**TECHNICAL NOTES ON OVEN TRAILERS,
BY DAN WING**

Kiko asked me to write a section about trailers for mobile ovens because I have built several of different kinds, and because I have a trailer-mounted oven that is still going strong ten years after I built it.

First, though: I agree with Kiko (and with the staff of American Flatbread) that for many purposes, building a temporary oven of rocks and mud, or of earth alone, over a platform of bricks that can be assembled and broken down on-site, is a better choice than a mobile oven. The reasons?

It is expensive to build a trailer strong and safe enough to haul an oven. Such a trailer is going to need a car or truck that is heavier than it is (preferably with four-wheel drive) to pull it. So if you already have a rig that can haul rocks, bricks, and dirt, you might want to spare yourself the extra cost of the trailer. It is easier to store a pile of rocks than a trailer and there is something about trailer tongues and trailer lights that seem to invite accidents — barked shins in the dark, lights smashed on unseen rocks, runaway trailer events that wreck the side of the neighbor's Honda. This accident-prone behavior is seen even in trailers that are parked and in use, because they take up more space than the oven alone would, and they are ungainly. Another practical difficulty is a basic, physical mismatch between masonry construction and moving down the highway: you will always be dealing with the vibration of the trailer versus the brittle, crack-prone nature of masonry.

Many times, the oven is going to be used in a context (school, camp, workshop, Creative Anachronism or Renaissance Faire gathering) where labor is plentiful, people are potentially bored, and the project of building, using, and breaking down the oven can be an important part of the group process. Trailers that are strong enough for an oven don't have much aesthetic appeal, and that may not help set the mood for your gathering.

On the other hand, there are needs and situations that can be best met by a mobile oven. For example: a catering business or a focaccia business, where you bake every week at a farmer's market. A trailer oven allows you to avoid overhead expenses (and some of the fire and health laws) because you are a food peddler, not a store.

So, let's assume you are going to have a mobile oven. It does not have to be on a trailer. You could build it onto a flatbed truck and drive it around that way (there is a great masonry-oven catering setup built onto an antique truck near New Haven, CT, and oven trucks are relatively common in Europe). Truck beds are relatively high, and that gives you a convenient height for the hearth. If you have to use the truck for other uses, build the oven into a metal cradle with a ring on top, and lift it out with a suitable hoist as necessary — I have seen an outfit like that in Point Reyes, CA. Just use common sense about the combination of motor fuel and fire, by opening the oven toward the back of the truck, or on the side away from the fuel tank and filler.

BASIC CONSIDERATIONS

1. Make sure your tow vehicle is adequate to the task.
2. Build a trailer from scratch, using rubber-sprung torsion axles. These combine a spring effect, a shock absorber effect, and cross-bracing for the trailer frame. This will be stronger and safer than anything you can make from the wrecking yard.
3. Use two axles. This will allow the heavy mass of the oven to stay balanced over the wheels.
4. Specify "free backing hydraulic brakes" for the axles, and install a hydraulic surge coupler as the trailer hitch. This ensures that the trailer brakes will always come on when you step on the brakes, and eliminates the need for a brake controller in your tow vehicle.
5. The metal deck for your oven should be part of the trailer's overall structure. The roof framing can be welded onto the deck, and will further stiffen it.
6. Since even the best trailer probably won't be able to keep a true mud oven intact, you'll need to build a dome from stronger material, either brick, or refractory cement, or both. At the very least, it will be more expensive than plain mud.
7. Weight considerations will limit how much mass you can easily build into a mobile oven. This may limit you to pizza and other flash-roasted foods, and perhaps a single batch of bread.

THE DETAILS

There is little good published information on building trailers. The one common series on the subject, Trailers, How to Design and Build, by M. M. Smith (Techni-Visions, Downey, CA), is not well written. I have found it better to rely on pdf. downloads from the corporate websites of parts manufacturers (such as Dexter Axle) and the large, free, illustrated catalogs of trailer parts wholesalers (such as Lucky B Trailer Parts) to see what is available and how to use it.

Some opinions based on experience (Please forgive the use of technical terms that will be explained later):

• For the best combination of low weight, structural integrity, and towability, it is better to build a trailer

dedicated to and designed with the intetnet of having oven mounted on it than to adapt an existing trailer. The exception is a multiple-use trailer on which you place the oven for special occasions, using the trailer for other purposes at other times.

