Troika™ TLUD Stove: First Look

Prepared by Paul Anderson   "Dr TLUD"   27 Nov 2013

This PowerPoint is intended to be read as a document either printed on paper or on a personal computer screen. It is not prepared for projection except to show the images.

Descriptions and instructions that follow are for the Natural Draft (ND) versions of Troika, with separate attention noted for the few differences related to the Forced Air (FA) capabilities.

Expect several updates of this document during 2013.   Updates will be available at the Home page of   www.drtlud.com/Resources

At left: outer cylinder made from sheet steel, with Quad 3 riser on top.
At right: outer cylinder made from five-gallon paint bucket.

Troika™ is a trademark of Paul S. Anderson, for exclusive use with stoves that meet his requirements, but can have variations from different fabricators.

Troika™ Summary Description:

(In a format compatible with Roth's revision of the *Micro-gasification* manual.)

Model : Troika TLUD

The Troika model is the 2013 addition to the "Champion Family" of TLUD cookstoves that include Champion (2009), Mwoto (2010), and Quad (2012). All four stoves have the same basic dimensions and performance, but with distinct constructions. The Troika can be either ND (Natural Draft) or FA (Forced Air).

Target area:	In-country fabrication anywhere.
Fuel type:	Any chunky dry solid biomass; rice husk possible in FA units.
Designed by:	Dr TLUD (Paul Anderson)
Retail price:	Local variations estimated to be US$ 18 to $30, depending on materials and labor at each production site.
Numbers sold:	None; Designs are available.
Start of production:	December 2013.
Manufactured by:	Cooperating producers in each country, including Awamu in Uganda.
Contact:	Dr. Paul S. Anderson (Dr TLUD) psanders@ilstu.edu

Left: 10" duct outside w/ 7" fuel cylinder. Natural Draft (ND). Combustor top from Quad stove.

Right: 20 liter Bucket. FA (Fan-Assist); Fan not shown.

Photo Source: Dr TLUD

Address:	Juntos Energy Solutions NFP 227 South Orr Drive, Normal, IL USA 61761 Phone: +1-309-452-7072 Skype: paultlud
Production capacity:	Depends upon capabilities of cooperating producers. Scalable upon demand.
Short Description:	All of the fundamental TLUD characteristics, plus evolutionary enhancements. Can have "pot on top" (like Mwoto & Quad) or separate pot support (like Champion). Component pieces for easy local assembly and maintenance. Can be enlarged beyond residential cookstove sizes, including for biochar production.
Features:	Three legs (wooden) for greater stability and cool handles. Stainless steel "bowl-grate" can permit continuous TLUD-BB operation. **Both** Natural Draft (ND) and Fan-Assisted (FA) in the same stove; (FA power and fan sold separately).
Handling/operations:	Virtually the same as for Champion, Mwoto and Quad TLUDs. Units with FA offer greater control of fire-power output.
Char-making ability:	Yes, with increased control of airflows that can impact biochar characteristics.
User feedback:	Not available yet.
Accidents reported:	None so far.
Performance data:	Equal to or improved over other TLUD-ND stoves, especially if using the FA capabilities. Expecting Tier 3 and 4 ratings.

Further info: Go to www.drtlud.com for the latest information and reports on usage.

Other comments: Dr TLUD makes the Troika(TM) designs available to all who participate in transparent further development. "Fair play" is expected. Cooperative efforts are encouraged. Stove Camp training for fabrication, household usage, and charcoal or biochar production can be arranged.

Description and Parts List

Basic description: The Troika™ TLUD, either Natural Draft (ND) or Forced Air (FA), consists of two joined concentric containers (cylinders with bottoms and with air inlets) that are supported by a tripod that attaches to the upper and lower areas of the outer cylinder. There are literally hundreds of combinations of materials to accomplish the construction of a Troika TLUD. Variations specific to the Forced Air (FA) versions are marked below in RED.

SHOWN ARE ONLY SIMPLE ASSEMBLIES OF PIECES of metal available from hardware stores in America.

Tripod support structure:

1. Legs (3) of wood (usually ~5 cm longer than the outer cylinder)
2. Upper Support Ring (diameter matching Outer Cylinder, w/ 3 brackets for legs)
3. Under Support (or side-attached with a ring or brackets to the Outer Cylinder)

Cylinders and air control:

4. Outer Cylinder (closed bottom) with air inlets on lower side
5. Inner (fuel) Cylinder, with closed bottom and a primary air inlet
6. Top or Upper Ring that joins the two cylinders (shown at right on inner cylinder, but in a lowered position)
7. Grate (not visible in the picture on right)
8. Primary Air entrance (shown is inlet pipe attached to Inner cylinder)
9. Primary Air controller for FA, and
10. Platform (optional) for support of FA unit
11. Forced Air (FA) unit (optional)
12. Other parts: Screws, bolts and nuts, paint for legs, serial number tag (optional), furnace cement (only used if air leaks are too big).

