

# ALL Power Labs: Tools for Power Hacking



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**The Science of Biomass Gasification**

**Gasifier Types**

**How to Build a Gasifier**  
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## The Gasifier Experimenters Kit (aka: the Lego gasifier)

The Gasifier Experimenters Kit (GEK) offers beginners through experts an easy way build, compare and customize a wide variety of gasifier reactor types and configurations. Whether you're a DIY enthusiast or a university researcher, the GEK will get you over the starting hurdles of biomass gasification, and on to the more rewarding work of refining specific architectures, testing fuels, and making power.

## Other Designs Online

### Gasifier System Components

### Technical Resources

[Gasification Workshop \(June, 08\)](#)

The GEK kit is designed in a modular fashion which allows for easy switching between common reactor types and operating regimes. Each "reactor type" is a separate assembly that bolts into a common "gas cowling and ash handling" base. [See here for the full list of planned GEK reactors](#). Within each reactor type, relevant variables are easily adjusted and sub-assemblies are simply replaced via standardized "bolt to" flanges.

The result is a Lego system of gasification- a motivated and flexible building system enabling you to run, compare and share results over a wide range of architectures and commonly discussed --but rarely implemented-- "expert configurations".

## Getting Started in Downdraft Gasification

The default reactor offered for the GEK system is a nozzle and constriction (Imbert type) downdraft reactor. An Imbert downdraft is the usual starting point for generating low tar wood gas to power internal combustion engines. The GEK version combines all common [Imbert type variations](#) into a single configurable reactor, with easy adjustability of all critical dimensions. Here's what it can do:

- variable combustion / reduction zone size and shape (tube, bell, inverted V, hourglass)
- variable air nozzle position and size
- air preheating (or lack there of)
- active tar recycling into incoming air
- variable air injection architecture ([air from top, bottom, or side annular ring](#))
- "monorator" type condensing hopper
- rotary grates/stirrer additions

The GEK Imbert reactor is delivered with a default configuration known to produce clean syngas when operated by a knowledgeable enthusiast. This default

configuration will run 5-20hp engines. Other GEK configurations will support up to 50hp engines. (typical disclaimers apply, given the variability of fuels and human operators)

- [Pictures of fully assembled GEK with downdraft reactor](#)
- [GEK reactor dimensions, general gasifier sizing charts, and other resources](#)

## Performance

To be clear, the GEK is not a turnkey wood gasification unit. It does not guarantee 24/7 hands free operation right out of the box. Such is usually a dubious claim anyways, given the fuel sensitivity and use variability of all small-scale gasifiers. What the GEK *does* promise is a highly motivated building and configuration system, enabling you to build, run and test all the best ideas in small scale biomass gasification. In the hands of a knowledgeable operator, the GEK will produce excellent results. And once you do achieve your performance goals, the [GEK manufacturing scenario](#) gives you an easy way to set up formal manufacturing of your solution in your local area.

## GEK Community

The expertise to support the GEK is the responsibility and opportunity of its community of users. We encourage the growth of specific set up suggestions, use reports, and quantitative data via the project wiki and general community collaboration. A basic instrumentation set comes with the full GEK kit, so you will be able to share quantitative data with others- maybe even help advance the general state of gasification.

The GEK design particulars and manufacturing technique are open source and well documented (see the [downloads page](#) for details). You are welcome to use this common

base "operating system" to build new "applications", "widges" or other customizations- whether open source or proprietary. Or to put it in gearhead terms, the GEK is the proposed "small block chevy" of gasification. It is now your job to build the better cams, carbs, cranks, and manifolds to make it go faster. . .

We invite you to join the GEK community of collaborative science and open source engineering.

Questions? Contact: [gek\\_at\\_allpowerlabs\\_dot\\_org](mailto:gek_at_allpowerlabs_dot_org)

















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[forward to Gasifier Experimenters Kit](#)

## Gasification

Gasification is the use of heat to transform solid biomass, or other carbonaceous solids, into a synthetic "natural gas like" flammable fuel. There are a wide variety of processes which fall under this general term- but all share the characteristic of transforming solid hydrocarbon material into simple hydrocarbon gases. The resulting gaseous fuel is usually called: "syngas", "woodgas", "producer gas", "generator gas" or "suction gas".

Through gasification, we can convert nearly any solid waste biomass into a clean burning, carbon neutral,

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[Gasification Workshop \(June, 08\)](#)

gaseous fuel. Whether starting with wood chips or coffee grounds, municipal trash or agricultural waste, the end product is a flexible gaseous fuel you can burn in your internal combustion engine, cooking stove, heating furnace and/or flamethrower. Upmigration to liquid fuels is also possible with some additional effort and common catalysts.

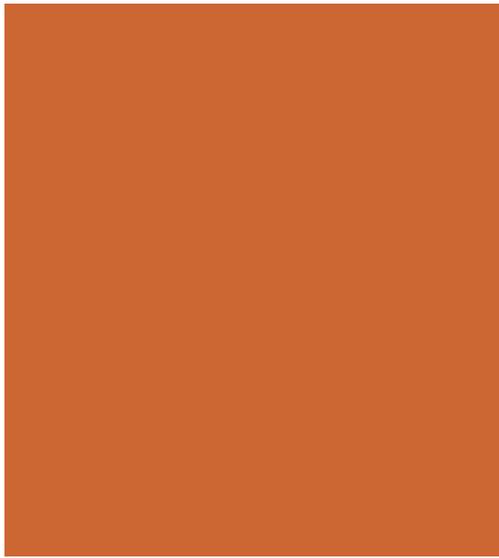
Sound impossible?

Well, over one million vehicles in Europe ran onboard gasifiers during WWII to make fuel from wood and charcoal, as gasoline and diesel were rationed and/or unavailable. Long before there was biodiesel and ethanol, we actually succeeded in a large-scale, alternative fuels redeployment-- and one which curiously used only cellulosic biomass, not the oil and sugar based biofuel sources which famously compete with food.

This redeployment was made possible by the gasification of waste biomass, using simple gasifiers about as complex as a traditional wood stove. These small-scale gasifiers are easily reproduced (and improved) today by DIY enthusiasts using simple hammer and wrench technology. The same principles are applied at much larger scale and complexity to recover a wide variety of municipal, agricultural, construction, forestry and industrial waste to energy, soil amendments and other useful end products.

ALL Power Labs now offers the [Gasifier Experimenters Kit \(GEK\)](#) to help you get starts in the biomass thermal conversion arts and sciences.

Questions? Contact: [gek\\_at\\_allpowerlabs\\_dot\\_org](mailto:gek_at_allpowerlabs_dot_org)





## The Quadrafire Gasifier:

A learning gasifier rig of updraft, downdraft, crossdraft, and fluidized bed on a single frame.

*Jim Mason.*

*Jan/Feb 2007*

*Sept, 08. See updated gasifier at: [Gasifier Experimenters Kit \(GEK\)](#)*

Recently I tired of my ever growing notebook of complex gasifier designs, all unbuilt, and decided to just get started building some simple and quick ones. It seemed far more would be learned by building multiple ones in quick iteration, using readily obtainable obtainium, than trying to straight out build the imagined "perfect" one. The process turned out to be vastly more educational than I ever imagined.

I decided to build one of each of the 4 main types of gasifiers (updraft, downdraft, cross-draft and fluidized bed) on the same frame and at the same size, allowing for easy comparisons between types. (ok, maybe I will eventually need a TLUD and a cyclonic one too, but for now, a 4 in 1 covers my main interests.)

To make it interesting (and fast and cheap), I decided that I could only build with junk i had lying around the shop, and a few home depot parts. Purposely

quick and crude and without any specialized parts. While learning, I was also curious to see how absolutely simple and hammer and wrench fab tech these can be made with. Expensive McMasterCarr orders and complicated heat recycling and embedded processor temp and mixture sensing/control will come later.

The result is the "Quadrafier Gasifier "

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## V1.0: Updraft



[all updraft pictures are temporarily here](#)

On New Year's Eve 06/07, several friends and I built our first gasifier using an old 2x tank air compressor set. I was a bit stunned how easy it is to build and get basic gas, as well as how flexible it was on fuels (which I later learned was only the case with updraft designs). Of course this was tarry and wet gas, but it burned clean as nat gas on your stove. even running coal. clean coal is not a myth . . . ;-)

The pictures at the link above show a short chemistry lesson on what is happening to educate the locals. welding and plumbing. then coffee drying on the wood stove, then filing the coffee grounds into the unit. set up of unit in yard. various lighting attempts, with success after awhile. then some poofs on a combined fuel of coffee and wood. then the hot tub and champagne reward afterwards. (we were trying for midnight new years eve, but didn't actually get it fired until 1am.)

We ran it on sawdust, cubed wood, coffee grounds and coal dust. all worked fine, but the coffee grounds were very difficult to get to light. though once lit, they burned fine. it should really run on any biomass that is reasonably dry and dense.

The tank we used is 6" in diameter and about two feet long. I put an angle fill pipe about 2/3 of the way up. the gas outlet is an existing 1/2" pipe fitting in the tank. The distance difference between fill point and gas outlet was to encourage dust settling, and used a gravity loop for the air in at the bottom.

As i have been long confused about the grates, and didn't have anything to use that was fine enough or heat resistant enough, i decided that a pipe protruding to the center of the tank in the base, and then curved upward outside the tank, would allow air in and not allow fuel out. my other main reason for this was that i wanted to be able to run dusts, like coal dust and coffee grounds, which seemed like a difficult proposition for grates. so gravity was engaged, and gravity proved to work rather well.

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## V2.0: Open Hopper Stratified Downdraft



[all stratified downdraft pictures are temporarily here](#)

The stratified downdraft was built from the same 2x air compressor tank as used for the first updraft. as for fuel, we ran: pellet wood, sawdust, coffee grounds, coal dust, coal chunks, pizza crusts, pistachio nut shells and cardboard. the pellets ran well, as did chunk coal, but the granular and loose paper fuels packed up more than in the updraft. makes sense, as in an updraft,

the draft is working against gravity. but not yet a fluidized bed.

tar seemed modest, but it was difficult to really tell, as much time was spent starting and stopping and getting fuels packed in it, during which the cool running would produce tar. but once hot, things seemed ok, though i don't have a tar testing rig set up.

we piped the gas into a 5kw genset, a typical 10hp briggs and stratten generac type. using a ball valve and some pipes, we made a wood gas "carburetor", retaining the original carburetor butterfly as the throttle. then we started the engine on gasoline. turned the gasoline off, fiddled with the air/woodgas mixture, and it continued to run just fine. we were all a bit stunned. soon we were making sparks with the power out of the generator.

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## V3.0: Crossdraft Gas-Can-i-Fier

The crossdraft unit was built from a 5 gal jerry type metal gas can. the existing fuel bung was piped with 2" black pipe for the gas exit, using some stainless steel mesh for the grate. The air inlet is movable so the distance between air inlet and grate can be varied for different load conditions. plumbing reducer couplings on the end of the air inlet allow for easy changing of air inlet volumes.

I did not allow myself to use the welder for this version. The only power tool used in the making was a drill and an angle grinder with a cut off wheel to make the fuel loading hopper. The fuel hopper doesn't even have a hinge other than bending the metal back to fill it. It doesn't get much easier than this. Build time: 4 hours.

We are running wood pellets in the pictures below. The first run melted the sealtite electrical flex conduit i was testing, so i went back to the flexible exhaust pipe and aluminum tape.

The sealed hopper proved to be much more sensitive to fuel moisture than either the open hopper stratified downdraft, or the updraft. On the first real run, it started strong, but was quickly overwhelmed by steam from the drying fuel inside the gasifier. Seeing the increased sensitivity to fuel moisture with the sealed hopper design was rather interesting. The argument for an open hopper or monorator type design clear.





# The gasifier in your shirt pocket (aka: the cigarette)

Packing cigarettes into a 1.5" black pipe "gasifier". 120 cigarettes (six packs). Aluminum foil is a poor attempt at insulation.



Cigifier cart and lighting the flare



Cigifier running a 10hp, 5kw generac generator (but not for very long), before ungasified cigarettes attempt immaculate passage through engine (unsuccessfully).



Sept, 08. See our current gasifier at: [Gasifier Experimenters Kit \(GEK\)](#)



Sept, 08. See updated gasifier at: [Gasifier Experimenters Kit \(GEK\)](#)

[Home](#)

## The Basics

How it works  
History (and  
Future)

Biomass as Solar  
Energy  
Pathways of  
Biomass

Conversion

[The Mechabolic  
Hypothesis](#)

## The Science of Gasification

Four Core

# Woodgas Pickup Truck

For the first "Power Exchange" workshop in March 07, our project was to convert a 1975 GMC pickup truck to woodgas operation. And do as such in one weekend. We didn't quite make the "one weekend" goal, but at some point the following week we did find ourselves with a working gasifier unit, driving around West Oakland and Berkeley, on nothing but wood pellets and grins.

The weekend workshop started Friday night with a not-so-short lecture, by me, on the technology, history and future opportunities of gasification. I smoked cigarettes (a readymade gasifier), heated steel pipes full of coffee grounds to make pyrolysis gas, and ran my little demo [Quadrafier](#) into a typical Home Depot 5kw generator. Saturday and Sunday was building, noon to nine each day, with about 15 people total. The names of all participants are at the bottom of this page.

Processes  
How a Match Burns  
Product Gas/Char  
Variability  
Biomass Fuel  
Variability  
Terra Preta

I purposely did not preacquire any materials for the workshop, or even really settle on any particular design or sizing before the weekend. I was interested in what we could do starting with nothing. Well, nothing on top of full fab and machine shop with lots of junk lying around, and a year plus of reading about everything "gasifier". So not really "nothing", but nothing purchased directly in preparation to do this. We tried to use only things readily available in most junkyards.

### Gasifier Types

4 Problems, 1000  
Solutions  
Updraft  
Downdraft  
Crossdraft  
Fluidized Bed  
Top Lit Updraft  
(TLUD)  
Entrained Flow  
Kalle  
Mason

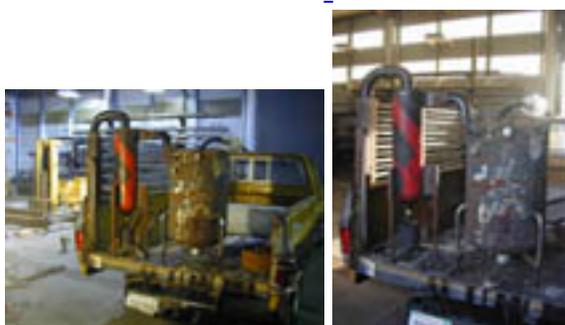
The finished rig is admittedly a bit of a carnival of gasification. No attempt was made to have it small, tight and discrete. On the contrary, the goal was to have all the systems exposed and exploded for easy teaching and demonstration. It is likely a beauty that only a gasification geek can appreciate. And maybe John Rinaldi too (aka: Chicken), the truck's current owner..

Pictures of the "finished" truck are below.



### Demos and Experiments

[Quadrafier \(4 in 1\)](#)  
[Gas-can-o-fire](#)  
[Cigifier](#)  
Toilet  
[GMC truck](#)



### How to Build a Gasifier

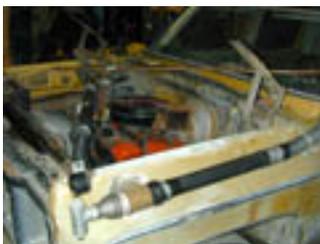
One Minute  
Designs  
One Hour Designs  
One Day Designs  
One Weekend  
Designs  
Design Your Own  
Sizing Calculator  
Other Designs



Online

**Full Gasifier  
Systems**

- What is Needed
- Particulate Filtering
- Coolers/Radiators
- Carburetors
- Plumbing
- Engine
- Modifications
- Fuel Pre-processing



**Technical  
Resources**

- Gas Charts
- Flow and Sizing  
Tables
- Common  
Conversions
- Sizing Calculator
- Test Equipment  
etc
- etc
- Links



Pictures of the construction process are at the following links.

[Les Young pictures](#)

[Phil Glau pictures](#)

[Jessica Hobbs pictures](#) (first firing attempt)

## Participants in Workshop and Fabrication

Jim Mason, Jessica Hobbs, Chicken John, Phil Glau, Alec Plauche, Les Young, Bruce Arneson, Steve Nelson, Roger Carr, Eric L. Forsman, Kiko Almund, Dov Jelen, Caroline Miller, Chris Schardt, Patrick Buckley, Dann Davis, Darrel Licks,

## Notes on Construction

We decided to start with the most simple type of downdraft gasifier: the stratified downdraft, based on the Reed/LaFontaine design in the FEMA, [Building a Simplified Downdraft Gasifier](#) book.

Our main variation on standard construction was to make the firetube easily replaceable. In fact, in the end our "gasifier" tank is really only a gas cowling and ash catcher. Firetubes or any other gasifier hearth center design can easily slide into the center and bolt down. This easy change out of the critical hearth/firetube section makes experimentation much easier, as well as adjustment of the gasifier size to match gas flow needs. Running all the "tubes within tubes" at the same time, down to the desired smallest one for fire, also creates excellent insulation of the operating firetube. We can restart the gasifier without a match after a full night of rest. The heat retention is exceptionally good with essentially a three or four wall tank.

Here's what we used in construction.

- a 25 gal propane tank, 14" in diameter, is the starting fire tube, with a 50 gal vehicular propane tank making the external gas cowling.
- inside this cowling, we can insert 12, 10, and 8 inch firetubes at the moment. more variations to come soon.
- the cyclone is made from a 8" diameter welding bottle with hvac reducers press fit inside to establish the needed taper.
- the radiator is 4" square tubing for tanks, with 3/4" emt conduit as the tubes, with the galvanizing removed in acid before welding.
- the dry filter is a shop vac filter in a 5 gal bucket
- the carburetor is a pipe T at the stock air cleaner inlet, with a butterfly valve on the air side. the butterfly in the stock carburetor is the throttle, as usual. gas is shut off to the carburetor to change over to woodgas. both woodgas and air pass through the stock air filter.
- plumbing is shop vac hose after the radiator. before the radiator is all steel drain piping, hard welded.

