like path air must pass to leave the door virtually assures minimal air leakage from the door.

Place another sheet of insulation over the entire back panel to prevent heat loss thru the wood closest to the flexible heating pipe. If you have thicker insulation use it on the back where the temperature difference between sides of the wood box are greatest.

**Water Supply**

Incubating eggs requires a high humidity (50 – 55%) to prevent desiccation. This incubator uses a quart of water a week. The fan blows warm air over a shallow pan of water. The water evaporates, maintaining the high humidity but also cooling the air somewhat. The surface area of the pan determines the humidity. If you need a higher humidity increase the diameter of the evaporating pan. I have used the bottom of a plastic gallon container trimmed to 12 mm depth.
The water supply is maintained by siphon just as in most chick waterers except the bottle is located outside the case.

Begin by selecting a liter (quart) plastic bottle a with a threaded plastic cap. Drill a hole a bit smaller than the plastic tubing you use to carry the water into the case. I use 10 mm (3/8”) plastic hose. Cut a gasket from inner tube rubber that seals the rim of the bottle and tightly fits around the hose. This gasket must make an air tight and water tight seal. Build a support for the water bottle with one end open so you can remove and install the bottle without disconnecting it.

I use a 300 mm (12”) piece of 10 mm (3/8”) copper pipe to guide the water into the case. This is not entirely necessary but you need to find some method to control the position of the section of hose that goes into the evaporating dish. The copper pipe is wedged in its hole with a screw.

When filling the bottle turn the bottle on the cap not the other way around. Avoid turning the cap on the hose so you don’t wreck the seal between the hose and gasket inside the cap. Position the bottle high enough so there is plenty of hose so you can remove the bottle, turn it right side up, and unscrew it from the cap.

**Final Assembly**

Cut holes in the back upper right and lower left of the case for the heat pipe entering and leaving. Wrap high temperature insulation around the pipe at the bottom where it enters the case. This will plug the hole and protect the wood from burning. Trim the insulation at the rear of the case as required to install the back. Install it and fix with screws. Fill gaps with silicone sealant. Leave a gap where the pipe exits at the top for fresh air to enter.

Cut four legs of appropriate length depending on the size of the chimney, tank, and burner glass. No two installations will be the same in this respect. I make a shelf to hold the tank between the legs so the entire incubator can be moved slightly as needed. One leg is attached to the back of the case rather than the side to make room for the burner and tank.

Figure out a place to put it (a bit late at this point) and see if you can get it there. This unit is large but not too large for most doors. Common sense dictates you will put the incubator somewhere with plenty of ventilation for exhaust gases to escape and where there is no danger to human or animal life. At times the unit must be fumigated with powerfully toxic gas to sterilize it. A basement or back room of a home therefore is not a good location. Fumigation (as I do it) takes several hours and no one should enter the building until all of the gas has dispersed.

**Thermometers**

You will need a thermometer or a couple thermometers to monitor the temperature inside the incubator. Books on incubation can be annoyingly fanatical about temperature. I have one that states “for most types of eggs the incubator temperature …. is set at 99 ½ to 99 ¾ °F.” There are not that many thermometers with that kind of resolution and fewer still with that accuracy. A visit to the thermometer rack in any store will teach you about accuracy. If there are a dozen thermometers in the rack you will find a dozen slightly different readings. GQF carries a digital thermometer that I trust which it claims is accurate to +/- .18 °F. This unit is good for checking other thermometers but not suited for monitoring the incubator because it runs on watch batteries which it will drain in a couple days if left on. I use large digital thermometers with an ‘outside’ temperature probe. These run months on an AA battery and can be read across the room. The advantage of the probe is you can place it in the air stream next to the thermostat so you know what temperature the thermostat thinks it is. Use the GQF thermometer to check the large digital one. I find temperature readings change when you change batteries suggesting the large digital models are not that accurate despite their 0.1° F screen resolution.
There are all kinds of design questions that I worried about initially such as ‘Are there hot spots and cold spots in the case?’, ‘Do lower trays run hotter than upper?’, ‘Would a more powerful fan increase or decrease performance?’ However, experience has made me ambivalent, there’s no discernable pattern to hatches and non hatches. Within trays, there does not seem to be any difference in hatch from front to back or middle to edges. Between trays one location seems as good as another.

Then there’s the question as to what temperature to run the unit. While my books talk about ‘99 ½ to 99 ¾ °F’ this unit varies from 37 and 39 °C (98 and 102 °F) between 5 am and 3 pm and my eggs hatch. My broody hens run at 40.5 °C (105 °F) themselves and are always shifting their eggs so some are outside and others underneath, then they get up for 25 minutes each day to eat, drink, and stretch. Their eggs hatch. My notes from a Poultry Science Intro course at U of F by a professor who oversees the hatching of hundreds of eggs a week states the incubation temperature should be ‘around 100 °F’ (38 °C). Embryo development is probably like corn development, a function of heat units accumulated over time within a temperature range. For me the best indicator of temperature range is incubation time. If the hatch is a day early, lower the temperature, if it is late, raise it.