• It is better to spend the money to buy new parts designed for trailer use and sized to your needs than to adapt old car, truck, or trailer parts. This is especially true for axles, wheels, and braking systems. An unsafe trailer is a weapon of mass destruction.

• Hydraulic or so-called "surge" braking systems are the easiest to set up and most reliable in operation, and become increasingly favored as the weight of the trailer and load increase. It is never safe to operate a brakeless heavy trailer on the road.

• The center of gravity of a trailer and its load should be kept as low as possible to reduce its tendency to roll and sway. If you need the hearth of the oven to be high for baking convenience, figure out how to raise the trailer and/or the oven up when you are parked, and keep the COG low when on the road. (I park my oven on a broad mound in my yard. The hearth height is thus improved when I am standing on the lower grade of the yard. Alternatively, take special ramps with you to pull the trailer up on when you get where you are going, or engineer a jack system to lift it safely up.

• Rubber damped torsion-sprung trailer axles are the easiest to install and set up. They also provide the smoothest ride for the oven and reduce the shock transmitted to the towing rig, Because the torsion tube becomes a rigid side-to-side part of the frame of the trailer, and because you eliminate heavy metal springs, torsion axles reduce overall and unsprung trailer weight, making for easier towing.

• If you use a conventional "straight" trailer axle with metal springs (which I do not advise) you may want to use (longer, more compliant) truck springs with shock absorbers and (preferably) an anti-sway bar. Trailer springs are short and stiff, and will provide a rough ride for the oven. Don't use truck springs without shock absorbers, though, as truck springs could allow up and down and side-to-side flexibility and may allow the trailer to set up a dangerous high-speed sway, tossing from side to side.

• Two-axle designs (so-called tandem trailers) with the trailer's center of gravity located near the center of the suspension (but far enough back to provide consistent "tongue weight") will sit somewhat level even when the tongue is not jacked up. Don't consider a single-axle design. Balancing the weight over one axle is an invitation to disaster — even if that axle has the rated capacity to hold it up. The trailer's tongue weight (downward load on the hitch) will vary too much as you go up and down hills, throwing the tow rig around.

• The distance from the trailer hitch to the axle(s) should be longer than you think. The main cause of poor trailer stability at low speed is a tongue that is too short, and a trailer with a short tongue is more difficult to back up.

• The tongue weight of the trailer should be at least 8% of its loaded weight, to reduce trailer pitching and sway. The maximum tongue weight is determined by the weight of the trailer and the rated capacity of the tow vehicle; too much tongue weight will make steering and braking unsafe. A goal is 10% of the trailer's loaded weight, and it should not be more than 15%. Design the tow hitch and trailer hitch/tongue so the trailer is approximately level when hitched.

• The tongue system of the trailer should be part of the frame of the trailer, either by having the frame rails extend to form the tongue or extending separate tongue members well back under the frame of the trailer to provide adequate structural attachment.. It is better to have a triangular tongue configuration than a single tube (T-bar), but a T-bar is acceptable if it is stiff enough (thick-walled) and extends well under the trailer.

For the unique construction of an oven trailer:

1. Form a 14 or 16 gauge sheet metal pan (4-5 inches deep) that will serve as the trailer "bed." It will also serve as the form for a) a thin insulating vermiculite/concrete or pumice/concrete layer and b) a thin, reinforced full-strength slab that serves as your hearth base.
2. Before you pour concrete into the pan, you can weld fore and aft frame rails (box beams) to the underside of the pan, with the correct spacing to accommodate the axle mounts.
3. If you don't attach the axles permanently at this time you can install the axles in their final positions after you have built the oven, which makes it easy to get their locations correct with respect to the center of gravity.
4. You will need a transverse crossmember of similar dimension securely welded between the stringers under the front (and back) of the pan, to prevent twisting of the bed and to support of the "legs" of the tongue, as they course back to end under the side stingers.
5. You do not need large crossmembers in the middle of the frame under the oven, but between and outside of the fore-and-aft stringers stringers you should weld a grid of stiffening webs (tacking them up to the pan as well) to reinforce it without adding much weight. They perform the function of the cross-sills in a conventional trailer, allowing frame/pan structure to create lightweight, stiff, unitized substructure for the masonry elements, while keeping the oven's center of gravity low.
6. You can weld stub pockets into the corner of the pan to catch the roof supports, and (if the oven door is at the rear of the oven) you can form a hearth-level shelf.