*more details coming soon.*

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[test reports](#) - [downloads](#) - [purchase](#)

## GEK: *Gallery of GEK Versions*

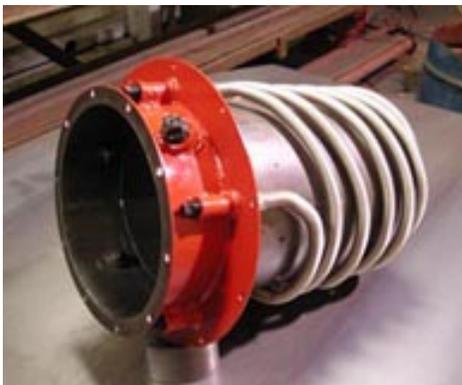
### **GEK V1.0 - V1.1: July/August, 2008**

*Full kit: Downdraft reactor, gas cowling, hopper, cyclone, filter, vac/blower, burner, plumbing, instrumentation*





*Air preheating / syngas cooling stainless steel heat exchanger*





### *Plumbing and Instrumentation*



***High vac centrifugal blower***





***Rotary ash grate, gas cowling and swirl burner***



***GEK kit at various levels of part count, welded state, and assembly/disassembly***





**GEK V0.9: June 18, 2008**

*Full GEK kit assembled, including temp and vac instrumentation*



*Newly combined cyclone and packed bed filter*



*Stainless steel air preheating tubes after running*



**GEK V0.8: May, 2008**

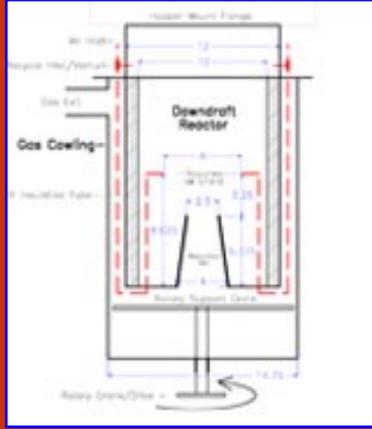




## GEK V0.7: March, 2008

External Gallery: <http://theshipyard.org/gek/index.html>

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## GEK: *Reactor Options*

Below is the full list of planned separate bolt-in reactors for the GEK system. We are starting with the nozzle and constriction (Imbert) downdraft type, as this is the usual desired starting point. Later in 2008 we plan to introduce a reactor to support common open core / stratified downdraft and multi-point air injection types, then followed by another reactor to support common pyrolysis designs for controlled biochar production. Later in this process we will introduce more complex reactors like fluidized beds and cyclonic types. Later still, maybe it will be you who offers the microwave or plasma arc bolt in reactor for the GEK . . .

List of planned GEK reactors

1. Downdraft (nozzle and constriction / "Imbert")  
[pictures in gallery](#)
2. Downdraft (open core / stratified downdraft, multi-point air injection)
3. Pyrolyser (direct and retort, batch and continuous rotary/auger)
4. Updraft and TLUD (top lit updraft / inverted stratified downdraft)
5. Crossdraft and Kalle
6. Fluidized Bed (bubbling and circulating)
7. Cyclonic/Vortex/Swirl





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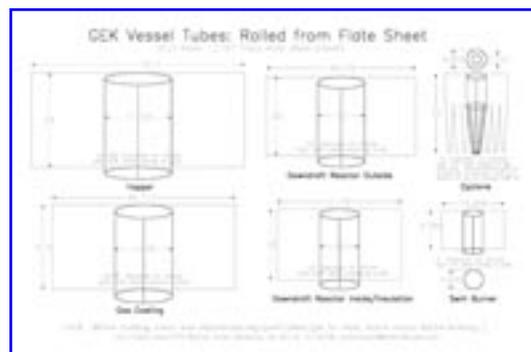
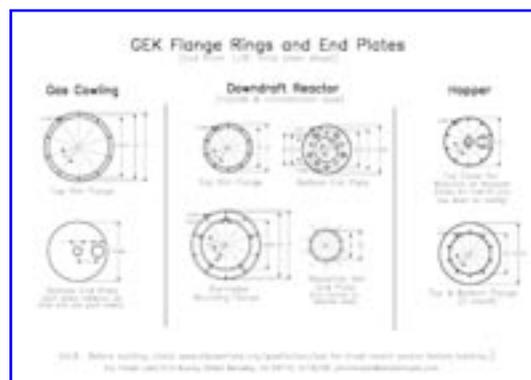
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## Gasifier Experimenters Kit: *Manufacturing Strategy*

The GEK is easily manufactured at small or large scale using standard sheet steel. No dimensioned metal or other specialized shapes are required.

The sheet steel is cut into three basic part types: vessel tubes, flange rings, and end plates. Here are the CAD drawings for all parts to form the hopper, gas cowling, downdraft reactor (nozzle and constriction type) cyclone and swirl burner:



The resulting parts are pictured below. (left to right: hopper, gas cowling, downdraft reactor and insulation tube, cyclone, and swirl burner)

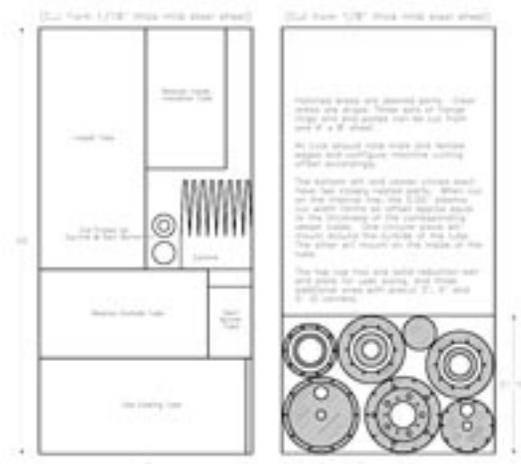


[more pictures](#)

The full set of vessel tubes is cut from one sheet of 4' x 8' mild steel (1/16" thick). A typical three wheel manual roller forms the flat parts into cylinders. All the flanges and end plates are cut from one third of a 4' x 8' sheet mild steel (1/8" thick).

Below is the layout pattern for the 1/16" and 1/8" sheets. Note the nesting of "rings within rings" for the flange rings and end plates. The width of a plasma cut is about equal to the 1/16" vessel tube thickness. Therefore the offset between the outer and inner cut parts corresponds nicely with the outer and inner diameter of the related vessel tube. This layout method minimizes wasted material and cut time, while insuring a perfect "on dimension" fit. The flange rings and end plates also second as the the "jig" to final form the tubes

to true round before welding the tube seams



The ALL Power Labs shop cuts these part with a CNC plasma table that achieves 0.05" accuracy to the CAD drawings. The parts can also be cut by hand with a handheld plasma torch and a homemade protractor to guide the torch around the circles. For larger production runs, the pieces could be punched, likely also with a reduction in metal thickness. We are using metal that is thicker than necessary as it easier for the end user to weld and modify.



To simplify shipping, the kit is designed so vessel tubes nest inside each other like a "Russian Doll". Flange rings and end plates similarly bunch into a thin pancake. Total package dimension: 24" x 17". The weight is below 150lbs, so it can ship UPS ground, avoiding the hassles of freight shipment. The tube pieces can also be left unrolled and the entire kit shipped as a flat package.



Here are [pictures of a fully assembled GEK unit](#) built from scrap tanks and manufactured plates.

All GEK parts and assemblies are built on location at the ALL Power Labs shop in Berkeley, CA, USA.

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## GEK: *Frequently Asked Questions*

sorry, still in progress . . .

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[GEK Report #1:  
Air Preheating Tubes: Zero Tar Gas](#)



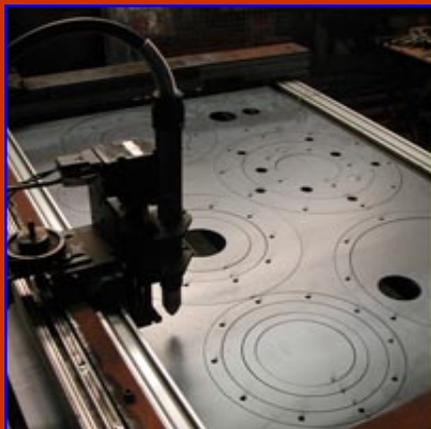
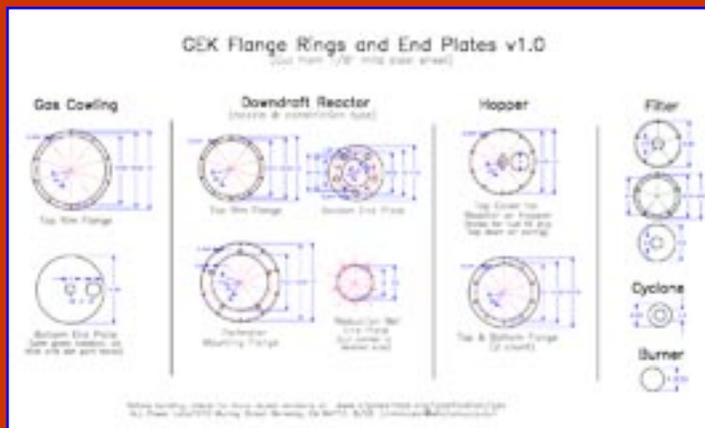
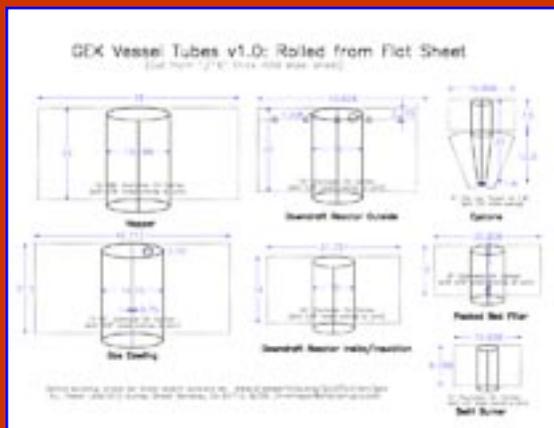
[GEK Report #2:  
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## GEK: *Downloads*

Here are the various dimension, documentation and instruction files for building the GEK. The files are version controlled so make sure you are working with the most recent version. G-code files and/or tool path corrected .dxf files for CNC plasma cutting are also available on request.

In addition to the sheetmetal parts described in the CAD drawings, you will also need the following [plumbing and auxillary parts](#) to assemble the unit.

## Gasifier System Components

### Technical Resources

[Gasification Workshop \(June, 08\)](#)

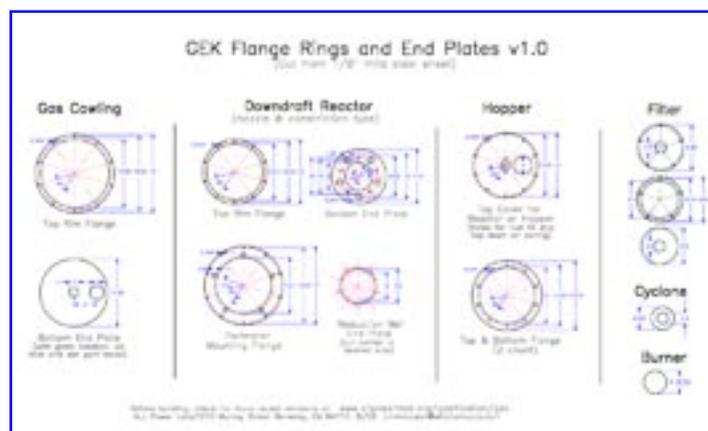
Sizing info for downdrafts and other configuration info is on the [resources page](#)

All the below material is open source and actively supported by ALL Power Labs. You are welcome to use it for any personal or non-commercial fabrication. We request you acknowledge the source and similarly post documentation for updates and/or new additions you come up with for the GEK.

Using these materials for commercial manufacturing requires a licensing agreement with ALL Power Labs. The licensing fee is a simple 10% on retail sales. If you are going in this direction, please contact Jim Mason at "gek\_(at)\_allpowerlabs\_(dot)\_org for more details.

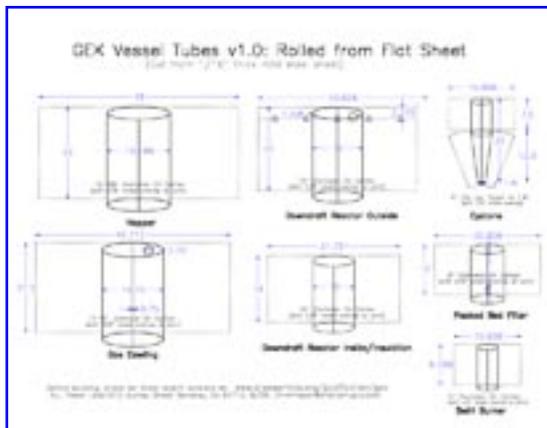
(Note: The formal building instructions are still in progress. In the interim, look at the pictures in the [gallery](#) to understand how the pieces in the drawings below fit together. It is really very simple- just flange rings and end plates welded on vessel tubes. All vessels are made with the same method.)

## V1.0 CAD Files



**All Flange Rings and End Plates:**

[.jpg](#), [.pdf](#), [.dxf](#)

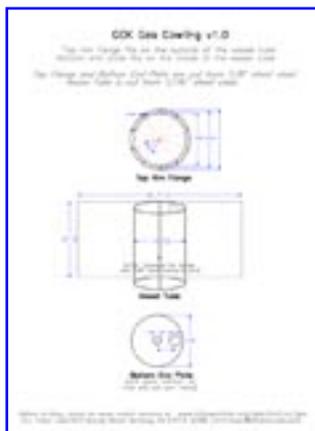


All Vessel Tubes: [.jpg](#), [.pdf](#), [.dxf](#)

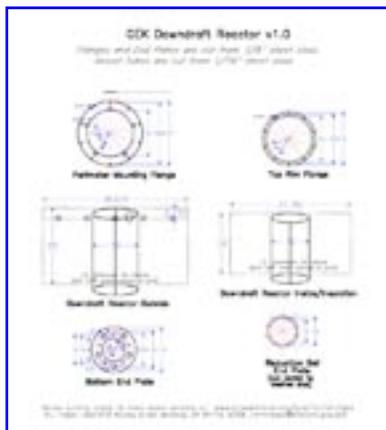
### Individual Component Drawings



Hopper: [.jpg](#), [.pdf](#), [.dxf](#)



Gas Cowling: [.jpg](#), [.pdf](#), [.dxf](#)



Downdraft

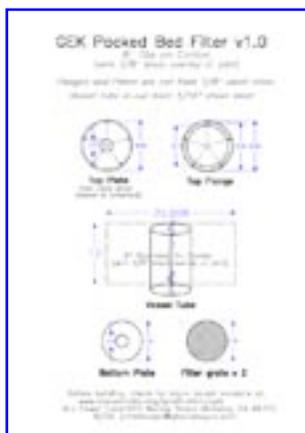
Reactor: [.jpg](#), [.pdf](#), [.dxf](#)

## [Downdraft Reactor Sizing Charts](#)



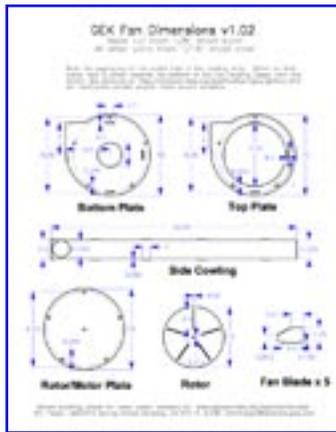
Cyclone: [.jpg](#), [.pdf](#),

[.dxf](#)



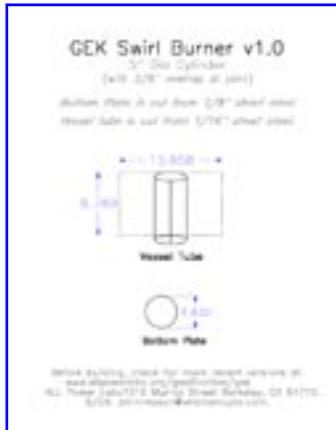
Packed Bed Filter :

[.jpg](#), [.pdf](#), [.dxf](#)



Vac/Blower: [.jpg](#),

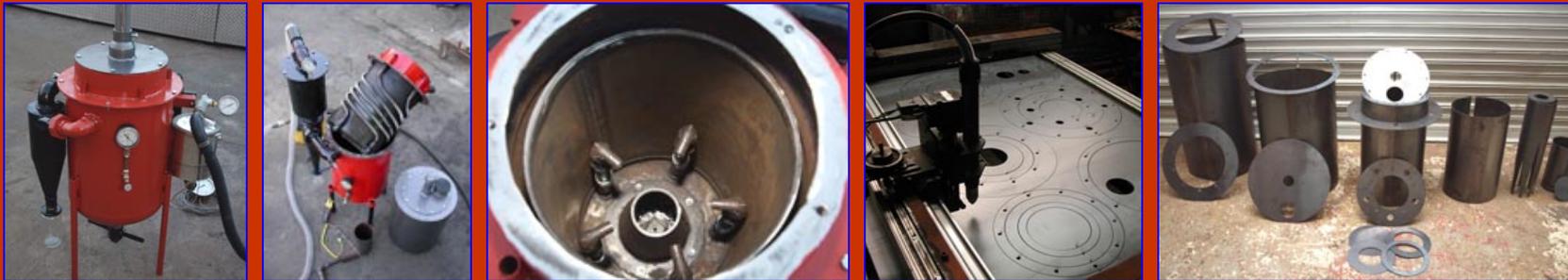
[.pdf](#), [.dxf](#)



Swirl Burner : [.jpg](#),

[.pdf](#), [.dxf](#)

# ALL Power Labs: Tools for Power Hacking



## [Gasification Home:](#)

### The Basics

### The Science of Biomass Gasification

### Gasifier Types

### How to Build a Gasifier

Gasifier Experimenters Kit (GEK)

[Quadrafire \(4 in 1\)](#)

[Gas-can-o-fire](#)

[Cigifier](#)

[GMC woodgas truck](#)

Other Designs Online

### Gasifier System Components

### Technical Resources

[Gasification Workshop \(June, 08\)](#)

[overview](#) - [gallery](#) - [reactor options](#) - [manufacturing](#) - [FAQ](#) - [test reports](#) - [downloads](#) - [purchase](#)

## GEK: *Purchase Options* (Note: as of September 2008, we're now delivering the GEK v2.0)

ALL Power Labs offers the GEK kit at a variety of part counts and states of assembly. From "You build it from scratch" to "We deliver it complete"; you decide the relative amount of "effort vs cost" you want to invest towards your finished unit.