**Incubator Operation**

**Initial Setup**

Fill the tank with kerosene, soak the wick, light the burner and hook it up to the flexible pipe. Adjust the flame as high as possible without black smoke coming out the pipe. The long wire from the main control arm should hang off to the side at this point. Attach the fan to a fully charged 12V battery. Fill the water pan with water. This involves carefully leveling the incubator. Fill the water bottle and put in place. If the bottle promptly empties itself into the incubator you have an air leak somewhere. The hose entering the water pan is the water level adjustment.

The incubator should come up to 38 °C (99 °F) within 30 – 45 minutes. The thermostat does not begin to raise the long adjusting arm until the temperature is above 36 °C (96 °F). Adjust the burner by hand until the unit is stable at 38 °C (99 °F) for two hours or more. Now adjust the two lever arms so they are both horizontal. For the long arm this means turning the adjusting screw and if necessary changing the length of the rod between the thermostat and long arm. For the short lever arm on the burner this involves clamping the adjusting arm shaft in pliers and sliding the arm to horizontal position. Raise (turn) the burner arm slightly and the flame should lower. If the flame increases, the arm is pointing the wrong direction, turn it 180°, now the flame should lower when the arm is raised. When both arms are level, trim, bend, and install the galvanized wire connecting the two lever arms adjusting as needed.

You will run the incubator a couple days before trusting it with eggs. There are usually a few bugs to work out before the unit is running smoothly. The tank should sit on a shelf attached to the incubator legs. If not, any shifting of the incubator will change the distance between the burner and incubator and therefore of the flame.

**Loading The Incubator**

Load the eggs into the trays big end up. To do this stand the tray at a 45° angle on one corner. I have a special frame for this. When the tray is full, stuff the empty spaces with newspaper. Check that the eggs are snug and don’t flop around as you tilt the tray from side to side. I got the idea of packing eggs this way at a commercial hatchery.
The incubator can be run continuously or in batches. Having three trays it makes it easy to add a tray and remove a tray each week for hatching.

**Periodic Maintenance**

Once in operation, the incubator must be checked several times a day to tilt the eggs and see that all is well. Check the temperature, burner flame, and water bottle. If the temperature is too high or low you can adjust it slightly by turning the screw on the long lever arm. Often a large change in temperature means the wick needs trimming. In 5 to 15 days depending on the quality of your kerosene, the wick crusts up with tar. If not attended to the wick will stick and there will be no temperature regulation.

To clean the wick pull out the tank and remove the chimney and glass. Crank down the wick and run a screw driver or similar object across the inside of the burner to clean out the crust. Trim the wick with scissors. Trim the corners slightly to promote a round flame tall in the center. The edges of the wick tend to get hung up on the channel. When you trim the wick, the relative position of the lever arms verses the flame must be reset with pliers and sliding the arm.

During the summer in Haiti, the outdoor temperature rises into the high 90’s such that the incubator hardly needs any heat at all. Often the thermostat lowers the flame so much it goes out. The solution is to make a smaller flame. Do this by trimming the wick to a long taper. The result is a smaller flame and one that requires more lever arm travel to increase or decrease relative to the non-tapered wicks.

Despite regular trimming a 150 mm (6”) wick will last a year. When it no longer reaches the bottom of the tank there is danger the wick will run dry before the tank does. Replacement wicks are as easy to find in Haiti as are burners.

Aside from the above, the only other maintenance is to periodically spray the fan with WD 40 or equivalent and see that the tank does not run dry. The trays need to be soaked in a bleach solution to sterilize them. A small amount of bleach can be added to the water bottle to sterilize water in the evaporating pan. If an egg should crack and leak the entire inside of the incubator needs to be cleaned with a bleach solution.

**Hatching**

At 19 days of incubation the eggs should be moved to a hatcher. I use a box 635 x 535 x 215 mm (25 x 21 x 8 ½”) with a front door for a hatcher. A single loop of flexible pipe warms the unit. It has 25 mm(1”) insulation inside on top. This unit has a burner for heating but no fan. Humidity is maintained by a pan suspended from the ceiling supplied by a water bottle. Candle the eggs so duds don’t take up room in the hatcher. You will need lots of newspaper to absorb the mess of hatching. Beyond this point there is abundant literature on the internet and elsewhere on raising chicks.

**Conclusion**

University web sites have abundant information on incubation, particularly on problems with incubation. It’s amazing how much work it is to replicate what hens do so easily. My struggles maintaining an exact temperature in a well insulated box has given me a new appreciation for the precision of temperature control in warm blooded animals. Folks who talk so glibly about evolution don’t spend much time trying to design and build things that really work; if they did there would be more talk about a Creator who’s creation is witness to his wonderful designs.
Sources of Materials

G.Q.F. Manufacturing Co, P.O.Box 1552, Savannah, Ga 31402-1551, WWW.GQFMFG.COM

Wonderful folks that happily cater to a tiny operator as myself. Strange name, must have begun as a quail farm. From them I get:

- Thermostats
- Thermometers
- Water hose
- Disinfectant
- Lots of poultry raising supplies

J.C. Whitney, 1 JC Whitney Way, P.O. Box 3000, Lasalle, IL, 61301-0300; WWW.JCWHITNEY.COM

From them I get:

- 12 V gooseneck fan, p/n 12nU2734Y
- 1 –1/2” stainless steel flexible exhaust tubing, p/n 21NU4035X
- Insulating wrap for headers and exhausts, p/n 71NU1303A