Differences between conventional and oven trailers:
Running gear for CONVENTIONAL trailers consists of:
1. spring perches and shackles between the frame and the springs,
2. longitudinal metal springs,
3. straight axles hung from the springs,
4. wheel spindles welded to the ends of the axles,
5. Brake baking plates bolted to the ends of the axles to hold the brake parts,
6. brake parts (operating mechanism, with shoes and links) attached to the backing plate,
7. wheel hubs, which contain the lubricated bearings that ride on the spindles,
8. brake drums for the shoes to work against,
9. wheels, and
10. tires.

I have mentioned that the lack of compliance of metal springs makes for a bumpy ride for the masonry. It also means the tow vehicle is jarred by a strong longitudinal tongue force (trailer tugging backward) when the wheels of the trailer encounter a bump. The entire axle assembly represents an undesirable mass, called "unsprung weight" (because it is supported by the road but not by the springs) and the vertical force that accelerates this mass upward over a bump has a horizontal component that is transferred to the tow vehicle as a longitudinal shock. Because the springs and shackles introduce a plane of flexibility between the axle and the body of the trailer, the strength of the straight axle(s) cannot be considered as a side-to-side stiffener (crossmember) of the trailer frame, so in conventional trailers additional weight is devoted to strong transverse steel elements to hold the longitudinal stringers in place.

You can avoid these problems by using rubber-sprung torsion axles. The style appropriate for an oven consists of a rigid tube (usually square in sectional view) welded to flanges near each end. The flanges can be bolted or (carefully) welded to the longitudinal stringers of a trailer frame. Within the square tube are two high-strength steel stub axles, one at each end, with rubber cords trapped inside between tube and axle stub. A short (roughly horizontal) crank arm is welded to the outboard end of the stub, and a brake backing plate and wheel spindle are welded to the other end of the crank. The crank is always set up to "trail" the axle. When the trailer is loaded, the stub axle turns slightly inside the tube, loading the rubber cords, which act as the springs.

When the wheel hits a bump the crank is twisted up and away from the bump, further compressing the cords inside the tube. Because the wheel moves smoothly away from the bump, and because the unsprung weight is low (basically just the weight of the wheel and the brake) there is almost no bump effect on the tow vehicle and little jarring of the load. Also, the rigid tube can be counted on as part of the frame of the trailer, eliminating heavy side-to-side framing under the oven. The starting angle of the crank can be ordered in several positions, so it is easy to get the trailer and oven center of gravity low, while preserving ground clearance. Also, up to three axles can be used without requiring mechanical links (equalizers) between them (such as are necessary with conventional axles). When you order the axles, specify:
a) the load capacity of the axle,
b) the overall width (brake drum outer surface to brake drum outer surface) you need,
c) the crank angle, and
d) the location of the flanges that attach the tube to the trailer (according to the spacing of your stringers).
The cost of each axle, including hydraulic free-backing brakes, wheels, and tires, is about $450 for 3,500 lb axles.

Brakes, lights, fenders
Conventional electric trailer brakes can be energized by the electric signal from your brake light switch, and there are many problems with this arrangement, and it is not recommended. Some of them can be overcome by using a separate trailer brake controller mounted below your dashboard, but that is an extra expense and complication. Hydraulic brakes are a much better option, especially for something as heavy as an oven. In this system, the hitch on the trailer is joined to a brake master cylinder that is progressively pressurized as more and more longitudinal braking load is experienced by the hitch: the harder you brake, the harder the trailer brakes come on, automatically. There is no direct hydraulic connection to your tow vehicle, so it even works if you shift gears down on a hill, and the trailer brakes are set up to automatically come on full if the trailer comes unhitched or breaks free. "Free backing" brakes at the wheels mean you do not need to place a bolt in the hitch to lock out braking when you back up — a great convenience. The hydraulic hitches cost about $130, plus $10 for a connection kit.

