Biomass Gasification: 3-can woodgas camp stove

Dr. Ben Ballard

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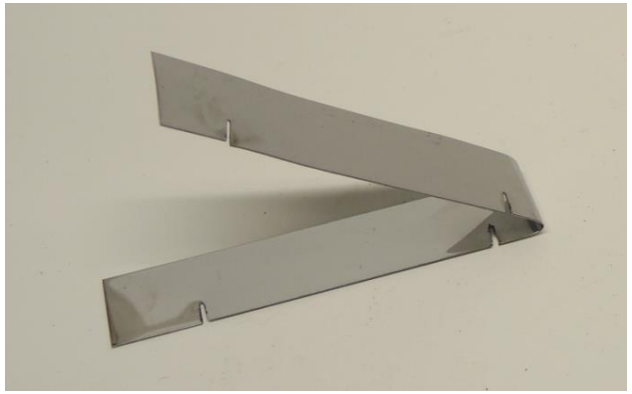
A simple inverted downdraft gasifier with staged secondary/tertiary air → clean, smoke-free combustion

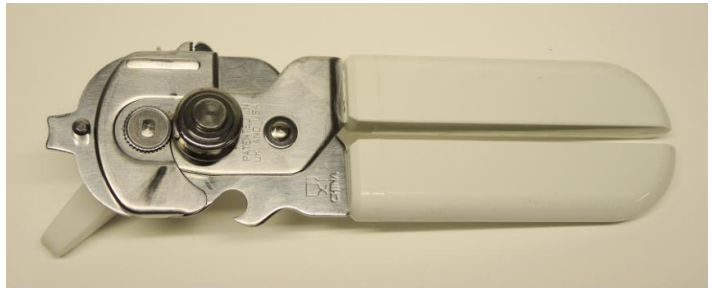
CAUTION: Although these camp stoves generally burn cleanly and efficiently, they will produce **carbon monoxide** (CO) gas and some smoke (tars). CO output is highest during during the charcoal burn. Carbon monoxide is a significantly toxic gas, but it is difficult to detect because it is colorless, odorless, tasteless, and non-irritating. After woodgas flames go out, there is typically a small amount of smoke produced for 30-60 seconds while the stove transitions to charcoal burning. New cans may also produce unpleasant fumes during the first firing. **Therefore, stoves should only be used outdoors with adequate ventilation. These stoves are not toys! Adult supervision required. Never leave any fire unattended**. We recommend using a CO detector & keeping a fire extinguisher on hand.

Materials for construction

- **One 10-oz. "soup" can** (standard or pull top, rounded bottom edges)
- **Two (2) 14- or 15-oz. cans** with pull tops (bottom lid NOT rounded on at least one; bottom lid must be removable with can opener on one can)
- One light gauge steel strip ~1" x 7" long; metal banding from shipping/packing crates works well



Tools



Can opener: safety lid type (preferred)

Awl(s)/punch

Tin snips

Hammer
(recommended)

Half-round file

Permanent marker

Pencil and paper

Recommended: step drill bit (and drill)

Materials for operation

- Lighter
- 1-2 cotton balls
- Alcohol (denatured or isopropyl)
  - We have found this to be a very effective, clean method to start woodgas camp stoves.
- Optional:
  - pot/can (for heating water)
  - thermometer (for testing stove & fuels)

+

Recommended: Claw grabber pickup tool (to insert lit cotton ball into stove)

Fuels

- Wood pellets (or other biomass pellets)
- Wood chips, sticks, twigs
- nut shells
- "other"

- Note that most "simple" (batch) gasifiers (or combustion devices) will perform best with a specific type of fuel.
- For example, a gasifier-stove designed/ optimized for clean gasification and combustion of pellets will probably not perform as well with wood chips (and vice versa)

Step-by-step fabrication instructions

- There are many possible variations on this basic design and construction method.
- The following is an example that works well.