All GEK kits include relevant parts for a full gasifier system-- not just the raw gas making reactor. Most builders quickly learn that a wood gas unit is as much as filtering, cooling, vac/blower, burner and fuel feed system, as it is the core gas making reactor. Do not underestimate the challenges of these other upstream and downstream components. The GEK kit is honest about the full range of challenges, and doesn't leave you to discover these realities later on your own. Every GEK kit addresses the following components:

- fuel hopper
- reactor
- gas/ash cowling
- cyclone
- packed bed filter
- vac/blower
- burner

What varies between different kit "levels" is how many parts we include (i.e. how many we leave you to buy/source), and how much fabrication we contribute towards the final integrated unit. The end GEK is the same whichever route you choose to realize it. Thus all GEKs are comparable and solutions shareable between different users.

| Kit Levels and Cost | Parts Included |
|---------------------|----------------|
|                     |                |

**Level I: \$350  
Scrap Tank Kit**



**Flanges and End Plates. No vessel tubes** (*You provide scrap tanks*)

You can build your GEK for minimum money (and maximum effort) from scrap tanks and the above flange and end plate kit. GEK vessel dimensions are based on common propane and air tanks found in North America, so the same flanges and end plates will work for an "obtainium" build as our purpose manufactured vessel tubes described in Level II-IV.

For the "build it from junk" route, you will need scrap tanks of 10", 12" and 14.75" diameters. 10" is typical for hand held air transfer tanks and some truck pony tanks. 12" is typical for 5 and 10 gal propane tanks. 14.75" is typical for a 100lb/25gal propane tank. (Warning: There's a surprising amount dimensional variation on "standardized tanks" between different tank manufacturers. This can complicate the fit of flanges and end plates to the scrap tanks.)

You fight the grease, rusted in valves, and smelly impregnated gas, then cut the tanks apart (taking care to avoid unwanted internal combustion), and weld on the above flanges and end plates. You will still have to improvise for the cyclone, filter, blower, burner and hopper.

Full dimensions and instructions are findable on the [download page here](#).

**Level II: \$695  
All Sheetmetal**



**All the above + Vessel Tubes**

We encourage you to resist the temptations of the "build it from junk" route, and at least start with a full CNC plasma cut sheetmetal vessel kit. The full sheetmetal kit greatly simplifies the building process, while increasing the accuracy and impress of the finished product. The Level II kit gives you all the tubes, flanges and end plates you need to build all component vessels --clean, accurate and ready-to-weld together-- delivered right to your door.

You will still have to source all the plumbing parts, gaskets, motor, fasteners, instruments, etc to build it. The [list of additional needed parts](#) is here. Sourcing these remaining parts will likely cost you more in money and certainly more time in hassle than just getting it all together as a Level III or IV kit. But some like to do it the hard way, thus we continue to offer the Level I and II kits. For everyone else, we encourage you to choose the Level III or Level IV kit below.

**Level III: \$1395**  
**All Parts, no welding**



**All above + plumbing, hoses, blower/vac, instrumentation, and other details.**

This is the "Everything down to the last nut and bolt" kit. Well, everything that is, except welding and painting (which is the Level IV kit). The Level III kit includes many accessory parts past the obvious plumbing needs. See list below. We also include good temperature and pressure instruments so you can explore what is happening in your GEK, and share the knowledge with others.

**Plumbing and Accessories:**

- plumbing to make air inlets and nozzles
- stainless steel air preheating / gas cooling tubes. 6' long.
- ash handling mechanical parts
- gas cowling legs
- output gas plumbing
- cyclone and filter plumbing
- centrifugal vac/blower and motor
- 10' soft hose to burner
- burner nozzle and plumbing
- hose clamps
- filter packing
- gasket material
- pipe tape
- nuts and bolts
- etc etc.

**Instrumentation:**

- two channel digital thermocouple reader (type K)
- two type K soft thermocouples, each 40" long
- one type K hard probe of 24" length, with handle (good Omega instrument)
- low pressure inches of H<sub>2</sub>O vacuum gauge.

See here for the [fabrication instructions](#).

**Level IV:  
Everything Complete,  
Not Painted: \$1995**

**Everything Complete  
and Painted: \$2145**



**Complete unit. All welding and metal fab completed. Minor Assembly Required.**

Can't weld? Then maybe the "All parts, we weld, you assemble" option is what you need. This means we weld all vessel tubes, flanges and endplates, as well as weld plumbing and fixture fittings into appropriate locations. You receive an expert and accurate fabrication of all component units. You complete the final assembly details. The Level IV kit includes the same "Everything down to the last nut and bolt" parts set as the Level III kit.

Assembly is simple, requiring only basic wrench turning and painting (if you choose the no paint option). About the same difficulty as an IKEA bookcase or Christmas morning toy assembly.

[Assembly and First Firing instructions](#) are here. If you get confused, you can call Jim Mason with questions.



## Individual Components and Parts

|   |  |
|---|--|
| <p><b>Fan Kit:</b></p> <p><i>Raw sheetmetal pieces, no motor, \$49</i></p> <p><i>Raw sheetmetal pieces, motor included, \$79</i></p> <p><i>Welded sheetmetal, no motor, \$99</i></p> <p><i>Welded sheetmetal, motor included, \$129</i></p> |  <p>The vac/blower is a long-standing difficulty for the DIY gasifier builder. There is no good equivalent from other industries that shows up as obtainium. Thus we built one and now offer the same to you in a variety of states of assembly.</p> <p>This vac/blower kit is a proper high rpm centrifugal fan that will generate the needed 5-10 inches of h20 vacuum (a typical squirrel cage will only generate 1" of h20 vac). All metal construction will take the heat. No more melting shop vacs and/or mom's hairdryer. The motor shaft is well protected and sealed to avoid tar fouling.</p> <p>The intake is 3" in diamter. The output is a 2" sch 40 pipe nipple, threaded. The rotor is 7.5" in diameter, with a 5/16" shaft collar to accept the motor. The internals are configured so that gas can pass through the fan housing without constriction when the fan is not running. Thus you can put it inline with your gas piping and avoid the separate valved branch circuit. See more detailed pictures in the <a href="#">gallery</a>.</p> <p>The optional motor is a 12vdc three speed motor (2800, 4000 and 7500rpm).</p> |
| <p><b>Cyclone Kit:</b></p> <p><i>Rolled sheetmetal pieces, no welding, \$79</i></p> <p><i>Welded and painted, \$149</i></p>   |  <p>This is the standard 5" diameter cyclone from the GEK kit. It comes with a 2" box flange attachment at the inlet, and a 2" threaded NPT nipple for the outlet. A glass Mason jar and adapter is included for the particulate/condensate/tar catch.</p> <p>(Note: picture has 2" NPT nipple with union at the inlet. This method was replaced at v2.0 with a square sheetmetal tube and flange plate. No picture yet.)</p>  |

## Payment

Orders can be placed using the "buy now" buttons above, or via check to:

ALL Power Labs  
 1010 Murray Street  
 Berkeley, CA 94710

All prices are freight on board, Berkeley, CA, 94710. California sales tax of 8.75% applies to all domestic US orders.

Questions? Contact: [gek\\_at\\_allpowerlabs\\_dot\\_org](mailto:gek_at_allpowerlabs_dot_org)

## Shipping

Domestic shipping is charged at real UPS ground rates, to the best approximation we can manage. For international shipping, write us before ordering so we can figure out a specific method and quote. GEK units can also be picked up at the shop in Berkeley, California.

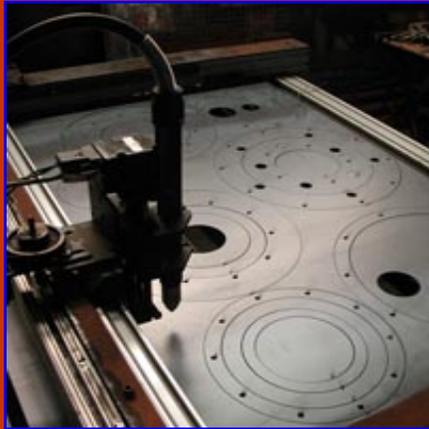
All sheetmetal vessel tubes "Russian Doll" for ease of shipping. Level III and Level IV kits are shipped in two boxes to stay below the UPS 150lb weight limit.



The weight for each kit level is approximately as follows:

Level I: 50 lbs  
Level II: 100lbs  
Level III: 170lbs  
Level IV: 180lbs

# ALL Power Labs: Tools for Power Hacking



## [Gasification Home:](#)

**The Basics**

**The Science of Gasification**

**Gasifier Types**

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**Gasifier System Components**

[overview](#) - [gallery](#) - [reactor options](#) -  
[manufacturing](#) - [FAQ](#) - [test reports](#) - [downloads](#) -  
[purchase](#)

**Gasification Workshop #2:  
GEK Building and Honda  
Accord conversion**

*Gasification Lecture and Demo:*

*Thurs, June 12, 7:30-9:30PM*

*Build Days: 4 Saturdays (June 14,  
21, 28 and July 5), 11am - 7pm*

## Technical Resources

### [Gasification Workshop \(June, 08\)](#)

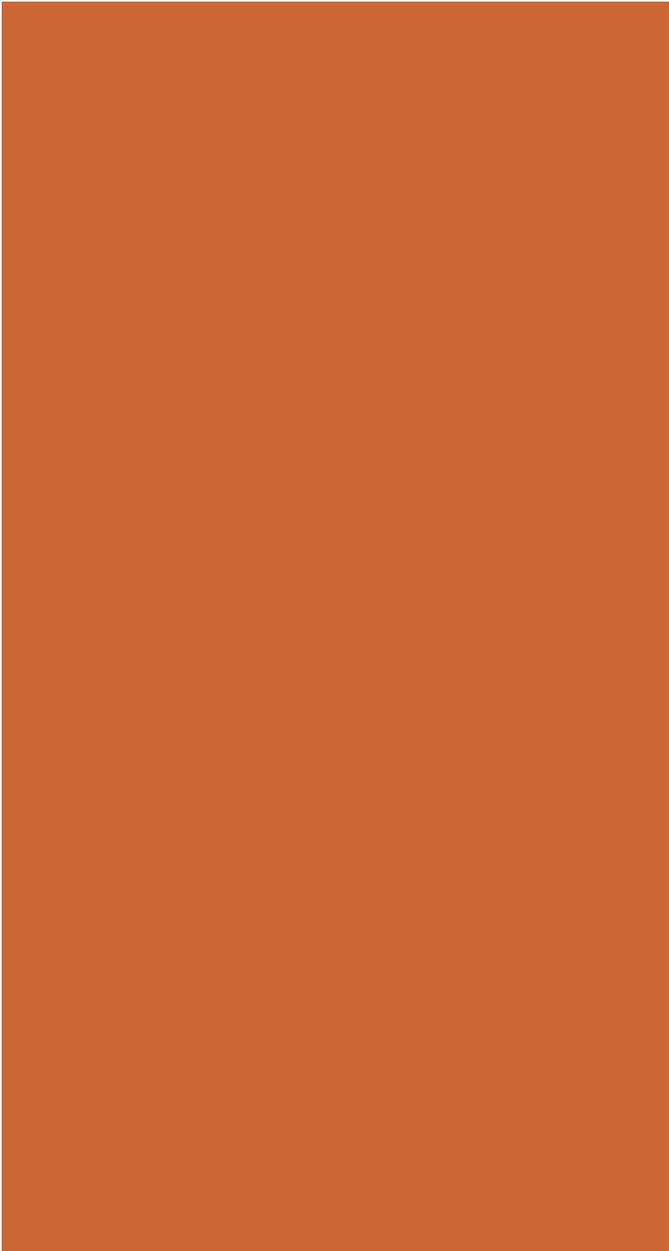
Cost: \$350 (or free with purchase of a [GEK kit, Level II or higher](#))

The recently lauched [Gasifier Experimenters Kit \(GEK\)](#) grew out of the first Gasification Workshop, held at the Shipyard in Spring in 07. [See here for pictures and report.](#)

Now that we have an easy to assemble and well performing kit, the next Gasification Workshop will focus on building these kits and documenting their performance over various configurations, fuels and use scenarios. We will be using our new 6 gas sensing rig (see below), tar tester, thermocouples, moisture meters and other instrumentation to generate quantitative run data and resulting refinements.



The main group project will be using the GEK kit to convert a Honda Accord to run on walnut shells. The goal is a polished and automated installation that is acceptable as a daily driver. Maybe even something that's more interesting to look at than the [previous effort](#) . Towards this goal, we will be developing air/syngas mixture automation mechatronics, condensate/steam reinjection systems and other automated sensing and control devices.

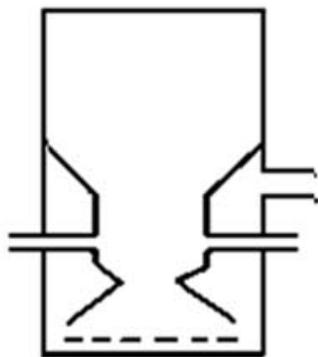


Along side the Honda Accord project, participants are encouraged to build their own GEK for personal projects. Maybe you want to convert a vehicle, generator, forge, lawnmower, hot water heater, or fire art project. Or maybe a racer for the [Escape from Berkeley \(by any non-petroleum means\)](#) rally. Now's your chance. All tools and help needed to assemble the kits will be provided during the weekend build days. You will need to buy at least the Level II form of the kit, but not any of the assembly options. The workshop is FREE for anyone who purchases the material kit.

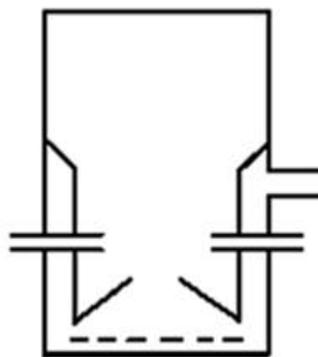
The workshop begins with an evening talk and discussion on the science of gasification a survey of its design and social history. Both beginning and expert reactor assemblies will be presented, with pointers to further reading and current issues and opportunities in the field. Also included is a basic introduction to biochar / Terra Preta and the related pyrolysis reactors.

## Downdraft Gasifier Types

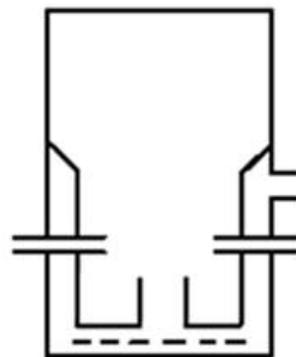
### Nozzel and Constriction Closed Top Designs (aka: Imbert type)



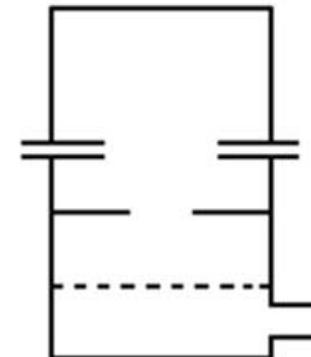
Imbert Hourglass  
(double throat)



Inverted V Hearth  
(Swedish origin)

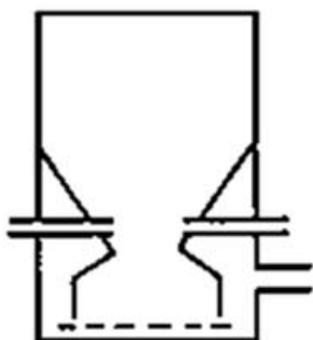


Straight Reduction Tube

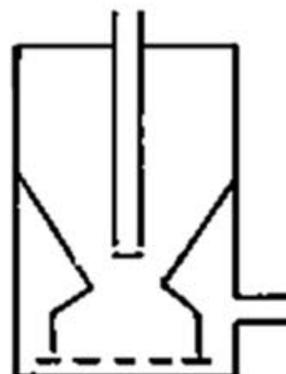


Constriction Plate

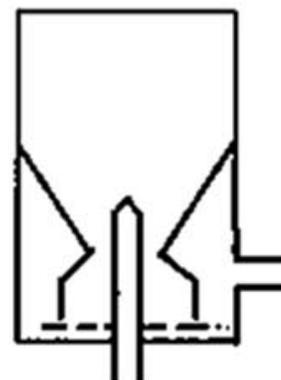
### Air Inlet Variations (shown with Imbert Hourglass single throat type)



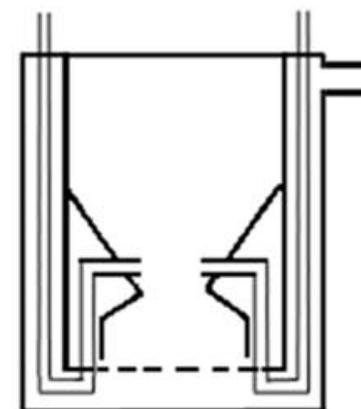
Side Inlets



Central Inlet  
(down from top)



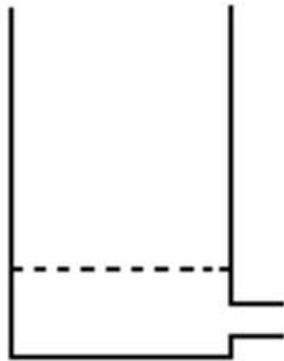
Central Inlet  
(up from bottom)