Draft creation:

13. If with ND, then a concentrator lid plus a 3 – 4 inch riser (such as a cylinder 5 – 7 inches in diameter) is needed. It can be attached to the stove structure as in the tripod pot support of the Champion TLUD built by Servals. Or the upper part (combustor) of a Quad TLUD stove can be used with its attached pot rests, as seen in the photo on page 1.

If with Forced Air (FA), a fan unit (#11 above) is needed (not shown and not required with ND).

Assembly:

The Troika TLUD could be assembled with rivets, tabs & slots, or other ways to hold the pieces together. All pieces can be shipped as flat-packs provided that rolling and closing of the cylinders and the attachment of the cylinder bottoms can be done at the point of assembly.

1. Legs

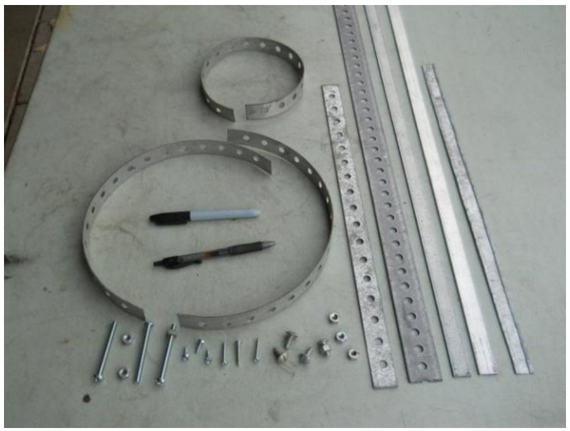
Photos below:
Round or square dowels, minimum 1” (25 mm), unless for a smaller stove.
Shown: 1 3/8” round, 1 1/4” round, 1” round, 1” square, 1” square that has been shaped with yellow shaping tool.
*** Cut to desired length. 48” dowels yield 3 legs of 16 “ each. 36” dowels yield 2 legs of 18” or 3 legs of 12 “.

Photos left and below:
Wooden legs drilled and with bolt and nut for attachment to brackets on Upper Support Ring.

Photo below:
One example of legs assembled with the Upper Support Ring with brackets, plus Under Support of the cross-member style.

2. Upper Support Ring, with 3 brackets for legs.

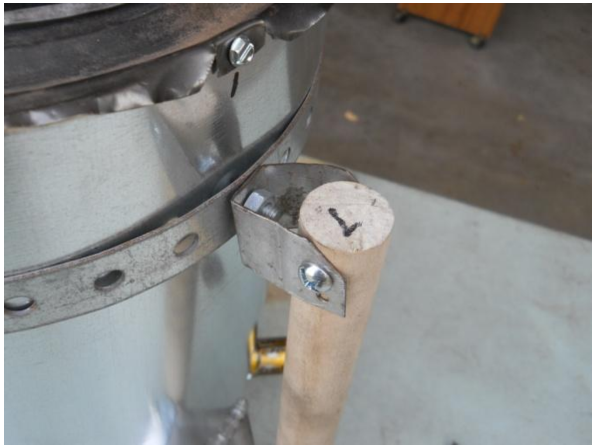
Photo upper-left: The Upper Support Ring can be made of steel bands with pre-drilled holes or flat bands which require holes to be drilled, or of heavier metal with multiple gauges and widths that could be welded. 1” (25 mm) is probably a good minimum width and 3/64” (~1.2 mm) a good minimum thickness, which could be attained by doubling over 24-gauge sheet metal. Aluminum can be used, which is lighter, but may be too flexible to provide adequate support through heavy use (to be determined). Other photos show making simple brackets to be welded (or bolted) to the Upper Support Ring, to attach legs.



Below: Longer bracket gives greater displacement from cylinder.

2. Upper Support Ring, continued

Brackets for securing the 3 legs can be used with bolts and nuts or welding to secure the bracket to the ring. Then screws or bolts/nuts can be used to attach the bracket to the legs. If no brackets are available, the ring ends can be bent to accommodate the leg, and screws or bolts/nuts can be used to attach the leg to the ring.



Shown below is a thinner variation of the support ring without brackets, attached to a typical #10 tin can.

3. Under Support

One style of Under Support attaches to the bottoms of the three legs and provides a base for the outer cylinder structure. The shown design is made from bent steel bands and attached to the legs with screws. It also shows an additional bend to provide support for a bottom of the recommended inlet for Secondary Air. It also provides a support for a Forced-Air (FA) unit, if used.
Another alternative is to use a second ring, similar to the already-discussed Upper Support Ring. Brackets could be made longer to accommodate the extra distance from the ring due to the angle of the legs. An example bracket is shown holding a leg. [Readers are requested to offer other alternatives.]