1. Prepare soup cans

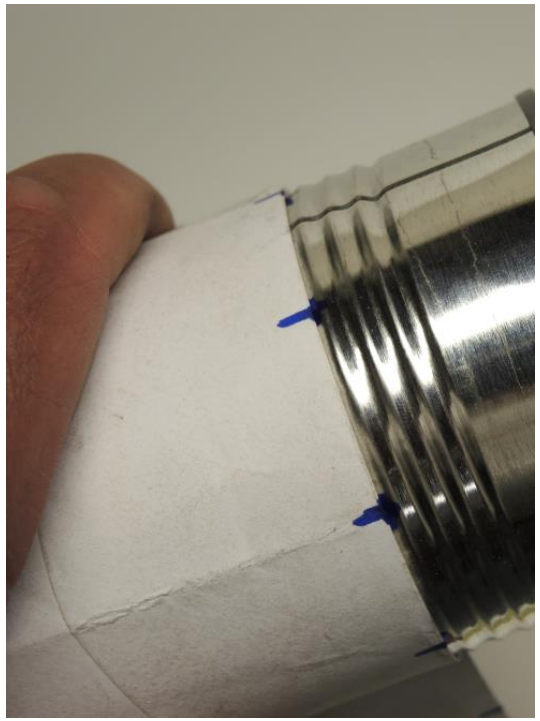
- Remove tops from the three soup cans (if not done already)
- If possible, save the top of the 10-oz. soup can to be used later
- Remove all labels/paper and adhesive
- Do NOT remove the bottoms from the cans

2. Mark out and punch primary air holes in the 10-oz. can

This can will be the inner cowling, which holds the fuel.

3. Mark out 13 secondary air holes on the side of the 10-oz. can, ~1" from the TOP of can.

- To get the hole spacing, wrap a piece of paper around the can and mark the circumference length.
- Using a marker and ruler, mark out **~5/8" spacing between marks** (you should have equal spacing between marks).
- Wrap the marked paper around the can and transfer the marks at ~1" from the top of the can.



<u>Step 3</u>: 5/8” spacing (13 holes)

Wrap this paper around the 10-oz. can and transfer the arrow marks at ~1” from the **<u>TOP</u>** of the can, then make 3/16” diameter holes at all 13 marks.

<u>Step 6 & 11</u>: 1-1/8” spacing (8 holes)

<u>Step 6</u>: Wrap this paper around the 14-oz. can and transfer the marks at ~1.5” from the **<u>BOTTOM</u>** , then make 5/16” diameter holes at each mark.
<u>Step 11</u>: AFTER completing step 10, use the same spacing as step 6, make 5/16” diameter holes ~5/8” from the “top” of the 14-oz. afterburner can.

<u>Step 10</u>: 3/4” spacing (12 holes)

Wrap this paper around the 14-oz. “afterburner” can and transfer the marks at ~1-1/8” from *the end of the can* ***that had the pull tab lid*** *(the original “TOP”)*, then make 3/16” diameter holes at each mark.

<u>Cut along line to make two sets of templates</u>

<u>Step 3</u>: 5/8” spacing (13 holes)

Wrap this paper around the 10-oz. can and transfer the arrow marks at ~1” from the **<u>TOP</u>** of the can, then make 3/16” diameter holes at all 13 marks.

<u>Step 6 & 11</u>: 1-1/8” spacing (8 holes)

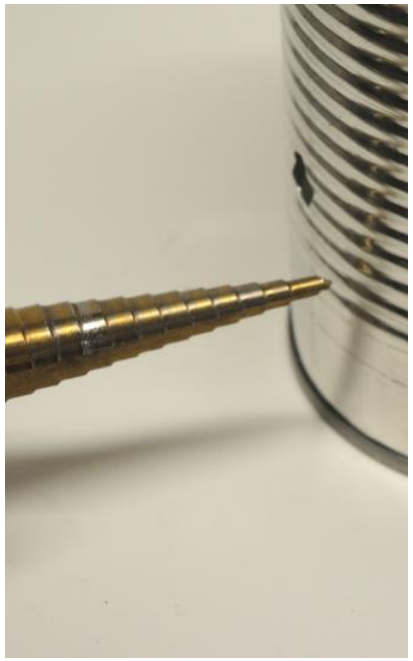
<u>Step 6</u>: Wrap this paper around the 14-oz. can and transfer the marks at ~1.5” from the **<u>BOTTOM</u>** , then make 5/16” diameter holes at each mark.
<u>Step 11</u>: AFTER completing step 10, use the same spacing as step 6, make 5/16” diameter holes ~5/8” from the “top” of the 14-oz. afterburner can.

<u>Step 10</u>: 3/4” spacing (12 holes)

Wrap this paper around the 14-oz. “afterburner” can and transfer the marks at ~1-1/8” from *the end of the can* ***that had the pull tab lid*** *(the original “TOP”)*, then make 3/16” diameter holes at each mark.