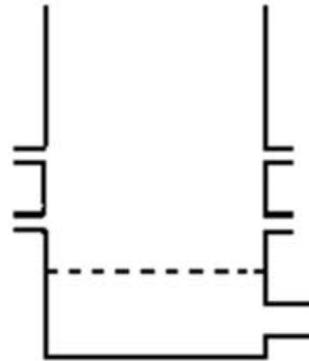
J tube  
(air preheating)

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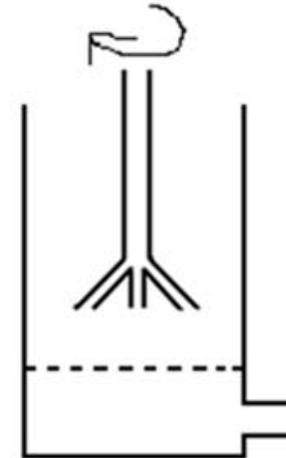
## Open Core Designs



**Stratified Downdraft**  
(Tom Reed, FEMA)



**Multi-point Air Injection**  
(Mukunda, CPC)



**Buck Rogers**

# ALL Power Labs: Tools for Power Hacking



## Gasification:

**The Basics**

**The Science of Gasification**

**Gasifier Types**

**How to Build a Gasifier**

[Gasifier Experimenters Kit  
\(GEK\)](#)

[Quadrafire \(4 in 1\)](#)

[Gas-can-o-fire](#)

[Cigifier](#)

[GMC truck](#)

**Other Designs Online**

[back to Gasifier Experimenters Kit](#)

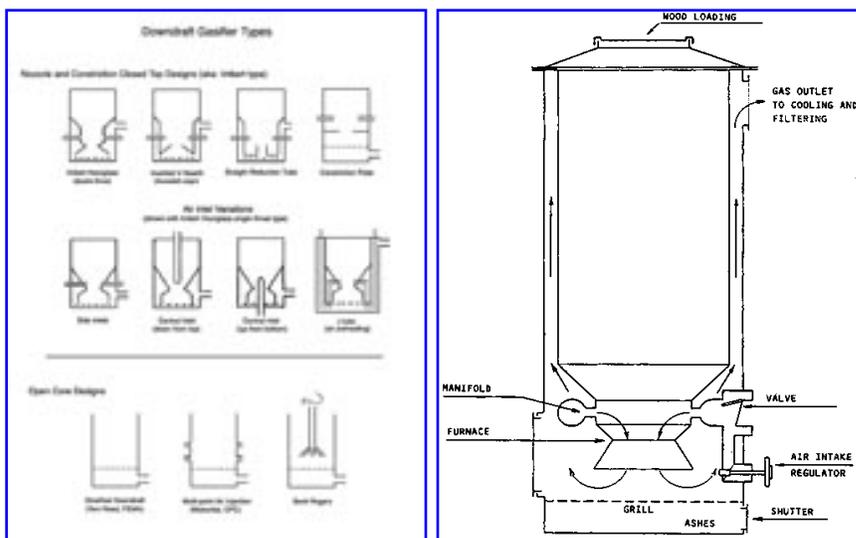
## Resources for Gasification

### Downdraft Gasifier Types

## Gasifier System Components

### Technical Resources

[Gasification Workshop \(June, 08\)](#)



## Downdraft Gasifier Sizing

Here's some rough equivalencies, approximations and rules of thumb to understand downdraft gasifier gas flow needs, HP equivalencies and reactor sizing. For engine applications, I find it easier to size by actual HP needed, not by swept volume x RPM. Seldom is an engine running at wide open throttle, as such calculations suggest.

In general, size your gasifier for typical power needs, not the rare max rates. If in doubt, err on the size of too small to lessen tar risks from too low of temps.

***Here's how to approximate the relationships of liquid fuel to HP to KWe in your vehicle or genset:***

1 gal of gasoline or diesel produces about 15HP mechanical for one hour, or 10kwh electricity in a genset.

How much HP is your vehicle using at cruise?

60MPG = 1gal/hr or 15HP for one hour

30MPG = 2gal/hr or 30HP for one hour

15MPG = 4gal/hr or 60HP for one hour

***Solid biomass to syngas to power:***

The best figures on Syngas - HP - KW equivalencies are found in the Fluidyne engine tables at <http://www.fluidynenz.250x.com>. Here's some important excerpts, with minor additions by me. Thank you goes to Doug Williams for authoring these numbers. (Note: If confused, ignore these details and skip to the rule of thumb at the end of the section)

1kg of wood 15% moisture content produces 2.185 cubic metres of gas  
or 3.165kW heat from burning gas direct  
or 0.837kW of shaft power (i.e engine)  
or 1.12HP of shaft power (i.e. engine)  
or 0.754kW of electric power generated

1lb of wood at 15% moisture content produces 35 cubic feet of gas  
or 4,900 BTU heat from burning the gas direct  
or 0.51 HP of shaft power (i.e engine)  
or 0.342kW of electric power generated

1HP = 1.95 cubic meters of gas per hour  
5HP = 9.75 m<sup>3</sup>/h  
10HP = 19.5 m<sup>3</sup>/h  
50HP = 90.75 m<sup>3</sup>/h  
100HP = 195 m<sup>3</sup>/h

*Thus, the main rule of thumb to remember:*  
2 lbs biomass ~ 1 kg of biomass ~ 2 m<sup>3</sup>/h of gas ~ 1HP

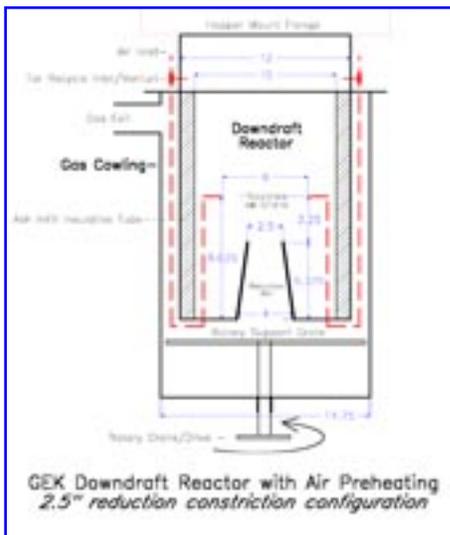
### ***Nozzle and Constriction (Imbert) type sizing charts***

Once you convert your HP needs to gas flow rates, use the following charts to determine starting dimensions for your reactor (hearth, restriction, reduction bell, nozzles, etc).

**Table 5-2: Invert Nozzle and Hearth Diameters**

| No. Nozzles | No. mm | Range of Gas Output     |                         | Maximum Wood Consumption | Air Flow Velocity |
|-------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------------------|-------------------------|--------------------------|-------------------|
|             |        |        |        |        |        |        |        |        |        |        |        |        |        | min. Nm <sup>3</sup> /h | max. Nm <sup>3</sup> /h |                          |                   |
| 200         | 80     | 200    | 150    | 80     | 250    | 100    | 5      | 7.5    | 7.8    | 4.5    | 1.20   | 30     | 4      | 14                      | 22.4                    |                          |                   |
| 200         | 80     | 200    | 170    | 90     | 250    | 100    | 5      | 9.0    | 9.4    | 3.3    | 1.10   | 44     | 5      | 21                      | 23.0                    |                          |                   |
| 200         | 100    | 200    | 200    | 100    | 250    | 100    | 5      | 10.5   | 10.9   | 2.7    | 1.00   | 63     | 6      | 30                      | 24.2                    |                          |                   |
| 200         | 100    | 200    | 210    | 110    | 250    | 100    | 5      | 12.0   | 12.5   | 2.2    | 0.90   | 90     | 10     | 42                      | 26.3                    |                          |                   |
| 300         | 100    | 300    | 200    | 100    | 275    | 110    | 5      | 10.0   | 10.5   | 3.0    | 1.00   | 77     | 10     | 36                      | 26.4                    |                          |                   |
| 300         | 110    | 300    | 200    | 105    | 275    | 110    | 5      | 11.5   | 12.0   | 2.6    | 0.90   | 95     | 12     | 46                      | 30.3                    |                          |                   |
| 300         | 130    | 300    | 240    | 110    | 275    | 110    | 5      | 12.5   | 13.0   | 2.3    | 0.80   | 110    | 15     | 50                      | 31.5                    |                          |                   |
| 300         | 150    | 300    | 250    | 120    | 275    | 110    | 5      | 14.0   | 14.5   | 1.9    | 0.80   | 140    | 18     | 67                      | 32.0                    |                          |                   |
| 400         | 130    | 400    | 250    | 110    | 275    | 100    | 7      | 12.0   | 12.5   | 3.1    | 0.80   | 100    | 17     | 57                      | 32.0                    |                          |                   |
| 400         | 150    | 400    | 250    | 120    | 275    | 100    | 7      | 13.0   | 13.5   | 2.7    | 0.80   | 100    | 21     | 71                      | 32.0                    |                          |                   |
| 400         | 170    | 400    | 260    | 130    | 275    | 100    | 7      | 13.5   | 14.0   | 2.3    | 0.70   | 140    | 25     | 80                      | 31.4                    |                          |                   |
| 400         | 200    | 400    | 270    | 140    | 275    | 100    | 7      | 14.0   | 14.5   | 2.0    | 0.70   | 200    | 30     | 110                     | 31.2                    |                          |                   |

Variables not given in figures are defined as follows:  
 $D_n$  = inner diameter of the nozzle  
 $A_n$  = sum of cross-sectional areas of the air jet openings in the nozzle  
 $A_h$  = cross-sectional area of the hearth  
 $A$  = number of nozzles  
 Source: Gaslog 1986a, Table 5, Fig. 16



## Stratified Down-draft type sizing chart

**Fire Tube Dimensions for Stratified Downdraft / Open Core Gasifier**  
(from FEMA Stratified Wood Gas Generator, LaPorte, Zimmerman, p. 74, Table 2-2)

| Inside diameter (inches) | Minimum length (inches) | Engine power (horsepower) | Typical engine displacement (cubic inches) |
|--------------------------|-------------------------|---------------------------|--|
| 2 <sup>1</sup>           | 16                      | 5                         | 10   |
| 4 <sup>1</sup>           | 16                      | 15                        | 30   |
| 6                        | 16                      | 30                        | 60   |
| 7                        | 18                      | 40                        | 80   |
| 8                        | 20                      | 50                        | 100  |
| 9                        | 22                      | 65                        | 130  |
| 10                       | 24                      | 80                        | 160  |
| 11                       | 26                      | 100                       | 200  |
| 12                       | 28                      | 120                       | 240  |
| 13                       | 30                      | 140                       | 280  |
| 14                       | 32                      | 160                       | 320  |

<sup>1</sup>A fire tube with an inside diameter of less than 6 in. would create bridging problems with wood chips and blocks. If the engine is rated at or below 15 horsepower, use a 6-in. minimum fire tube diameter and create a throat restriction in the bottom of the tube corresponding to the diameter entered in the above table.

## Fuel Combustion Characteristics

Table 1.19. Combustion characteristics of fuels\* (See also Tables 1.7, 1.8, 2.1, 2.12, and 2.1)

| Fuel                                     | Minimum ignition temp, °F | Calculated flame temperature, °F |                         | Flammability limits % fuel gas by volume |                   | Maximum flame velocity, fps and m/s in air | % Theoretical air for max. flame velocity |
|--|---------------------------|----------------------------------|-------------------------|--|-------------------|--|---|
|  |                           | In air                           | In O <sub>2</sub>       | lower                                    | upper             |  |   |
| Acetylene, C <sub>2</sub> H <sub>2</sub> | 581 <sup>1</sup> /305     | 4790/2632                        | 5630/3110               | 2.5                                      | 81.0              | 8.78/2.67                                  | —   |
| Blast furnace gas                        | —                         | 2650/1454                        | —                       | 25.0 <sup>2</sup>                        | 73.5              | —  | —   |
| Butane, commercial                       | 890/480                   | 3583/1973                        | —                       | 1.80                                     | 8.41              | 2.85/0.87                                  | —   |
| Butane, n-C <sub>4</sub> H <sub>10</sub> | 741/405                   | 3583/1973                        | —                       | 1.80                                     | 8.41              | 1.21/0.40                                  | —   |
| Carbon monoxide, CO                      | 1128 <sup>1</sup> /609    | 3542 <sup>1</sup> /1950          | —                       | 12.5 <sup>2</sup>                        | 74.2 <sup>2</sup> | 1.37/0.52                                  | —   |
| Carburized water gas                     | —                         | 3700/2036                        | 5650/2758               | 6.4                                      | 37.7              | 2.15/0.66                                  | —   |
| Coal oven gas                            | —                         | 3610/1988                        | —                       | 4.4 <sup>1</sup>                         | 34.8 <sup>1</sup> | 2.30/0.70                                  | —   |
| Ethane, C <sub>2</sub> H <sub>6</sub>    | 882 <sup>1</sup> /472     | 3540/1949                        | —                       | 3.0                                      | 12.5              | 1.56/0.48                                  | —   |
| Gasoline                                 | 536 <sup>1</sup> /280     | —                                | —                       | 1.4                                      | 7.8               | —  | —   |
| Hydrogen, H <sub>2</sub>                 | 1082 <sup>1</sup> /572    | 4810/2045                        | 5385/2874               | 4.0                                      | 74.2              | 8.3/2.83                                   | —   |
| Hydrogen sulfide, H <sub>2</sub> S       | 558 <sup>1</sup> /292     | —                                | —                       | 4.3                                      | 45.5              | —  | —   |
| Mapp gas, C <sub>2</sub> H <sub>4</sub>  | 850/455                   | —                                | 5301/2827               | 3.4                                      | 18.8              | —  | 15.4/4.89                                 |
| Methane, CH <sub>4</sub>                 | 1178 <sup>1</sup> /612    | 3484/1918                        | —                       | 5.0                                      | 18.0              | 1.48 <sup>1</sup> /0.45                    | 14.78/4.50                                |
| Methanol, CH <sub>3</sub> OH             | 725/385                   | 3480/1904                        | —                       | 6.7                                      | 36.0              | —  | 1.6/0.49                                  |
| Natural gas                              | —                         | 3525 <sup>1</sup> /1841          | 4780 <sup>1</sup> /2643 | 6.3                                      | 35.0              | 1.00/0.30                                  | 15.2/4.83                                 |
| Producer gas (See Part 1)                | —                         | 3010/1654                        | —                       | 13.0 <sup>2</sup>                        | 73.7              | 0.85/0.26                                  | —   |
| Propane, C <sub>3</sub> H <sub>8</sub>   | 871/466                   | 3573/1967                        | 5130/2812               | 2.1                                      | 18.1              | 1.52/0.45                                  | 12.2/3.71                                 |
| Propane, commercial                      | 832/500                   | 3573/1967                        | —                       | 2.37                                     | 9.50              | 2.78/0.85                                  | —   |
| Propylene, C <sub>3</sub> H <sub>6</sub> | —                         | —                                | 5240 <sup>1</sup> /2881 | —  | —                 | —  | —   |
| Town gas (Br. coal) <sup>3</sup>         | 790/370                   | 3710/2045                        | —                       | 4.8 <sup>1</sup>                         | 31.8              | —  | —   |

\*For combustion with air at standard temperature and pressure. These flame temperatures are calculated for 100% theoretical air, dissociation considered. Unless otherwise noted, data is from Reference 1.1.

<sup>1</sup>Flame temperatures are theoretical—calculated for stoichiometric ratio, dissociation considered.

<sup>2</sup>From private communications.

Small letters refer to references at end of Part 1.

## Books of Interest

### [Handbook of Biomass Downdraft Gasification](#)

Thomas Reed and Agua Das, SERI/SP-271-3022, DE88001135, March 1988.

(available in print from BEF at

<http://woodgas.com/bookstore.htm>. please support BEF. the entire BEF library is fabulous. buy the whole thing.)

### [FAO 72: Wood Gas as Engine Fuel](#)

ISBN92-5-02436-7, UN Food and Agricultural Organization, 1986

[FEMA Manual- Constructing a Simplified Wood Gas Generator for Fueling Internal Combustion Engines in a Petroleum Emergency](#)

Henry LaFontaine, F.P. Zimmerman, March 1989

(available in print from

<http://woodgas.com/bookstore.htm>. please support BEF. the entire BEF library is fabulous. buy the whole thing)

[Biomass Gasifier "Tars": Their Nature, Formation and Conversion](#)

T.A. Milne, R.J. Evans, N. Abatzoglou, NREL, November 1998

(available in print from

<http://woodgas.com/bookstore.htm>. please support BEF. the entire BEF library is fabulous. buy the whole thing)

## **Papers of Interest**

[Superficial Velocity- The Key to Downdraft Gasification](#)

T. B. Reed, R. Walt, S. Ellis, A. Das, S. Deutch.

Presented at 4th Biomass Conference of the Americas; Oakland, CA, 8/29/99

(mirrored from Biomass Energy Foundation, [www.woodgas.net](http://www.woodgas.net))

[Monorator- Gasifier for Damp Fuel](#)

Harald Kyrklund, Teknisk Tidskrift, July 21 1945.

(Translation 2000, Joacim Persson <[joacim@artech.se](mailto:joacim@artech.se)>)

(mirrored from: <http://www.hotel.ymex.net/~s-20222/gengas/>)

[Lutz: German Ideas on Improvements of Wood Gasifiers](#)

Summary in Teknisk Tidskrift of a thesis by H. Lutz, published in ATZ. Ed CVNordenswan, Sept. 1941.

(Translation to English, 2000, Joacim Persson <[joacim@ymex.net](mailto:joacim@ymex.net)>).