I like to temporarily bolt the flanges on the torsion axle to the stringers while I build the oven (or whatever I am attaching to the trailer structure), then set up the hitch, THEN adjust the position of the axles on the stringers to get the tongue weight I want before permanently bolting or welding them in place. Then I plumb the brake lines and wire the lights. All states require trailers to have some kind of fenders, and they can be built onto or attached to the metal pan that supports your oven. Lights are also always necessary, and may require an

electronic adapter from an auto parts store, if the tow vehicle has separate brake and turn signal bulbs. Tow axles, hitch, lights, and steel for an oven/trailer might run to $1500 if you can weld it yourself.

Notes on ovens:
Clay, mud, earth, and cob are not going to be good choices for a trailer oven, as road vibration will cause cracking and/or breakage. The other possibilities are:
a) solid refractory,
b) segmented refractory (modular) with a retention band of some type and,
c) brick dome with (concrete) cladding.
All of them are going to start with an insulated slab base, covered with firebrick.

Solid refractory: Refractory cements utilize a different chemistry than conventional Portland cement, which loses half of its strength at temperatures of 750 degrees F. They cannot be mixed with Portland, but are mixed with aggregates to make refractory concretes (or can be bought pre-mixed — wet or dry— as concretes and mortars).

Rigid metal reinforcement is inadvisable in a refractory mass exposed to great temperature swings, because the mass and the metal expand at different rates. However, thin, crimped metal rods may be used to join a refractory mass to a surrounding structure, like a trailer. The crimping increases the holding power of the reinforcement and shortens the length of each section of the rod, reducing expansion stresses.

A refractory dome is formed like an earth dome, over a sand form. The innermost layer of refractory is full strength and weight and about 2" thick, and followed immediately with a layer in which half of the dense aggregate is replaced with pumice, vermiculite, or non-siliconized perlite, followed by a layer mixed with lightweight aggregate only, which can be covered with a layer of tinted stucco. You may want a thermocouple probe at the boundary of the inner and middle layer, half way up the dome, if you are going to use a battery powered thermocouple temperature gauge.

Segmented refractory: Imagine that you peeled an orange, cut it in half at the equator, separated the half-segments, and then set them up on their cut ends in their original orientation. That is how some modular oven builders (such as Le Panyol) make their formed-refractory modular oven kits. You can put spacer sections between the tapered sections to make the oven longer or wider, if you like — to make it a little squared off or oblong to use the space on a trailer more efficiently. Because the segments are not going to meet perfectly well at the top, you can make a round, slightly tapered keystone of refractory for the top of the oven, and form flats on the top ends of the wedged sections to match. You make a special segment to form the doorway, with shortened wedges above it. All the other sections can be made in one mold, one at a time. After everything is in place, you have to either bind the segments together with a steel band around the outside (as Le Panyol does) or you pour a reinforcing buttress around the base of the arch wedges to keep them in place. You mix up a mortar slurry (quite thin), cover the hearth with plastic or paper, and work the slurry into all the gaps with gloved hands to seal the dome. Then you can insulate it and protect it as you wish.

Brick: Several ovens like the one Alan Scott and I describe in our book have been successfully built on trailers. The reinforced cladding holds the brick in place as you barrel down the road. As designed, though, the oven is going to be rather heavy for this application. That is because the emphasis in that design is on having enough mass for several bakes of loaf bread. If you are going to be primarily doing pizza or roasting, or if one bake per firing is sufficient, you can modify the design by turning the arch bricks sideways, to make the arches a little more than half as thick as the basic design, on a hearth that is again laid flat instead of on edge. You may want to omit the chimney, or you can make the chimney recess and stack out of metal, so you can clip it into place when you are firing and baking, and carry it in the back of the truck when you are on the move. There also is a free design for a round oven (the Pompeii) on James Bairey's website (Forno Bravo) which could be built in a 2-2" thickness (plus reinforced cladding) for mounting on a trailer.

Roof: My oven's roof consists of four box-tube posts up to gables (rafters) of box-tube, with lightweight box-tube stringers (purlins) to support formed-metal roofing, held on by neoprene-gasketed screws. I made the handles of my oven tools the same thickness as the purlins, so I can shove them lengthwise under the roof (over the gable structures) when I don't need them.