4. Punch/drill the 12 secondary air holes in the 10-oz. can, ~1" from the TOP

- Punch (and/or drill) 3/16" diameter holes at each mark, 12 holes total.



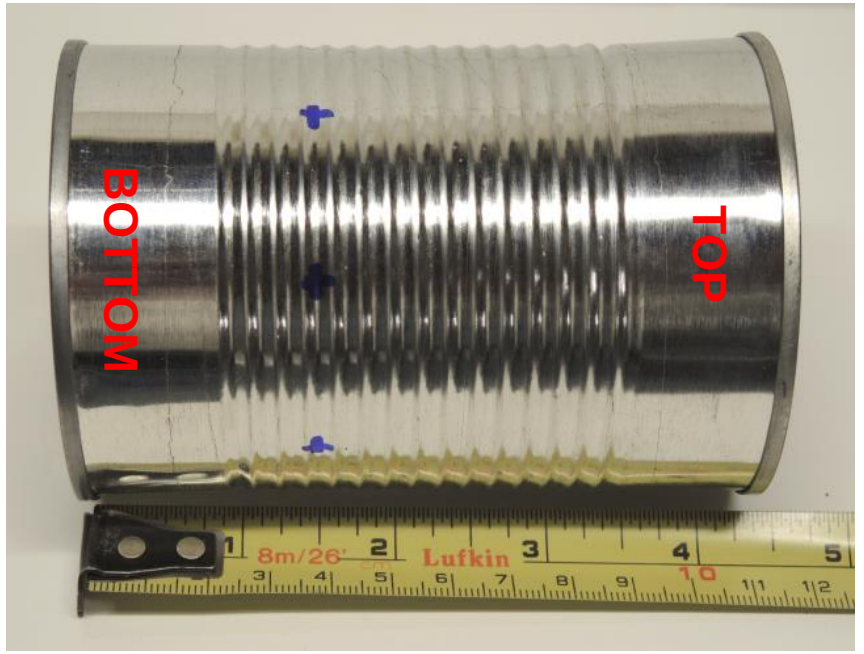
5. Mark out and make primary air holes in the bottom of a 14-oz. can

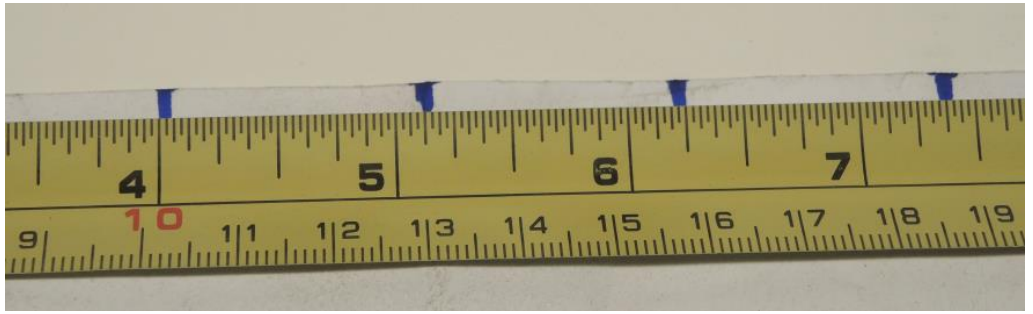
If one of your cans has a rounded bottom, use it for this step.
This can will be the outer cowling.

6. Mark out and make 8 secondary air holes in the same 14-oz. can

- Use the paper method from Step 3 to mark a new spacing template for eight (8) air holes on the side of the can (**1-1/8" spacing between holes**). Save this paper for Step 11.

- These 5/16" diameter holes should be placed ~1.5" from the <u>BOTTOM</u>.





7. If needed, widen the top opening of the 14-oz. cans

- Both 14-oz. can may need to be filed to allow the 10-oz. can to nest inside them.
- Use a half-round file to enlarge the opening(s), as needed.

8. Place a metal spacer in bottom of 14-oz can.

- Use a piece of bent metal banding (or the lid from the 10-oz. can if you have it) as a spacer in the outer cowling (bottom 14-oz. can).
- This bent metal should hold the 10-oz. can (inner cowling) off the bottom by ~7/8" when nested inside the 14-oz bottom can (outer cowling).