(mirrored from: <http://www.hotel.ymex.net/~s-20222/gengas/>)

[Comments on Lutz paper: Gasifier Efficiency](#)

E. Hubendick, Teknisk Tidskrift, Dec, 1941  
(Translation to English, 2000, Joacim Persson  
<joacim@ymex.net>)  
(mirrored from: <http://www.hotel.ymex.net/~s-20222/gengas/>)

[The Making of the Kalle Gasifier](#)

Torsten Kalle, January-February 1942.  
(Translation to English, 2000, Joacim Persson  
<joacim@ymex.net>)  
(mirrored from: <http://www.hotel.ymex.net/~s-20222/gengas/>)

[Modelling for Control of a Biomass Gasifier](#)

Dorus van der Hoeven, Thesis 0474218, Technische  
Universiteit Eindhoven, January 2005

Questions? Contact: gek\_at\_allpowerlabs\_dot\_org



































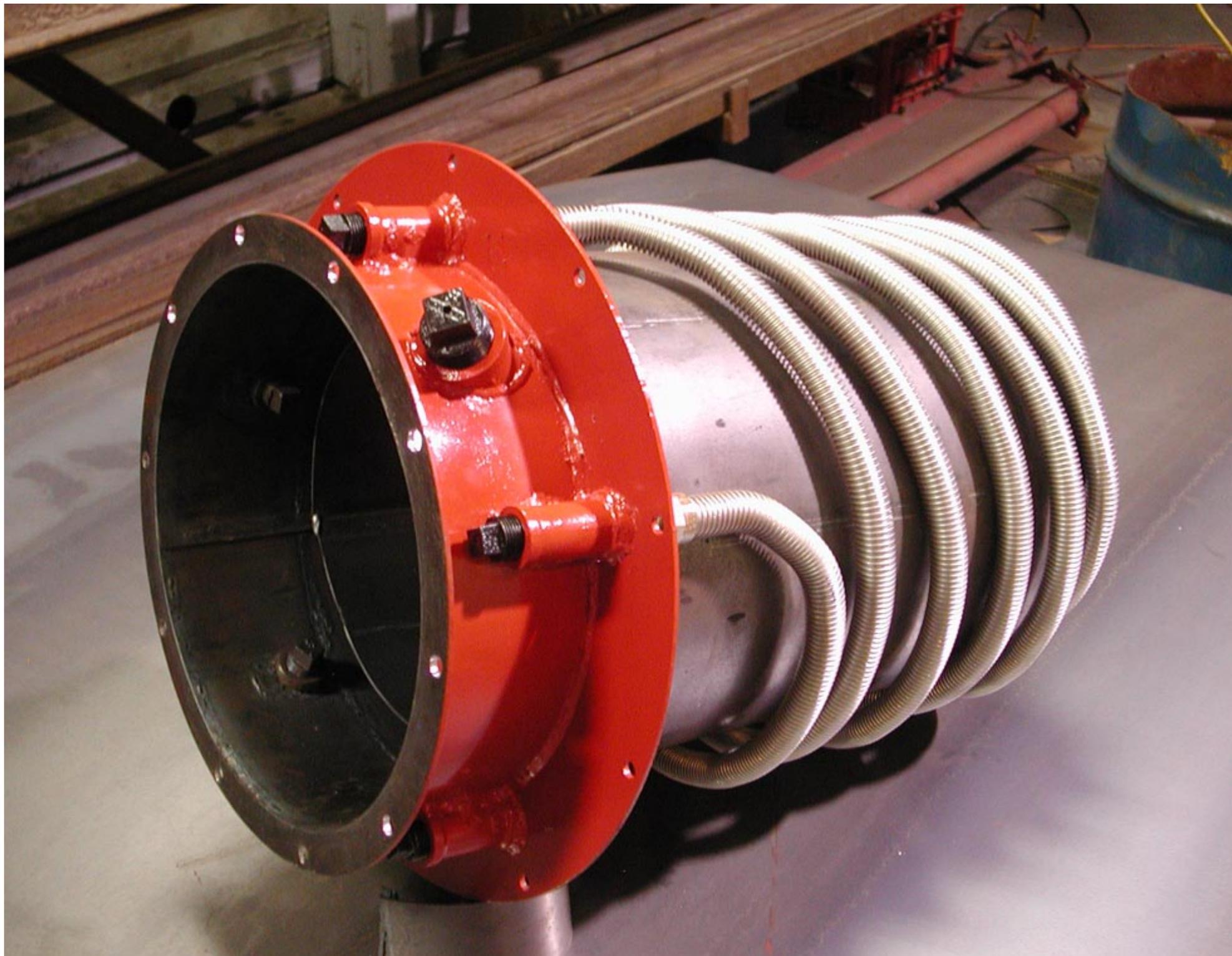




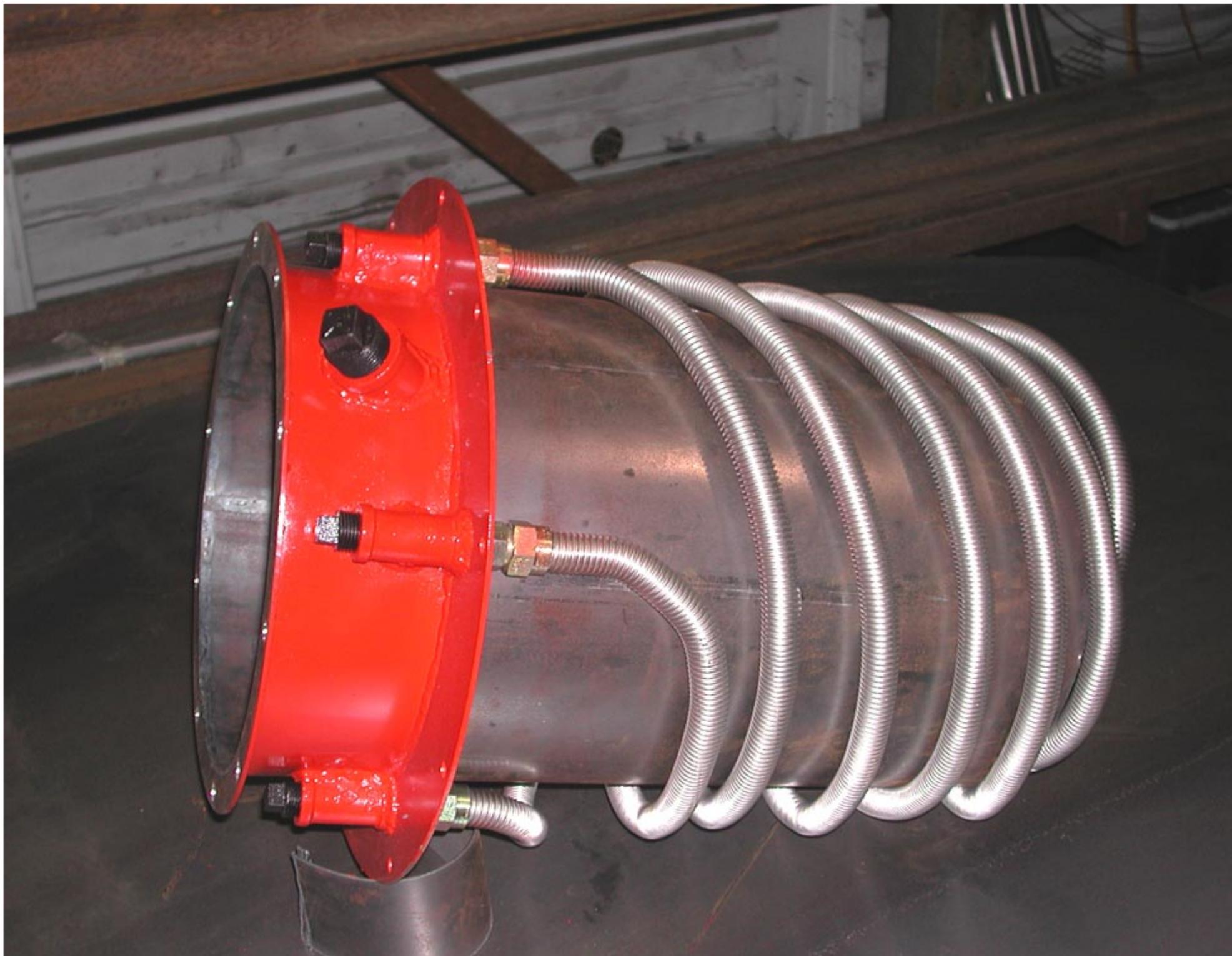








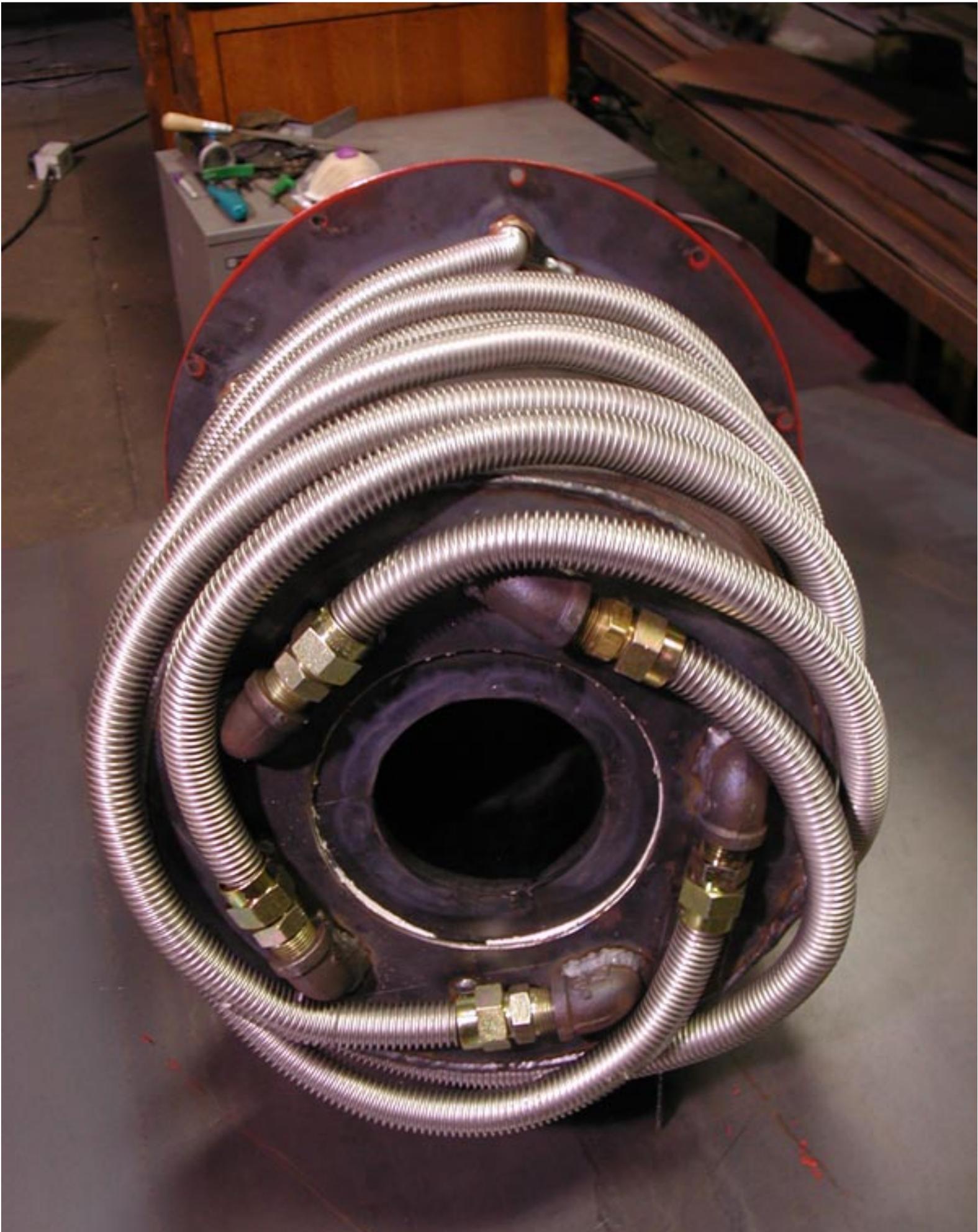




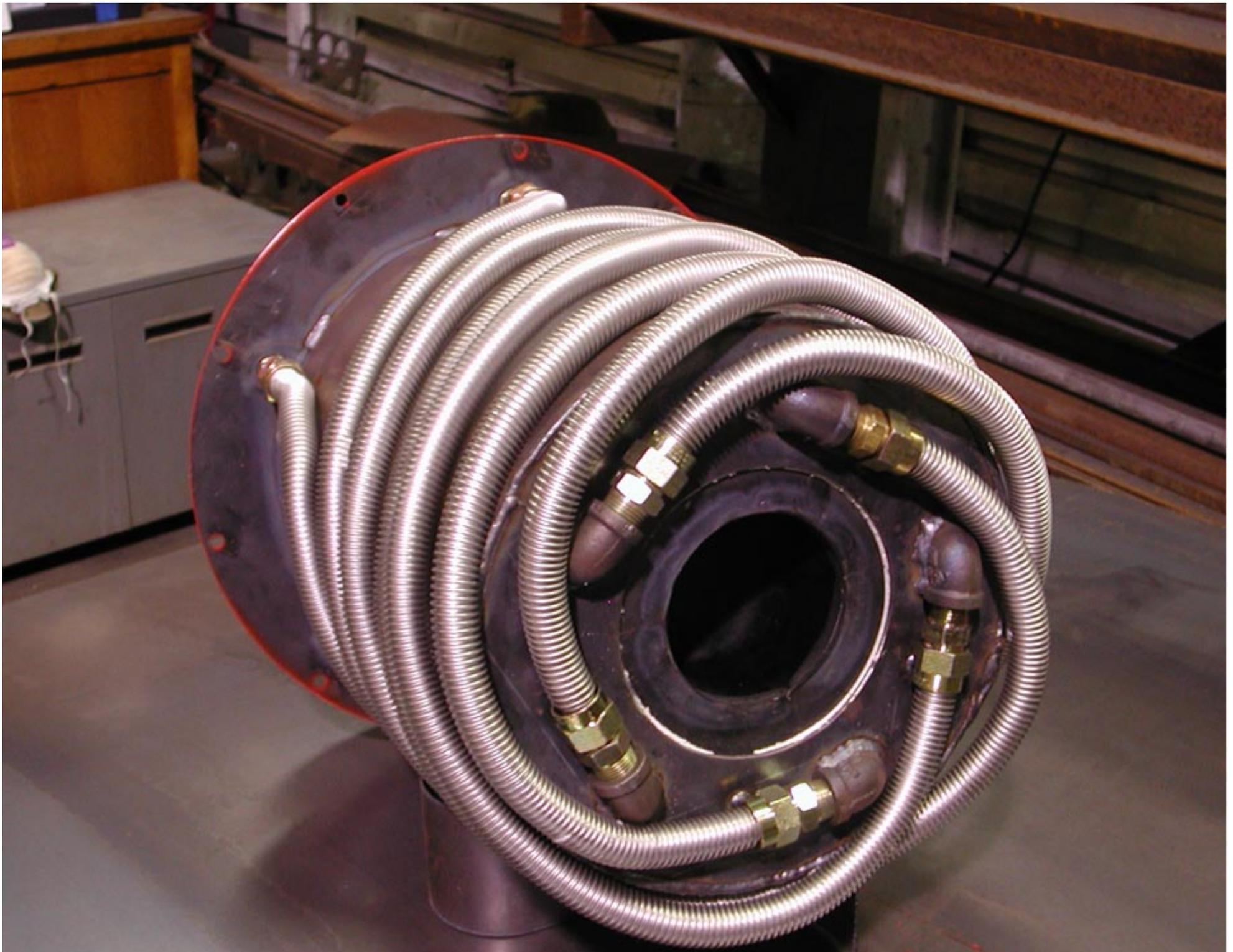




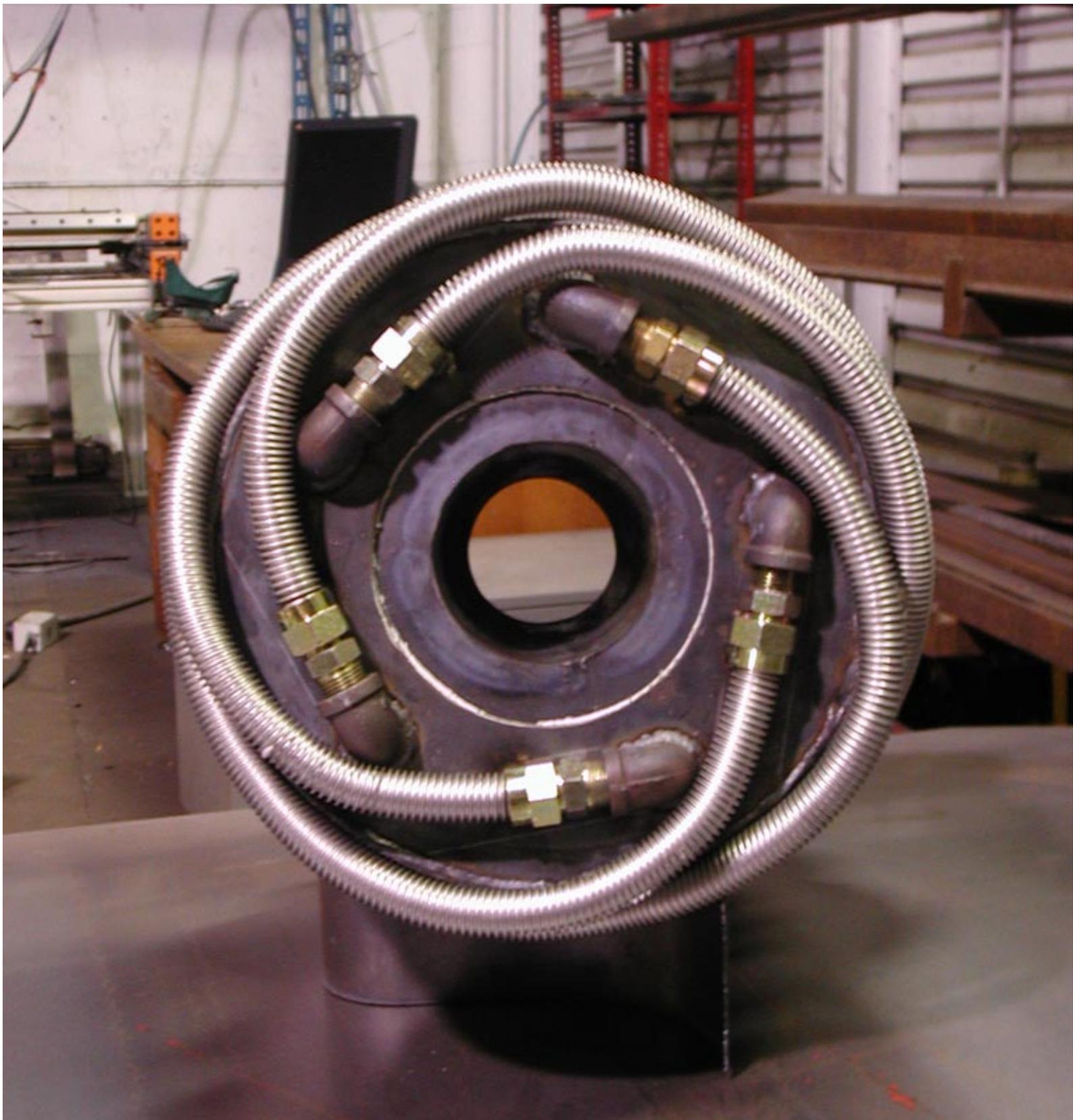


















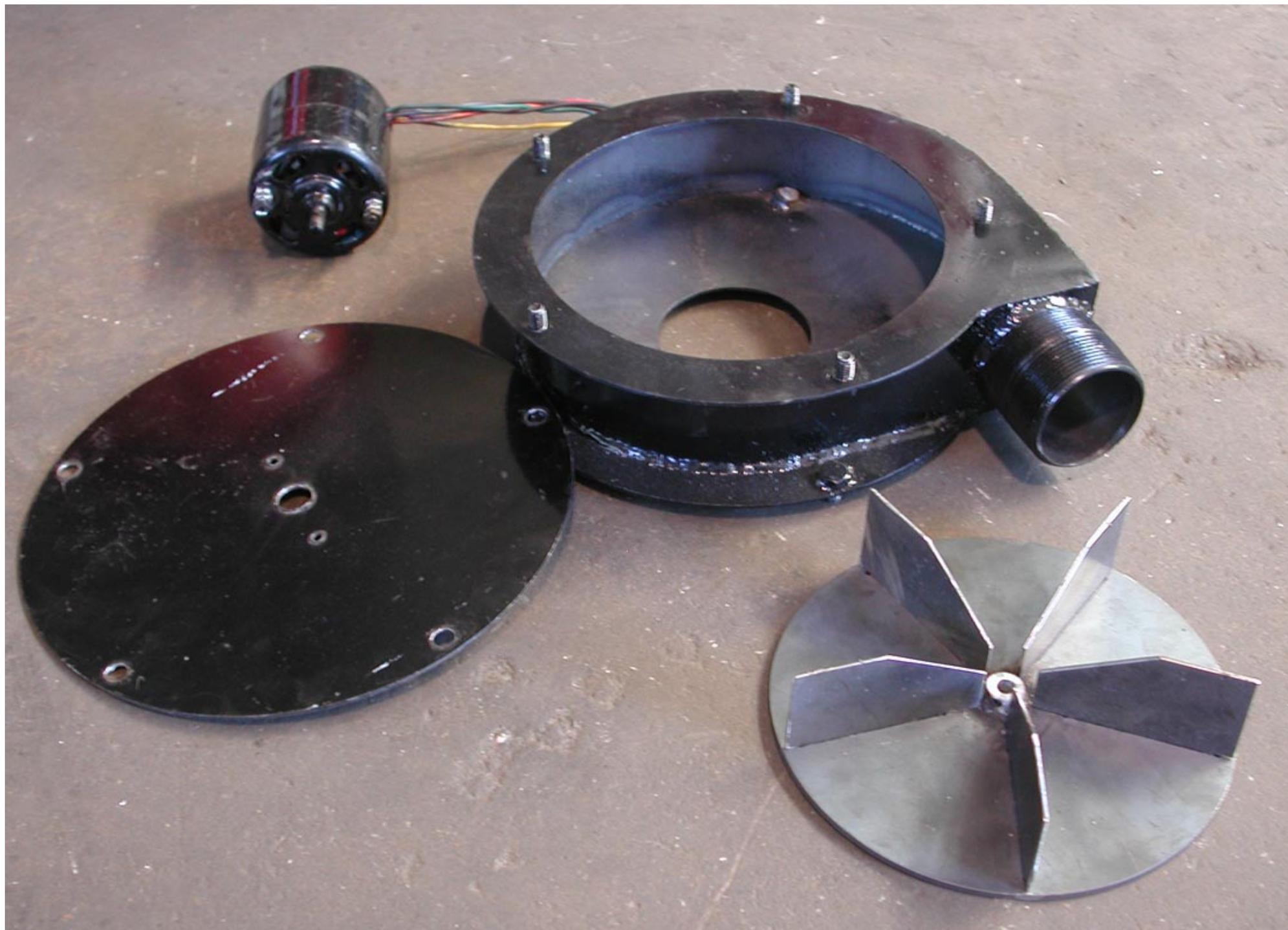






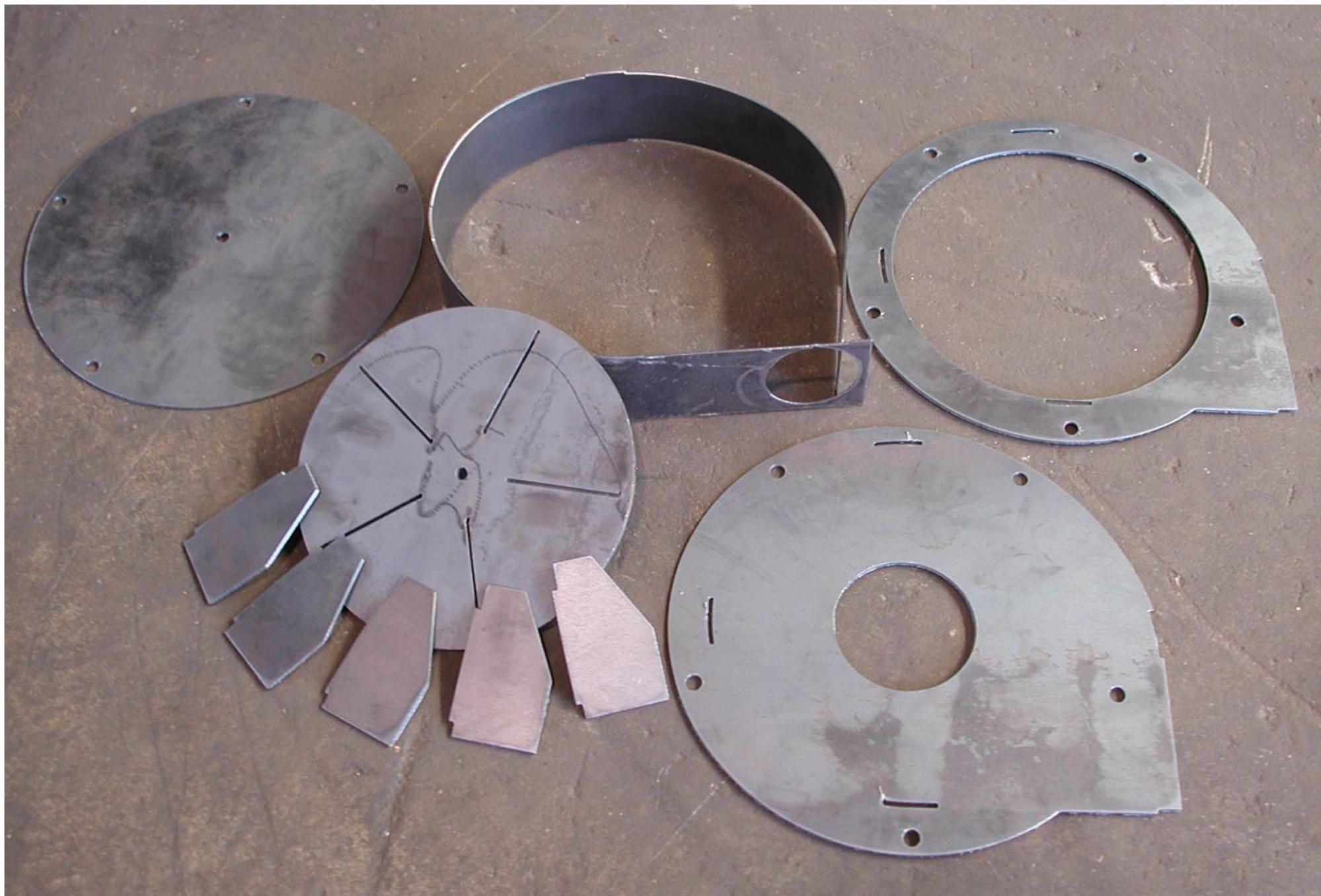
























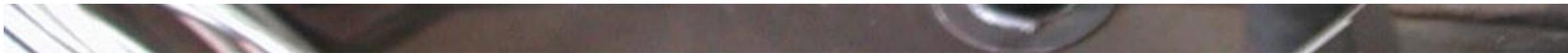














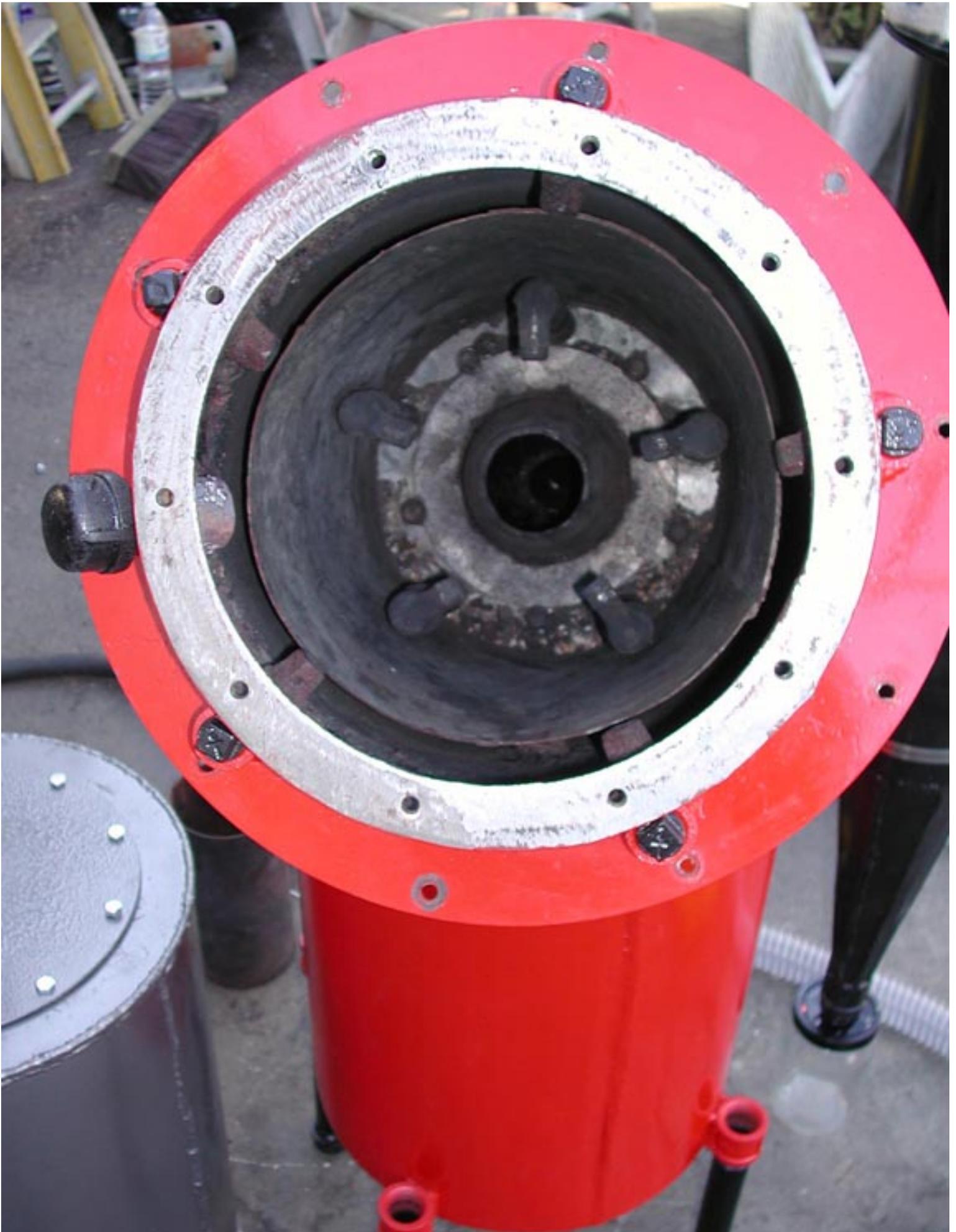


































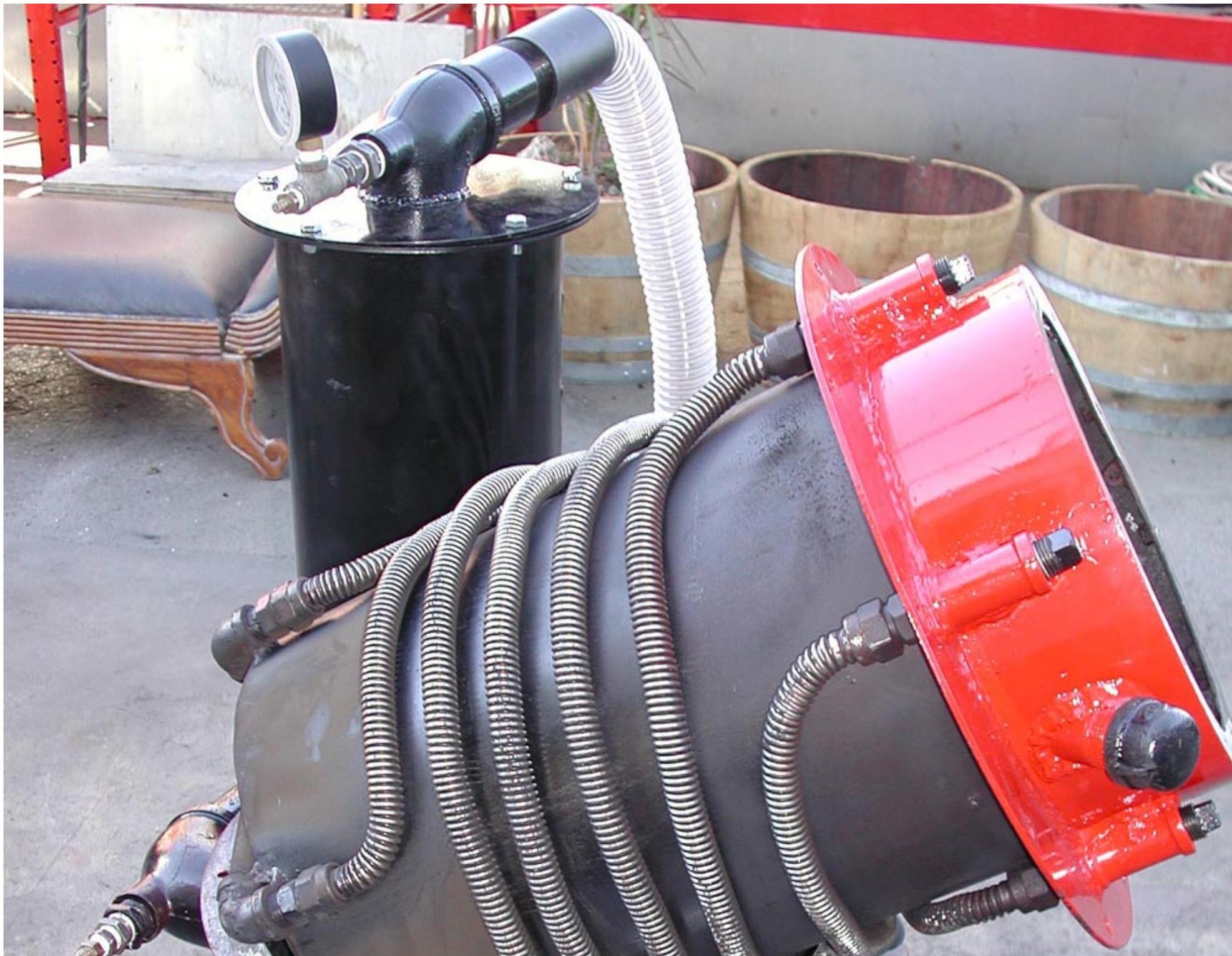






















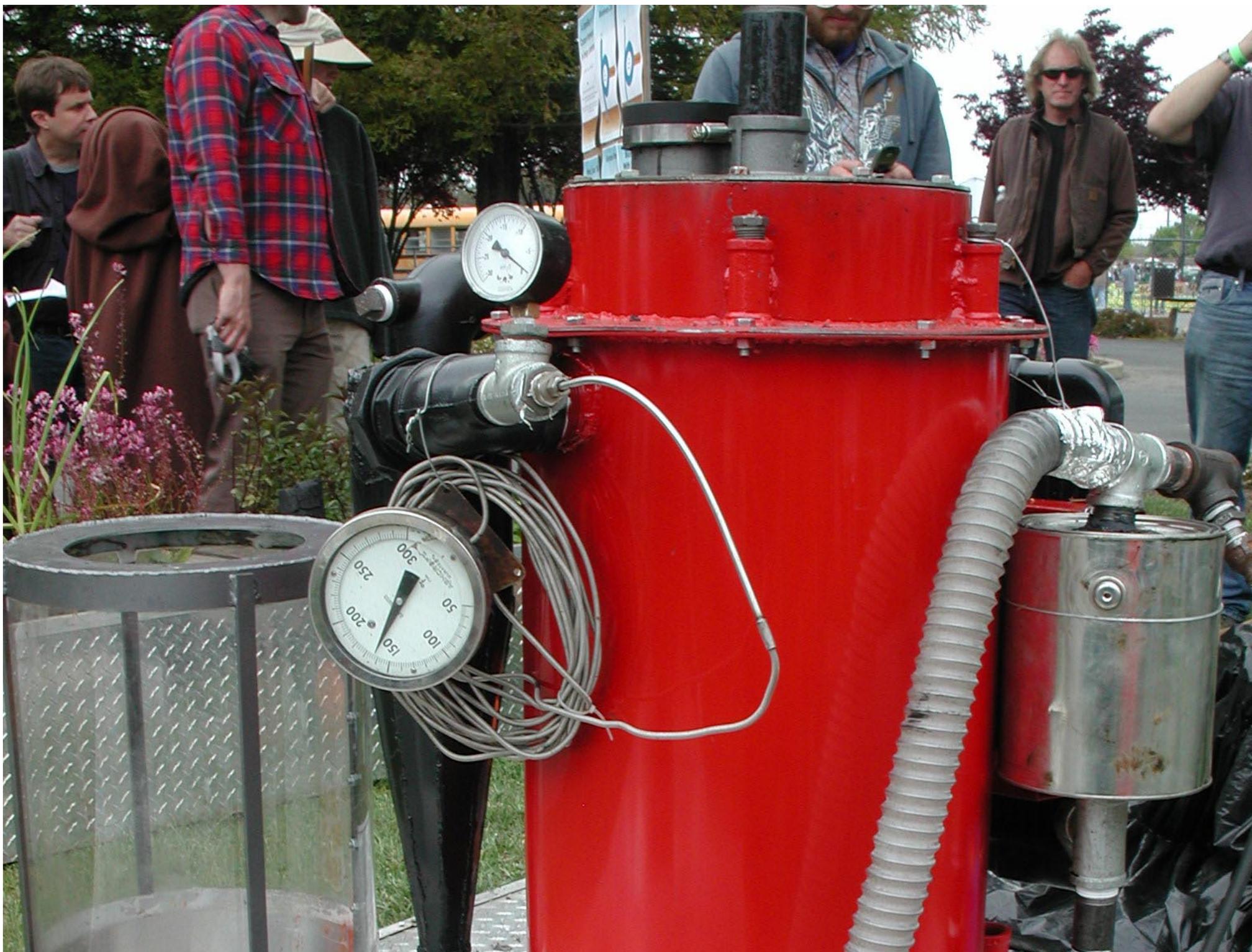






























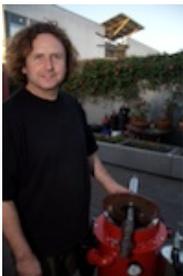




# Gasifier Experimenters Kit

- 
- 1
- 2
- *Next*

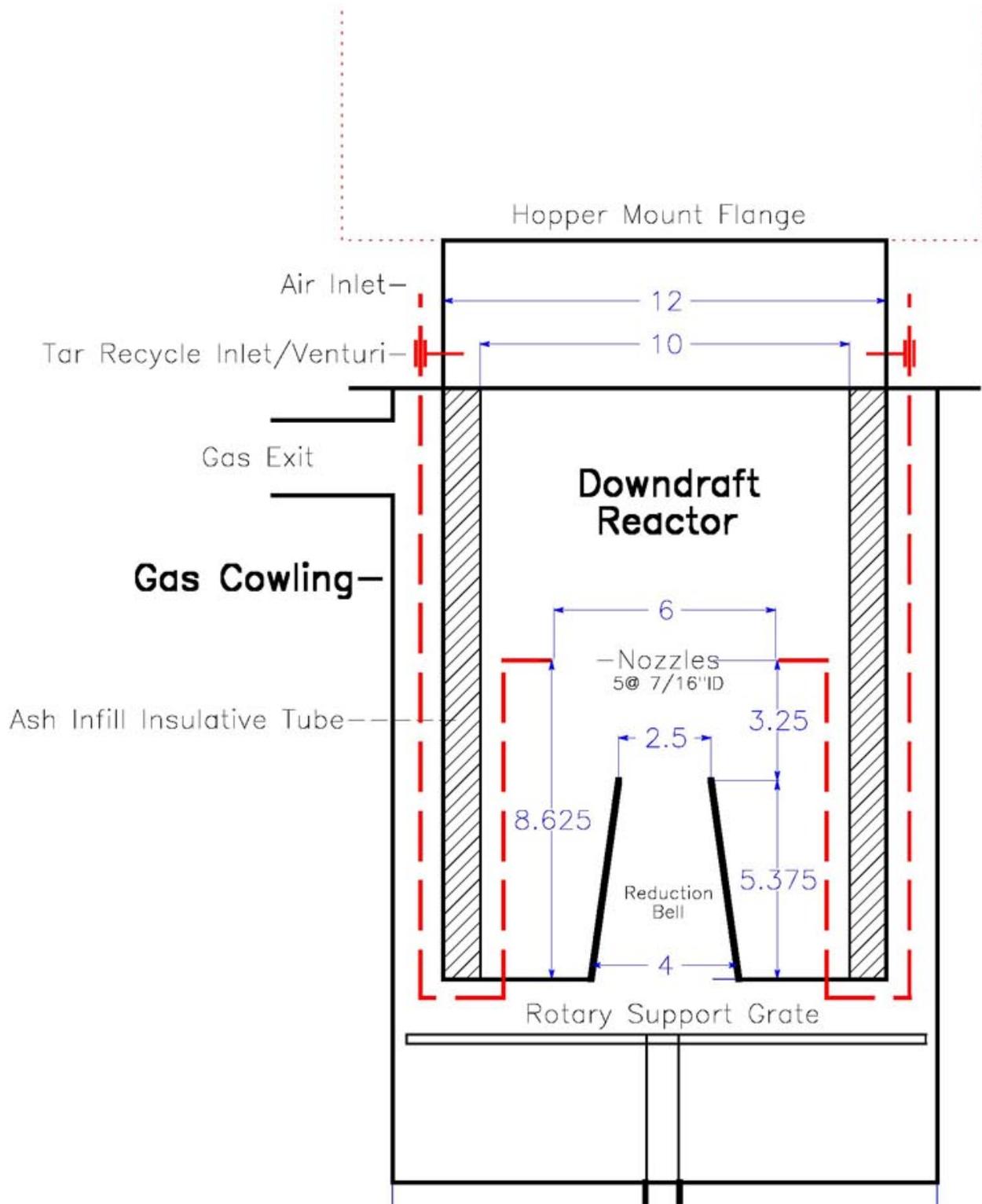
A Lego Set for Experimentation