Cylinders

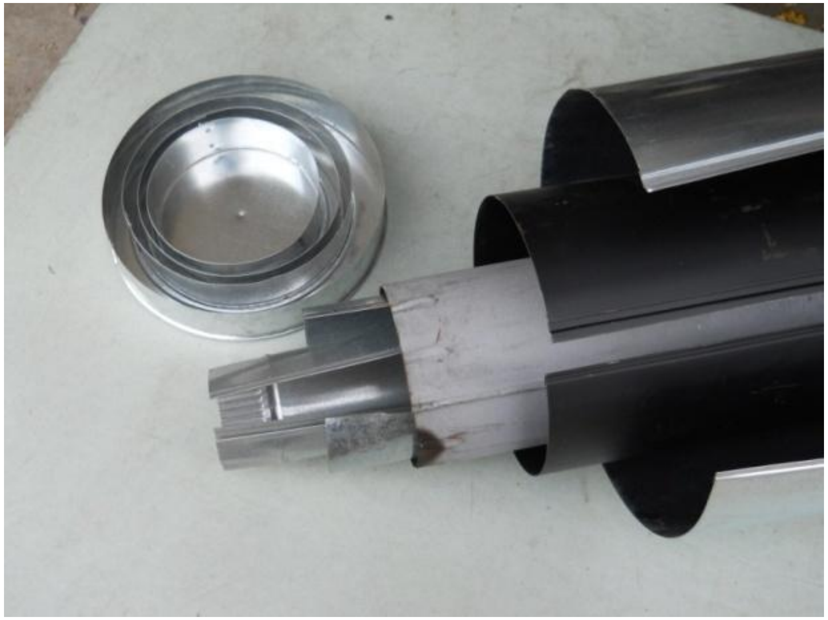
The two cylinders are the most important components, and they can be made in any reasonable way. Ready-made cans and buckets can be among the best sources of cylinders because of mass production and the quality of attachment of the container bottom (see left photo on following slide). At the other extreme, cylinders can be totally fabricated by tinsmiths from sheet metal that is new or recycled "scrap." Between the extremes are cylinders by metal workers who have rollers, "seamers," "jennys," bead rollers, and other useful machines, whether manual or powered.

The fabricator can select the quality of the metals ranging from new stainless steel sheets to scrap mild steel to recycled tin-cans that suit the budget and their availability. Because the physical strength of the unit is in the three legs and connecting pieces, the outer cylinder can be as thin as 28 gauge (and maybe 30 gauge) mild steel. If the outer cylinder is sufficiently strong (and at increased cost), it is probably possible (but not recommended) to attach the 3 legs directly to the cylinder instead of using an upper support band and the lower support pieces.

The height of the cylinder might be determined by the choice of container or cylinder materials available. Commonly, with 24 inch tall ducts readily available in hardware stoves in America, it is convenient to make 2 cylinders that are 12 inches tall. But whether using ducting or flat sheet metal, the fabricator can choose the height.

The use of HVAC (heating ventilation air conditioning) steel ducting or heavier "black stove pipe" is convenient wherever available at local hardware stores. The use of end-caps creates two difficulties: Air leaks and the need to cut through two layers of metal when placing the primary and secondary air inlets. Some extra screws are needed, plus furnace cement or other sealer that will withstand the heat in these areas.

Cylinders, continued



Above left are some example cylinder sources: sheet metal, two standard “tin cans”, a larger steel can, and a standard 5-gallon paint bucket (white).

Shown above right are multiple sizes and kinds of steel for cylinder construction: 10” sheet steel, 8” stove pipe (non-galvanized), 5” closed pipe, 4” pipe, and 3” pipe. Different gauges are available for various sizes, as well as galvanized, non-galvanized, and stainless, at different costs. Some sizes are more difficult to find in certain material types and gauges. Also shown is an assortment of HVAC caps: 10”, 8”, 7”, and 6”.   The use of inches (instead of SI metric measurements) to specify diameters is extremely common around the world.

4. Outer Cylinder / canister, 5-gallon (20 liter) bucket

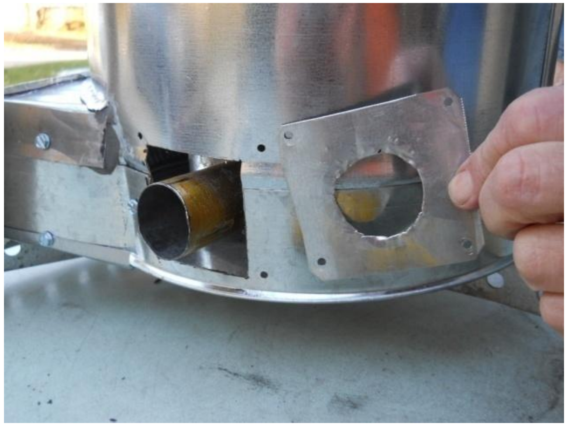
Clean new 5-gallon buckets with lids are commonly available at larger retail paint stores (approx. $7 to $10). The bale (wire handle) of the bucket can be removed. [If the stove is ignited, the user will not want to hold it with a handle directly above the flames.]