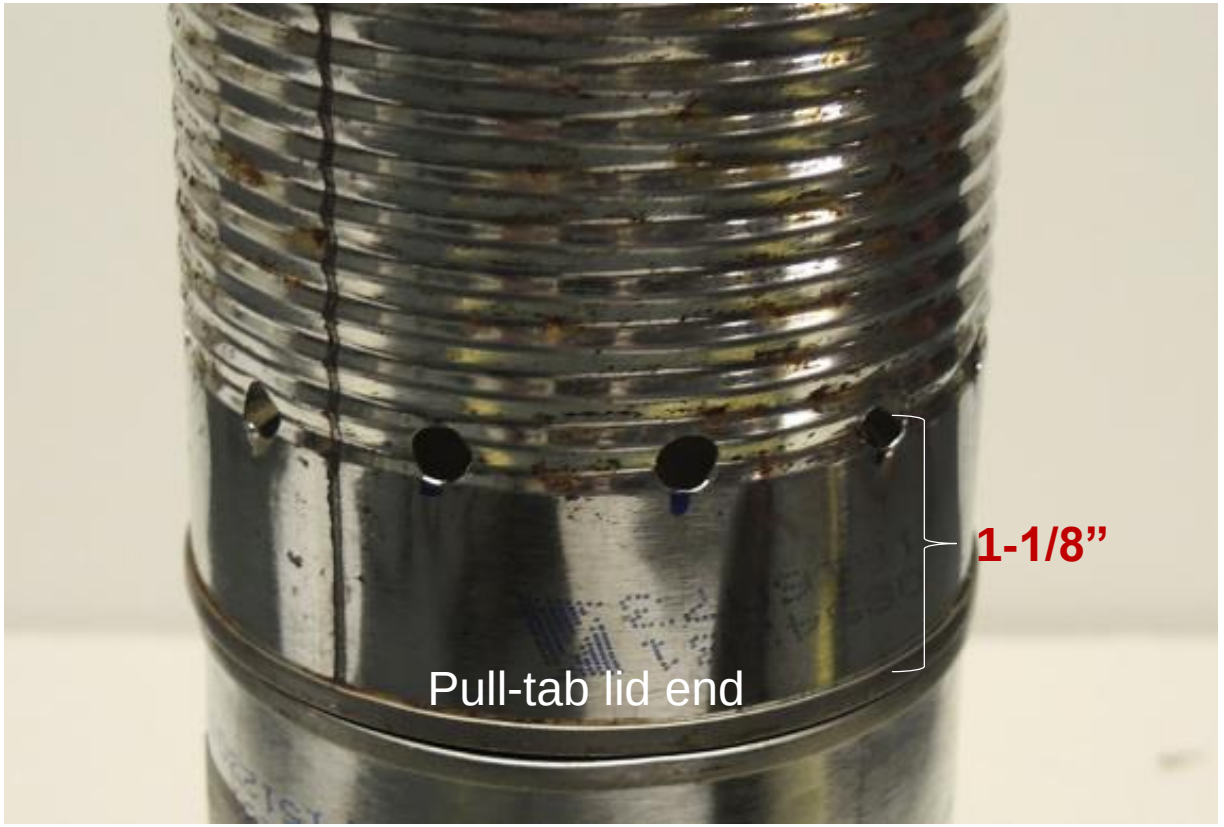
9. Nest inner and outer cowlings

- Nest the inner cowling (10-oz. can) inside the outer cowling (14-oz. can), with the bent metal placed in the bottom of the outer cowling.
- When fully inserted, the inner cowling should extend ~1/2” above the rim of the outer cowling.

10. Prepare the afterburner 14-oz. can by adding a set of "secondary" air holes.

- Use the paper method from Step 3 to mark out **12 air holes** on the side of the can (**~3/4" spacing** between holes).