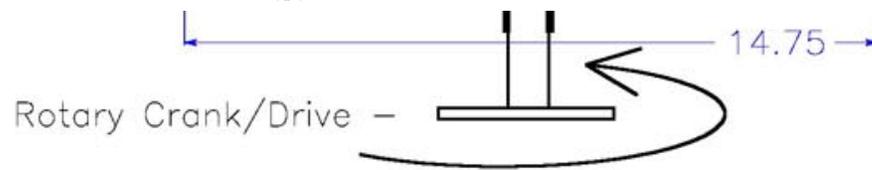




© Jim Mason







## GEK Downdraft Reactor with Air Preheating *2.5" reduction constriction configuration*

dimensions from Kaupp 1984a, Table 5, Fig75  
as reproduced in Handbook of Biomass Downdraft  
Gasifier Engine Systems: Thomas Reed and Agua Das

# Gasifier Experimenters Kit

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# ALL Power Labs: Tools for Power Hacking



About

**Gasification**

Biochar

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## Gasification

Gasification is the use of heat to transform solid biomass, or other carbonaceous solids, into a synthetic "natural gas like" flammable fuel. There are a wide variety of processes which fall under this general term- but all share the characteristic of transforming solid hydrocarbon material into simple hydrocarbon gases. The resulting gaseous fuel is usually called: "syngas", "woodgas", "producer gas", "generator gas" or "suction gas".

Through gasification, we can convert nearly any solid waste biomass into a clean burning, carbon neutral, gaseous fuel. Whether starting with wood chips or coffee grounds, municipal trash or agricultural waste, the end product is a flexible gaseous

fuel you can burn in your internal combustion engine, cooking stove, heating furnace and/or flamethrower. Upmigration to liquid fuels is also possible with some additional effort and common catalysts.

Sound impossible?