The opening for the secondary air on a Natural Draft Troika TLUD-ND can be of **almost** any reasonable arrangement, such as the rectangular hole in the outer cylinder in the Mwoto TLUDs (see photo at right.) However,….

For the Troika to ALSO be able to be with Forced Air, the recommendation is to open a flap of steel (bent on its right vertical edge). [Cutting can be done with a thin-wheel-cutter on a rotary tool such as a Dremel.] The outer edge of that flap is then attached with a screw to a wooden leg, adding stability to the stove (photo on next page). The height of the flap (approx. 3 inches) is not very important in a natural draft (ND) Troika TLUD. But in a forced air (FA) unit, the height should reasonably match the height of the fan unit, which is often 3 x 3 inches (76 x 76 mm).

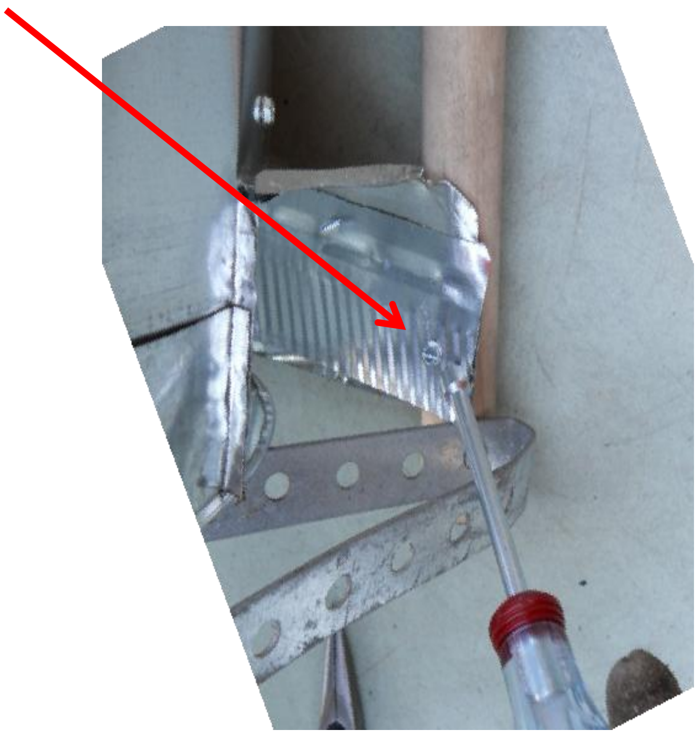
The top cover of this opened flap and the bottom plate (that also can support a FA unit) are not necessary in natural draft (ND) stoves, but the covers do improve appearance and should be included.

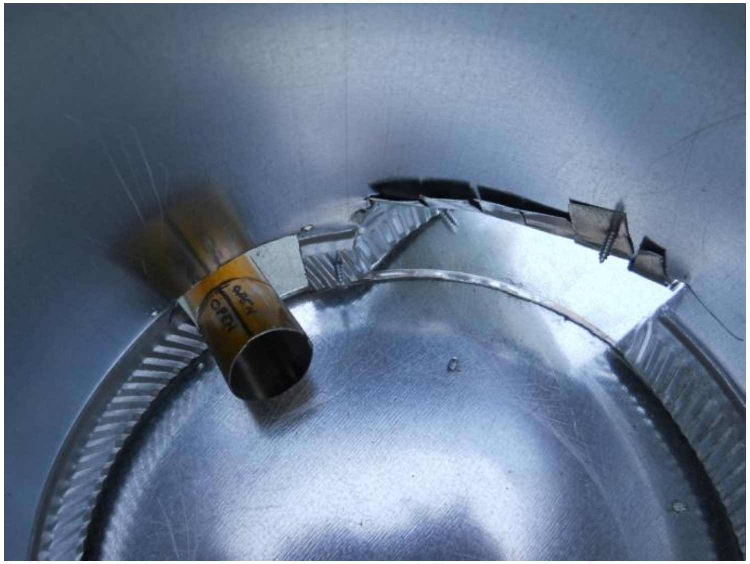
If the stove builder is following these instructions or wants the option to have FA capabilities, then a second opening approx. 5 x 5 cm (2 x 2 inches) is cut into the lower sidewall of the bucket, centered approximately one inch to the right of the bent edge of the flap. This is for passage of the primary air pipe that comes from the inner cylinder. It has a simple cover. See photos. [This is an area for further testing and more variations.]