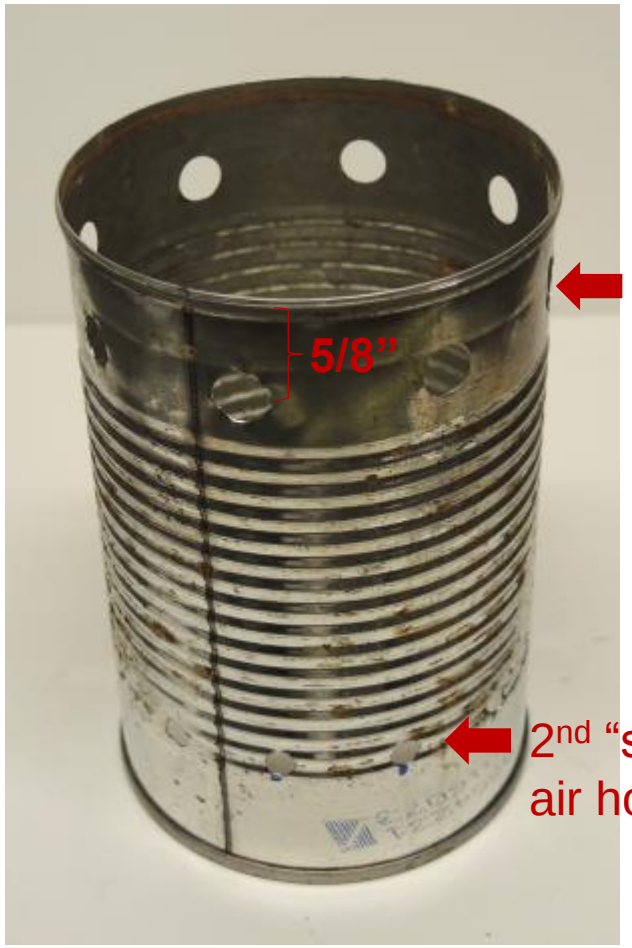
- These 3/16" diameter holes should be placed ~1-1/8" from *the end of the can that had the pull tab lid (the original "TOP")*.



11. Finish preparing the afterburner 14-oz. can, adding a set of "tertiary" air holes.

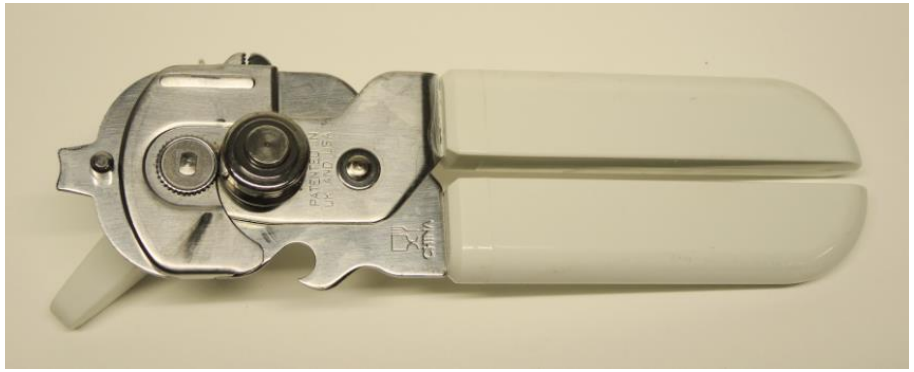
- Use the paper template from Step 6 to mark out eight (8) air holes on the side of the can (1-1/8" spacing between holes).

- These 5/16" diameter holes should be placed ~5/8" from the "top" of the afterburner can.



12. Remove the bottom of the other 14-oz. can, which will be the "afterburner"

- Using the can opener (safety lid type works best), remove the bottom lid from the "afterburner" 14-oz. can.
- This end of the can will be the **top** of the afterburner.



13. Place the afterburner on top of the cowlings

- Place the afterburner on top of the nested cowling cans.

- The afterburner can should fit snugly over the inner cowling can, so that it does not fall over easily.
- If needed, small metal "shims" (folded strips) can also be added to snug the fit.

14. Option: Create a pot support with the 1" wide flat stock.

- Bend the flat stock to form a "V" that will rest on the top of the top can.
- For additional stability, you can cut* ¼"-long slits to allow the pot support to slide onto the top of the can.

- *e.g., cut using tin snips, a rotary tool with cutoff wheel, or hack saw.