Well, over one million vehicles in Europe ran onboard gasifiers during WWII to make fuel from wood and charcoal, as gasoline and diesel were rationed and/or unavailable. Long before there was biodiesel and ethanol, we actually succeeded in a large-scale, alternative fuels redeployment-- and one which curiously used only cellulosic biomass, not the oil and sugar based biofuel sources which famously compete with food.

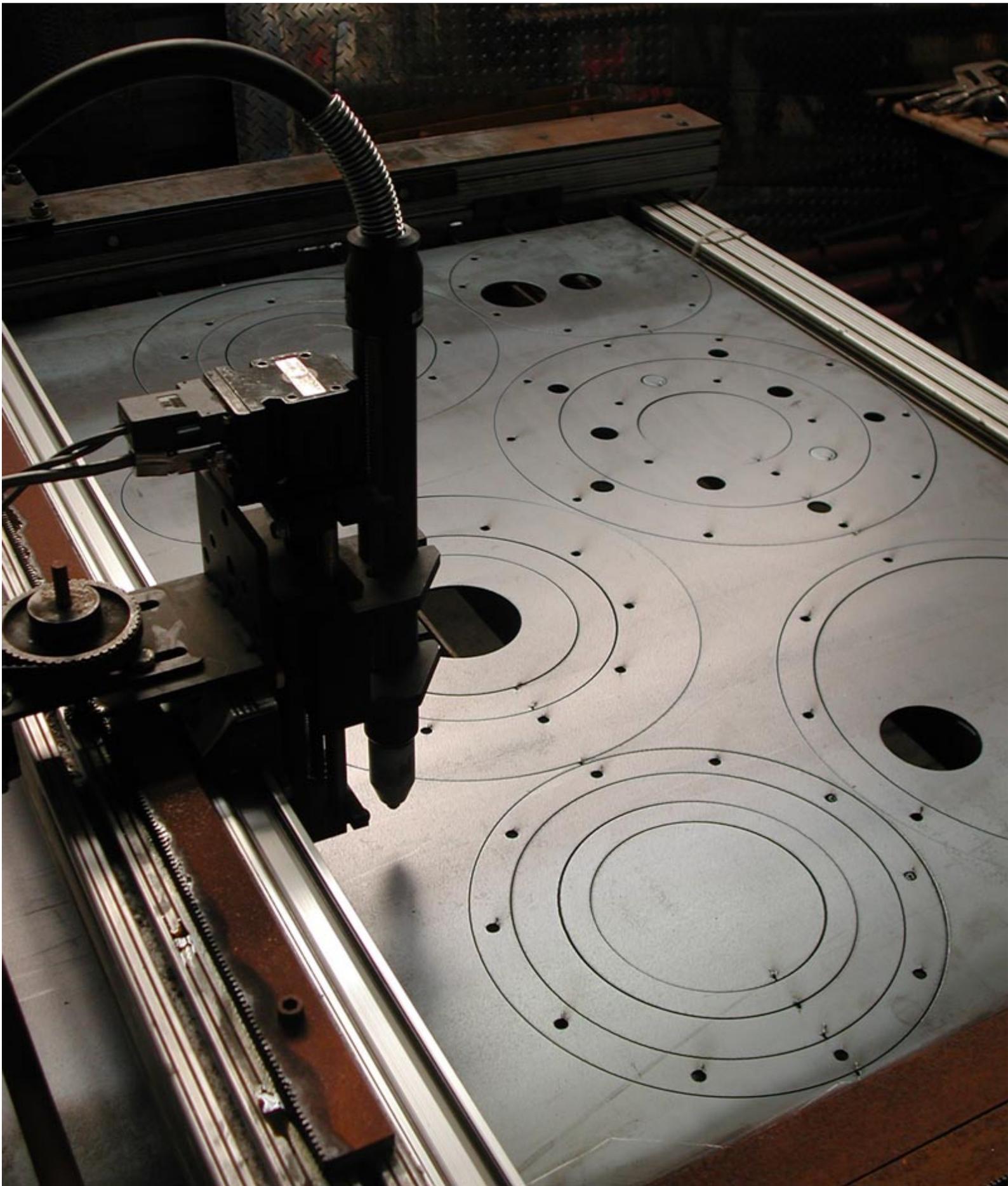
This redeployment was made possible by the gasification of waste biomass, using simple gasifiers about as complex as a traditional wood stove. These small-scale gasifiers are easily reproduced (and improved) today by DIY enthusiasts using simple hammer and wrench technology. The same principles are applied at much larger scale and complexity to recover a wide variety of municipal, agricultural, construction, forestry and industrial waste to energy, soil amendments and other useful end products.

ALL Power Labs now offers the [Gasifier Experimenters Kit \(GEK\)](#) to help you get started in the biomass thermal conversion arts and sciences.

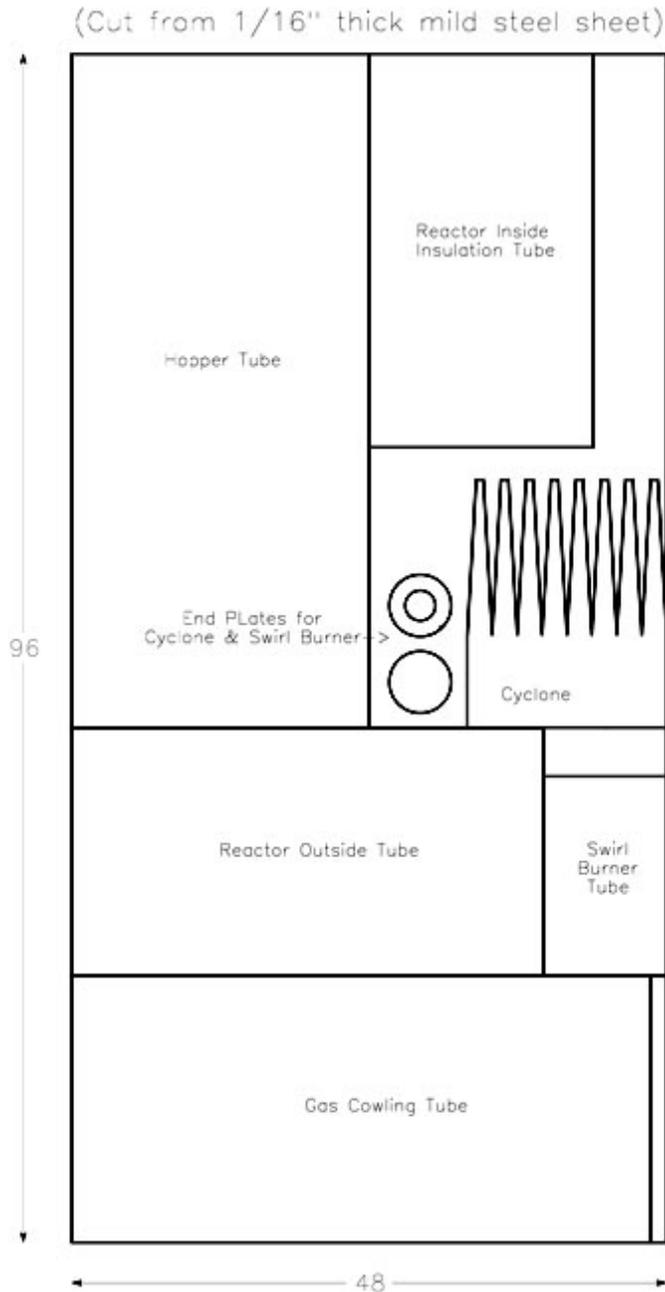
Questions? Contact: [gek\\_at\\_allpowerlabs\\_dot\\_org](mailto:gek_at_allpowerlabs_dot_org)



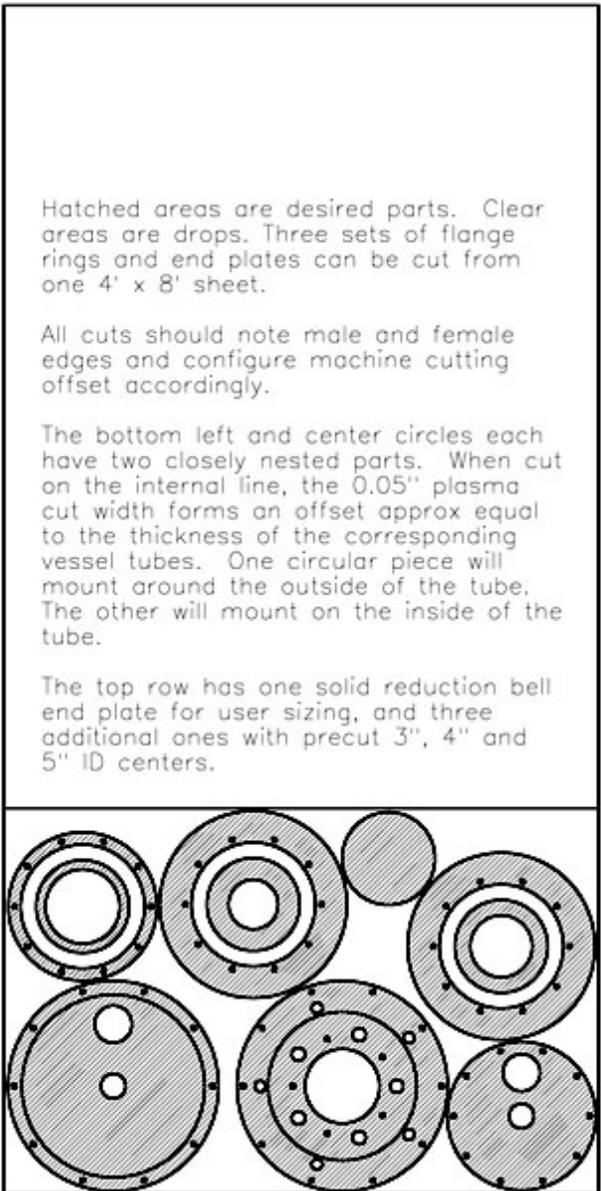




# Layout for CNC Plasma Cutting



(Cut from 1/8" thick mild steel sheet)



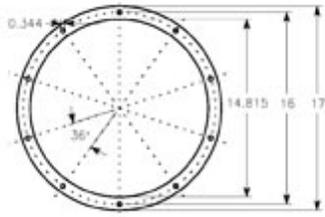
(v0.8. Before building, check [www.allpowerlabs.org/gasification/gek](http://www.allpowerlabs.org/gasification/gek) for most recent version before building.)