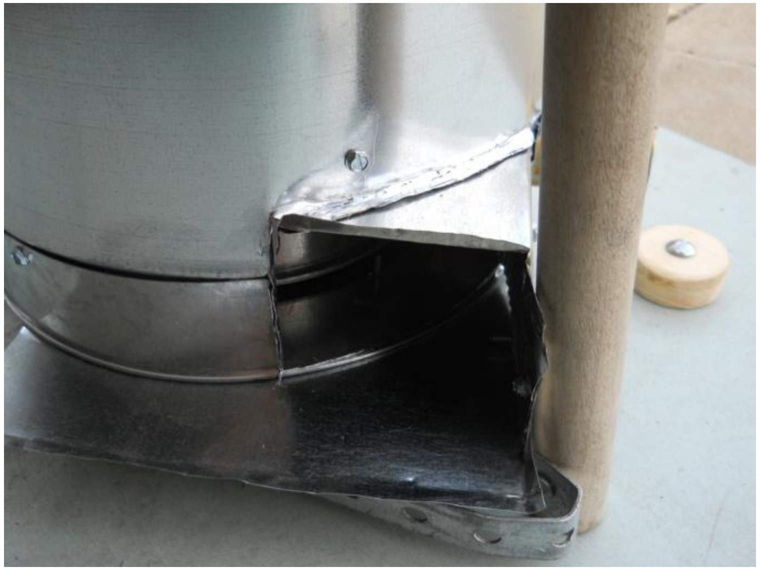


4. Outer Cylinder / canister, sheet metal material

This is very similar to the previous slide about using a bucket with a sealed bottom.
The sheet metal can be with a cap for a cylinder (as shown) or be made by a tinsmith who can attach a good bottom to a cylinder.
Top photo is viewing downward inside the outer cylinder, with a pipe showing position for exit of the primary air pipe.
Second photo shows the platform for the forced air unit.
The size of the square opening is 3 x 3 inches to match the size of a common forced air unit.
A screw secures the metal to the leg.







5. Inner Cylinder (also called Fuel Chamber)-- Bottom

Similar to the outer cylinder, the inner one can be from different types of materials and can have a bottom attached in a variety of way. However, for proper functioning to control the intensity of the pyrolysis and the fire at the top, it is very important that the fuel chamber does not allow leakage of air.

The sealed bottoms can be of several types: One is to use fabricated sheet-steel caps for cylinders such as HVAC ducting . Also, you can attach a bottom mechanically (as in making tin cans) or with tinsmith skills.

We discuss the bottom again concerning the Entrance for Primary Air (#8).

Instead of a regular cylinder, we can also consider the use of corrugated metal roofing as used by Hugh McLaughlin in the Toucan Flex TLUD Biochar maker.

5. Inner Cylinder (Fuel canister) – Entrance of Secondary Air

One type of entrance for secondary air into the fuel chamber can be by holes (shown in two photos to the right.) Diameter and number of holes are topics of research, but 6 – 8 mm diameter spaced at 2 to 3 cm is generally reasonable. Note that the upper edge of the inner (fuel) cylinder Is bent over to form a better seal with the ring.

A second type of entrance for secondary air is by creating a gap between the top of the fuel chamber and the horizontal connector (ring or plate) to the outer cylinder, as done with the Quad TLUDs shown below. Note in the upper photo that The metal tabs are downward from the horizontal plate, and in the lower photo the tabs are upward from the top of the fuel cylinder. Either way works fine. Approx. 1.5 mm gap works well.

6. Top or Upper Ring or Plate

The Upper Ring connects the Outer Cylinder and Inner (fuel) Cylinder. Quad stoves use a plate.

Some example rings (right photo)for the top of the outer cylinder including range-top burner covers and chimney "wall protectors". These rings are used for capping the secondary air chamber.

Similar rings can be used for the "Concentrator disk" that is needed in the Natural Draft (ND) versions of the Troika stove. This disk forces the secondary air to mix with the up-welling combustible gases, with the resultant fame and heat exiting through the concentrator ring.

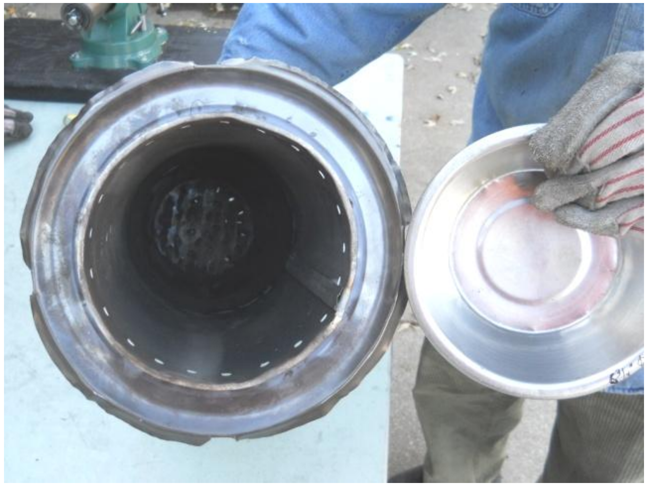
The five-gallon bucket design includes a lid which can be used as a capping ring if a properly-sized hole is cut out of the center. (Photo below.)