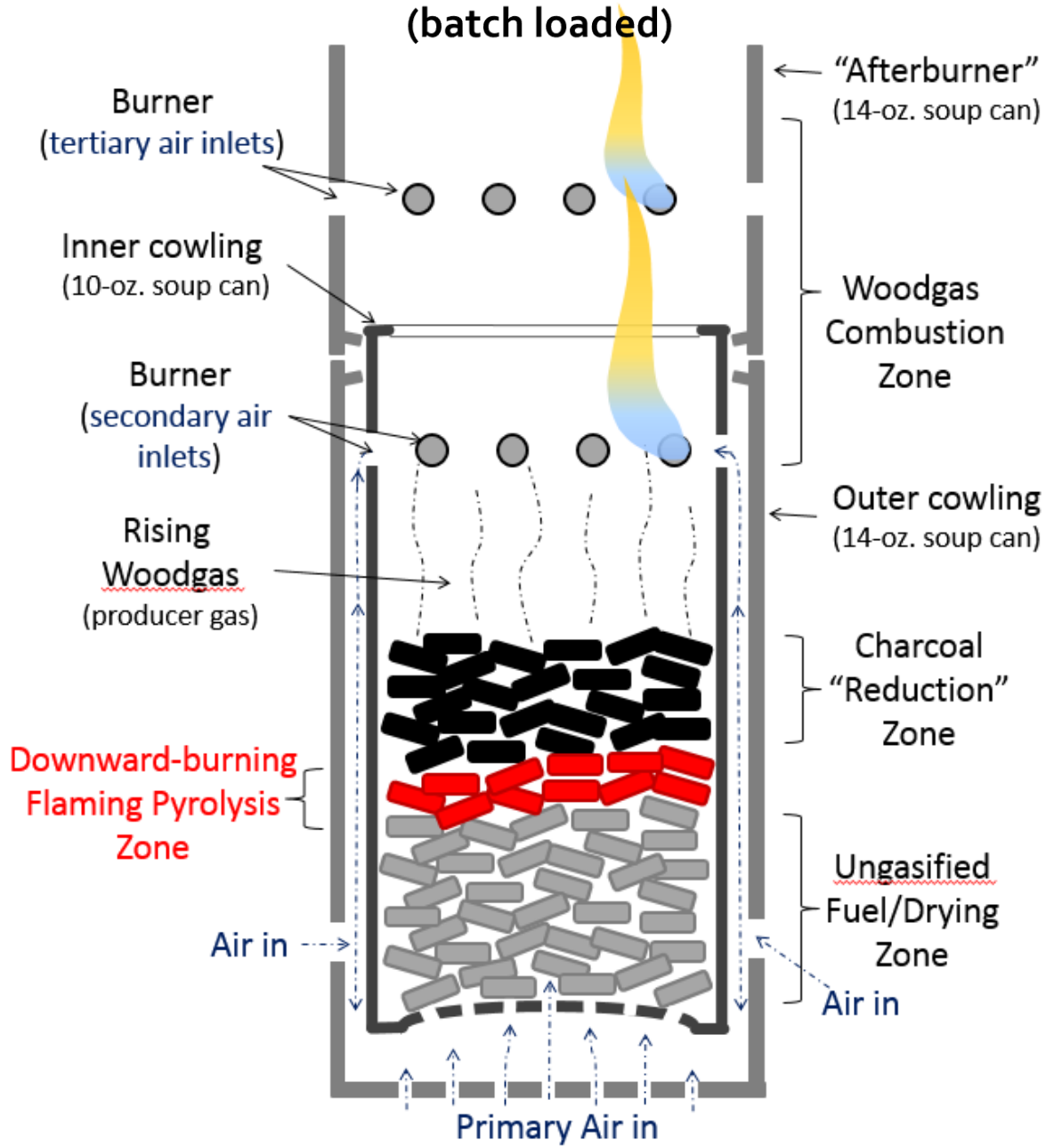
Completed stove

- Your stove is now complete!
- You can use another can or pot on top of the stove to heat/boil water.

- See the operating instructions on the following slides.

"Inverted" Downdraft Gasifier

(batch loaded)



Operating the stove with biomass pellets

- Load the fuel into the stove (into the 10-oz. can/soda can).
- ~½ cup of biomass pellet fuel will provide a reasonably good, long burn, and boil water.
- To light the stove, use 2 cotton balls partially saturated with alcohol.
- Place the cotton balls on the **top** of the pellets, and ignite with a lighter.
- It will take 3-5 minutes for the pellets to burn sufficiently to begin producing "woodgas" (you'll know when the flames shift to the first set of "secondary air" holes).
- This is a batch loaded system, burning from the top down, so **don't** add fuel (or disturb the fuel) after lighting it, as this will change the "zones" in the stove, resulting in very smoky operation.

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