7. Grate (Inside the Inner Cylinder)

The grate at the bottom of the Inner Cylinder can be made from a variety of materials. Simple grates of mild steel will need to be replaced occasionally, but can be very suitable is the char is emptied soon after pyrolysis finishes. (photo on right)

However, if Bottom Burning (TLUD-BB combustion) is intended (See *Micro-gasification Terminology* at www.drtlud.com/resources) consider using stainless steel as a more long-lasting alternative,. Some highly appropriate SS items are dinnerware of plates and bowls. Also, pet food bowls, strainers, etc. are excellent and have higher sides that help protect the inner walls of the fuel chamber. (See a selection of SS bowls, etc below center.)

Holes can be made with a hammer and chisel, a metal punch, a drill press, etc. Hole size, number, and placement need to insure that sufficient primary air can enter, but fuel should not fall through the holes. Shown at left are holes that should be larger. Shown at right is a pet food bowl without holes. Holes in the side walls of these bowl-grates are a topic of discussion and research.



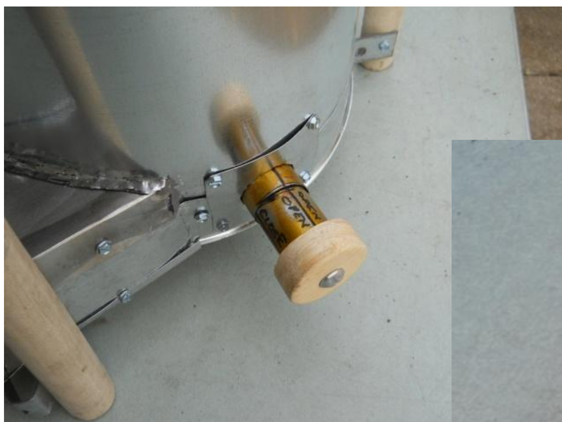
8. Primary Air Entrance

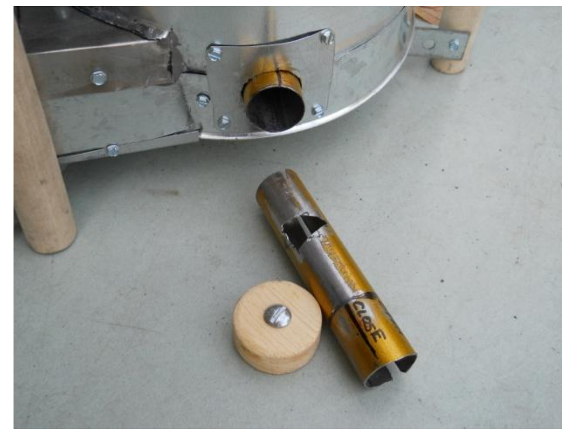
The entry of primary air into the fuel chamber and under the grate can be accomplished in many different ways. The most simple is merely a hole, as in the Champion TLUD by Servals (upper left photo). Other ways are sliders (on Mwoto stoves), box-snouts (on Quad stoves), and pipes as described in the next slides. It is optional but desirable to be able to adjust to allow varying levels of air into the chamber.

Shown are ways to block the in-flow of primary air (clockwise from upper left): Disk on rod; slider on fuel chamber; slider on snout; and snout with blocker piece.

8. Primary Air Entrance - - Pipe

A pipe can be fabricated in several ways. It is optional but desirable to be able to adjust to allow varying amounts of air into the chamber. Construction of the primary air entrance pipe shown below actually uses two pipes which slide into one another, with a hole in each pipe which opens and closes when the inner pipe is turned (see upper-right photo on next page).
Shown is a prototype which uses two pipe pieces of the same diameter, where the inner pipe has been cut lengthwise to allow it to fit inside the other. A hole has been cut to control the air levels. The wooden handle which rotates the inner pipe is removable, as is the inner pipe itself. The outer cylinder has a hole through which the primary air pipe passes, plus a small panel to cover the gap around the hole (photos on next page).





Assembly of Primary Air Entrance (6) to Inner Cylinder (5), with passage through Outer Cylinder (4):

Note the Primary Air Pipe at the bottom of the Inner Cylinder is sealed with furnace cement to close any air gaps.

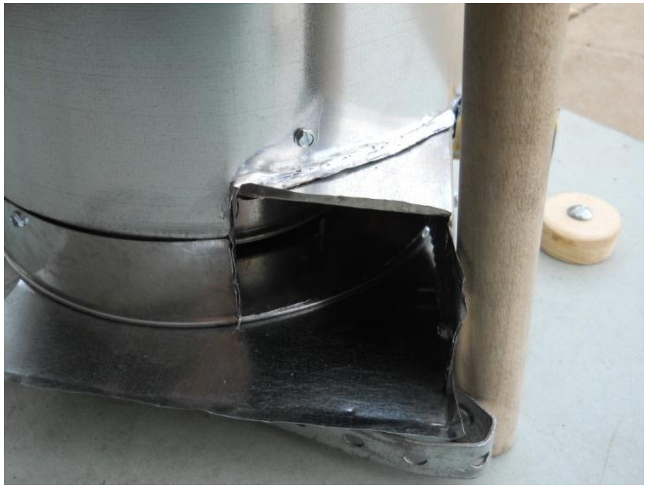
Assembly of Inner Cylinder (with Upper Ring, Grate and Primary Air Entrance) into Outer Cylinder.

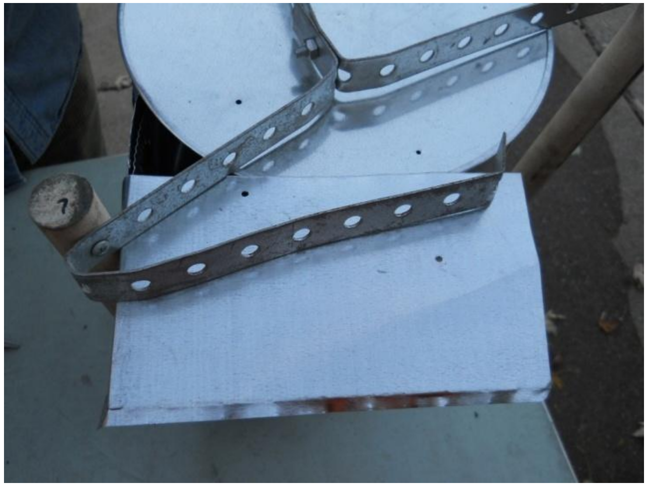
The grate and the primary air inlet (and air controller) need to be attached to the Inner (Fuel) Cylinder. A minimum 2" diameter difference is required between the outer and inner cylinders so that the pipe plus Inner Cylinder can enter into the Outer Cylinder and pass through the hole in the Outer Cylinder. This arrangement places half of the primary air pipe outside for access for controlling the airflow.

Using tabs and screws allows secure attachment and also the ability to easily change the entire inner fuel chamber and top ring for maintenance or to exchange different sizes of fuel chambers. This is especially useful when developing new configurations of inner cylinders, grates, materials, etc.

10. Platform for Forced-Air (FA) Unit

A simple platform to hold the forced-air unit is seen in these pictures. In this design, the platform is a piece of sheet metal attached to the bottom end-cap. Note the additional support from the bottom cross pieces, seen in lower left photo of the bottom side of the platform.



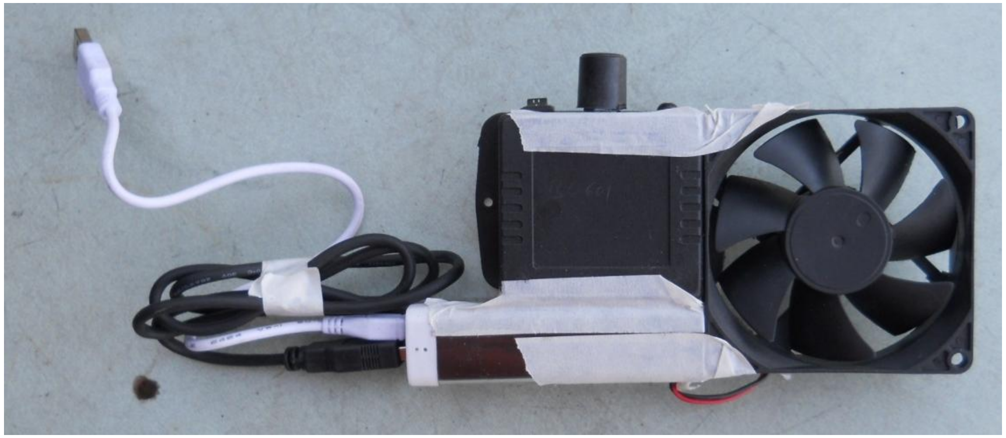


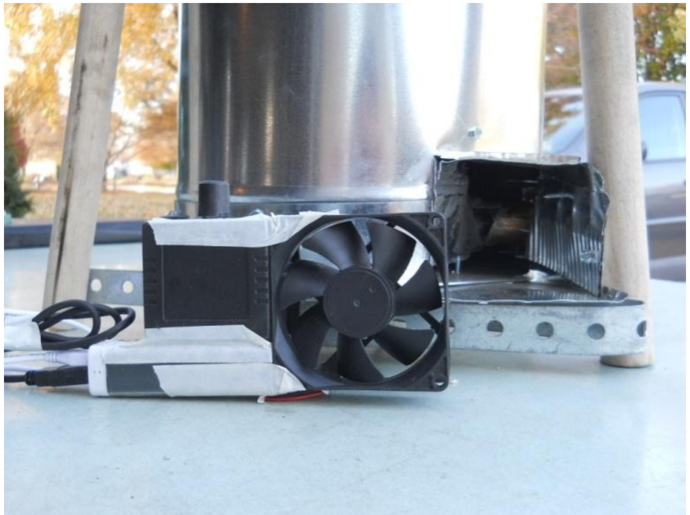
11. Forced Air (FA) unit

A battery-operated fan can be used to control the amount of air entering the primary and/or secondary air chambers. The fan is placed at the opening and is adjustable based on orientation, proximity, and fan speed via electronic control.

Details will be made available later. A quality unit is expected to be less than US$ 10, and eventually much lower.

For experimental purposes, almost any source of force air can be used. Consider using an old hair dryer which will give far too much forced air, so hold it far back from the air inlets.





12. Other parts

Screws: Used for various purposes: attaching legs to supports, attaching metal covers to the outer cylinder, securing the forced-air unit to the outer cylinder, etc.

Bolts and nuts: Used for various purposes: attaching support rings to the outer cylinder, brackets to support rings, legs to brackets, etc.

Paint for legs: Shown in some photos is an orange-colored paint that identifies gasifier stoves in Uganda.

Serial number tags: If serial numbers are desired, these can be stamped/embossed or created by an outside company and added to the stove.

Furnace cement: Furnace cement is used where needed to seal cracks and gaps. In a final design, it may or may not be necessary, depending on the precision of the tools and workers available to join the metal components.

Assembly Rationale and Sequence

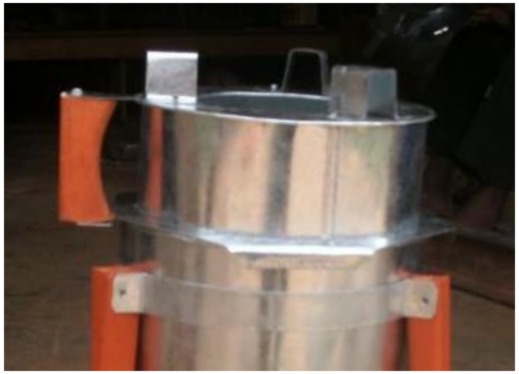
(see also photos on the other pages)

[This section will be expanded further in future revisions of this document.]

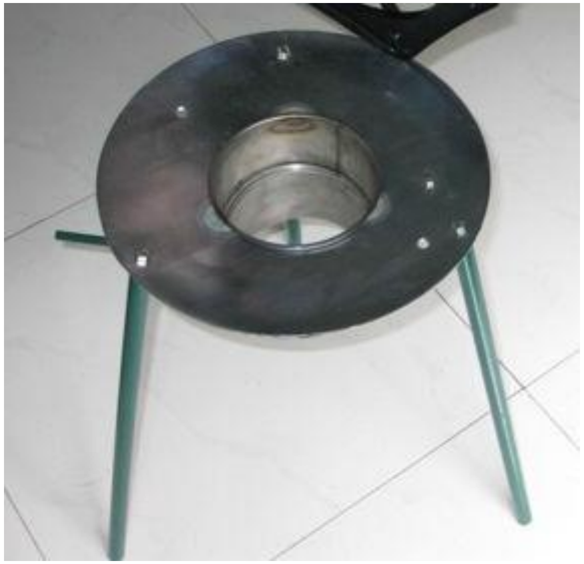
13. Riser for Natural Draft (ND) Operation

If the Troika stove is used with ND, then a concentrator lid plus a 3 – 4 inch riser (such as a cylinder 5 – 7 inches in diameter) is needed to provide sufficient draft.

The upper part (combustor) of the Quad stove can be used, and it has pot rests, as seen in the photos on page 1 and below left.



Also the riser can be attached to the stove structure as in the tripod pot support of the Champion TLUD built by Servals, shown below center and right.



Conclusion

The Troika TLUD is an evolutionary step in the development of micro-gasifier cookstoves.

This document will be updated with the various improvements of the Troika, and placed at:
www.drtlud.com/resources

The Troika™ name is copyrighted only to prevent its usage with products that are not faithful to the basic concepts of the Troika design, which is freely given for Public Domain usage.

Stove developers are encouraged to contribute their experiences and improvements for the benefit of others. Please send comments and photos to Dr TLUD (Paul Anderson) at:
psanders@ilstu.edu