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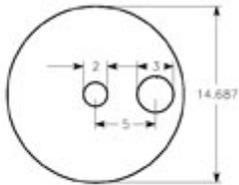
# GEK Flange Rings and End Plates

(Cut from 1/8" mild steel sheet)

## Gas Cowling

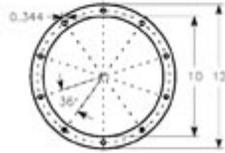


Top Rim Flange

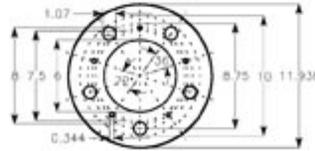


Bottom End Plate  
(with grate rotation, air inlet and ash port holes)

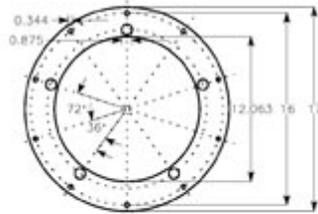
## Downdraft Reactor (nozzle & constriction type)



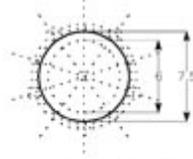
Top Rim Flange



Bottom End Plate

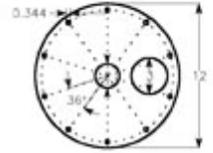


Perimeter Mounting Flange

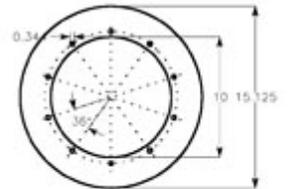


Reduction Bell End Plate  
(cut center to desired size)

## Hopper



Top Cover for Reactor or Hopper  
(holes for fuel fill and top down air config)



Top & Bottom Flange  
(2 count)

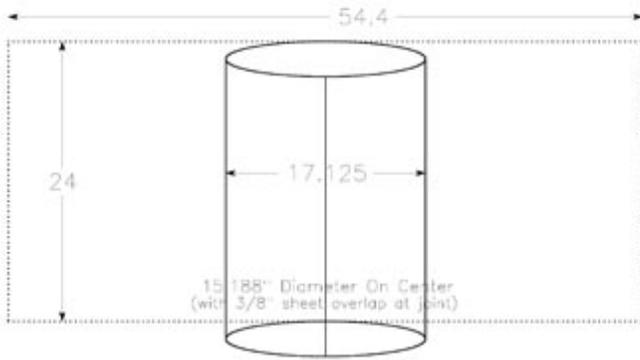
(v0.8. Before building, check [www.allpowerlabs.org/gasification/gek](http://www.allpowerlabs.org/gasification/gek) for most recent version before building.)

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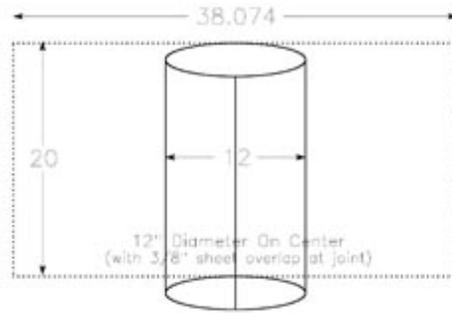


# GEK Vessel Tubes: Rolled from Flate Sheet

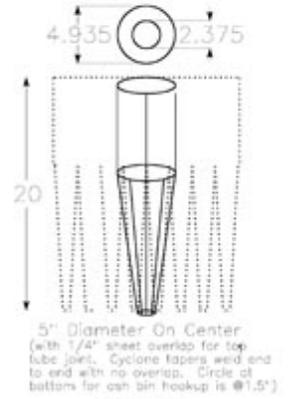
(Cut from 1/16" thick mild steel sheet)



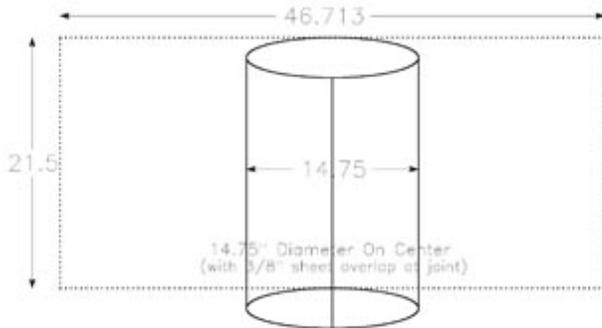
**Hopper**



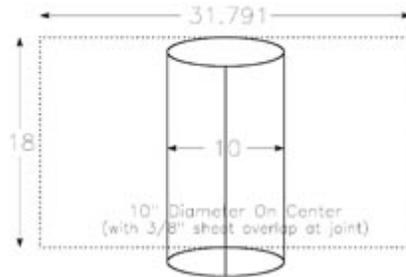
**Downdraft Reactor Outside**



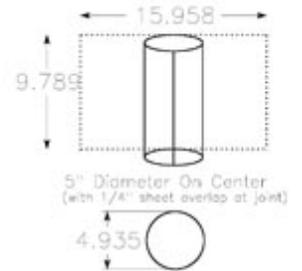
**Cyclone**



**Gas Cowling**



**Downdraft Reactor Inside/Insulation**



**Swirl Burner**

(v0.8. Before building, check [www.allpowerlabs.org/gasification/gek](http://www.allpowerlabs.org/gasification/gek) for most recent version before building.)

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# Gasifier Experimenters Kit

:

Vessel  
Tubes,  
Flanges,  
& End  
Plates



All Vessel Tubes, Flanges and End Plates



All Vessel Tubes, Flanges and End Plates



All Vessel Tubes, Flanges and End Plates



Hopper Tube and Flanges



Gas Cowling Tube, Flange, and End Plate



Downdraft Reactor Tubes, Flanges, End Plates, and Reduction Bell Weld Rings



Cyclone Tube and End Plate



Swirl Burner Tube and End Plate

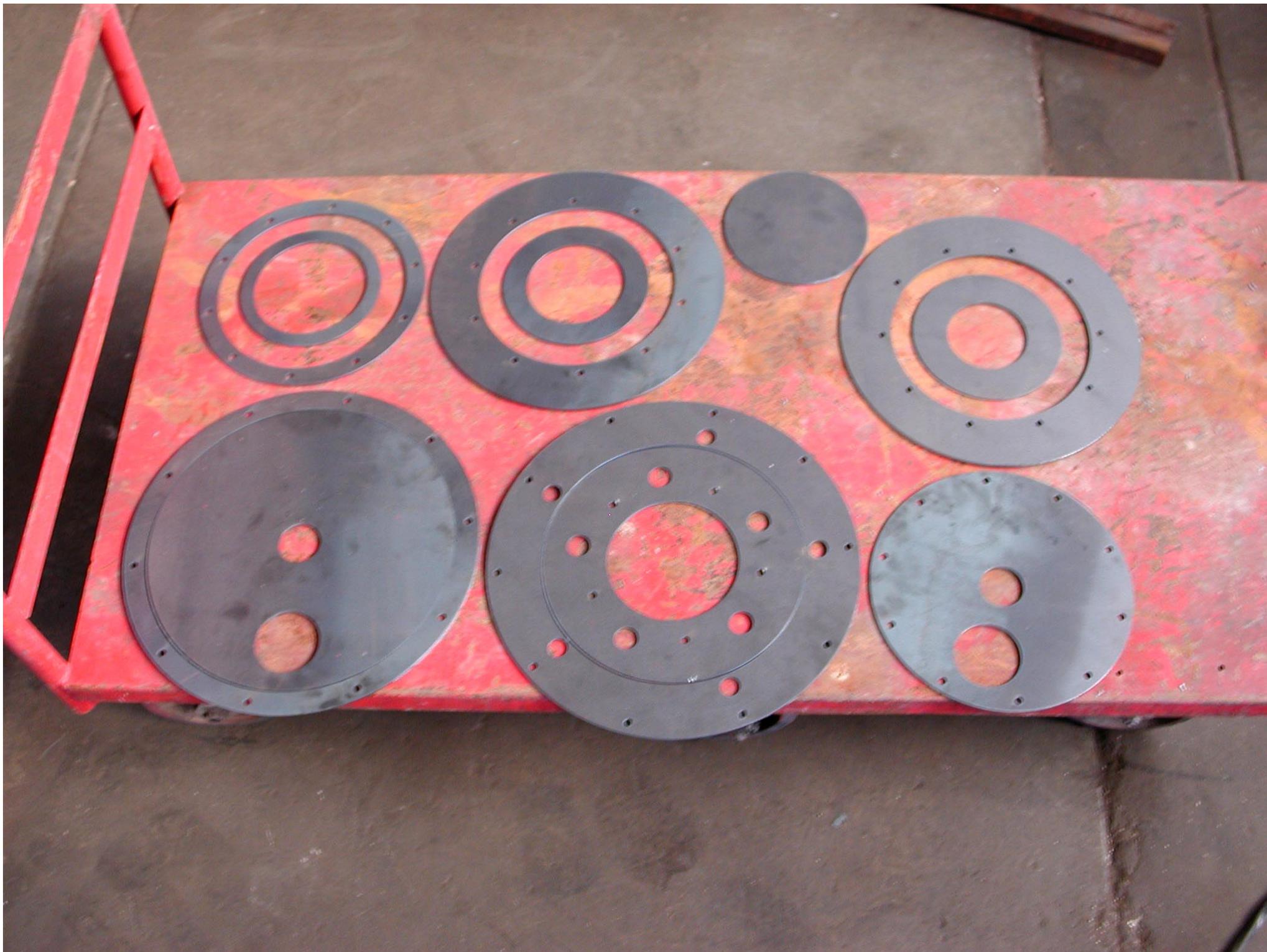


All Vessel Tubes

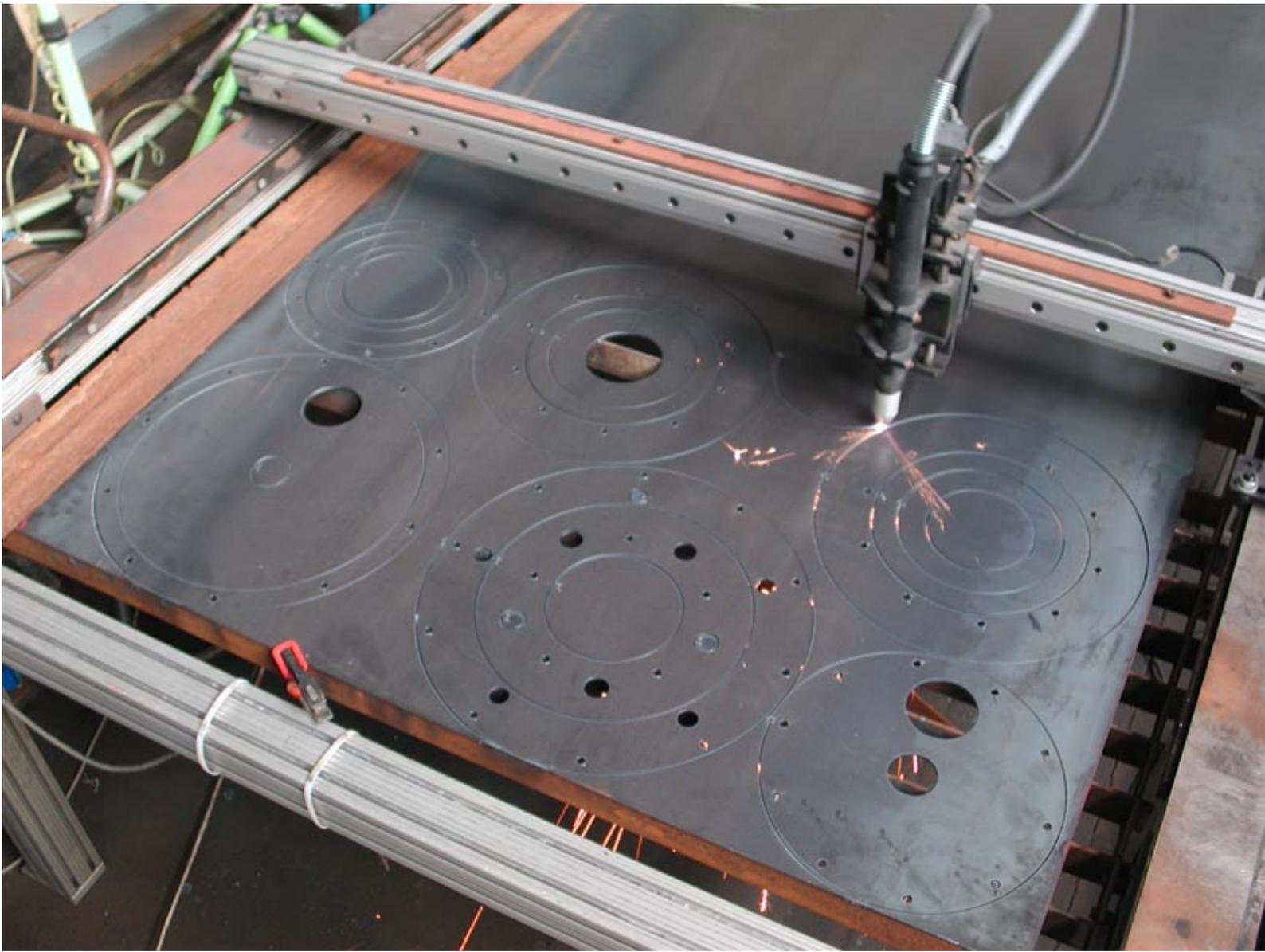


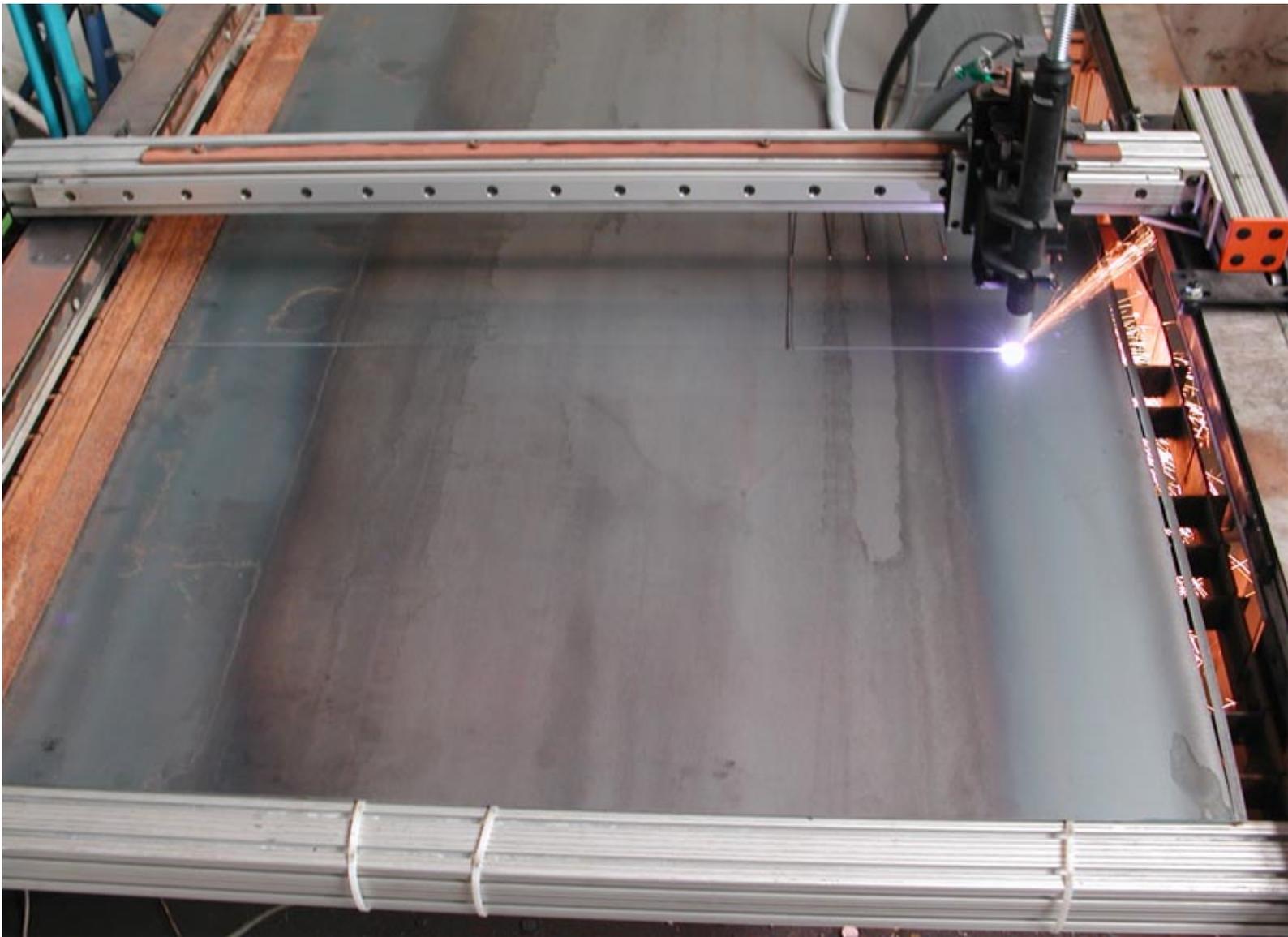
All Flanges and end Plates

© ALL Power Labs

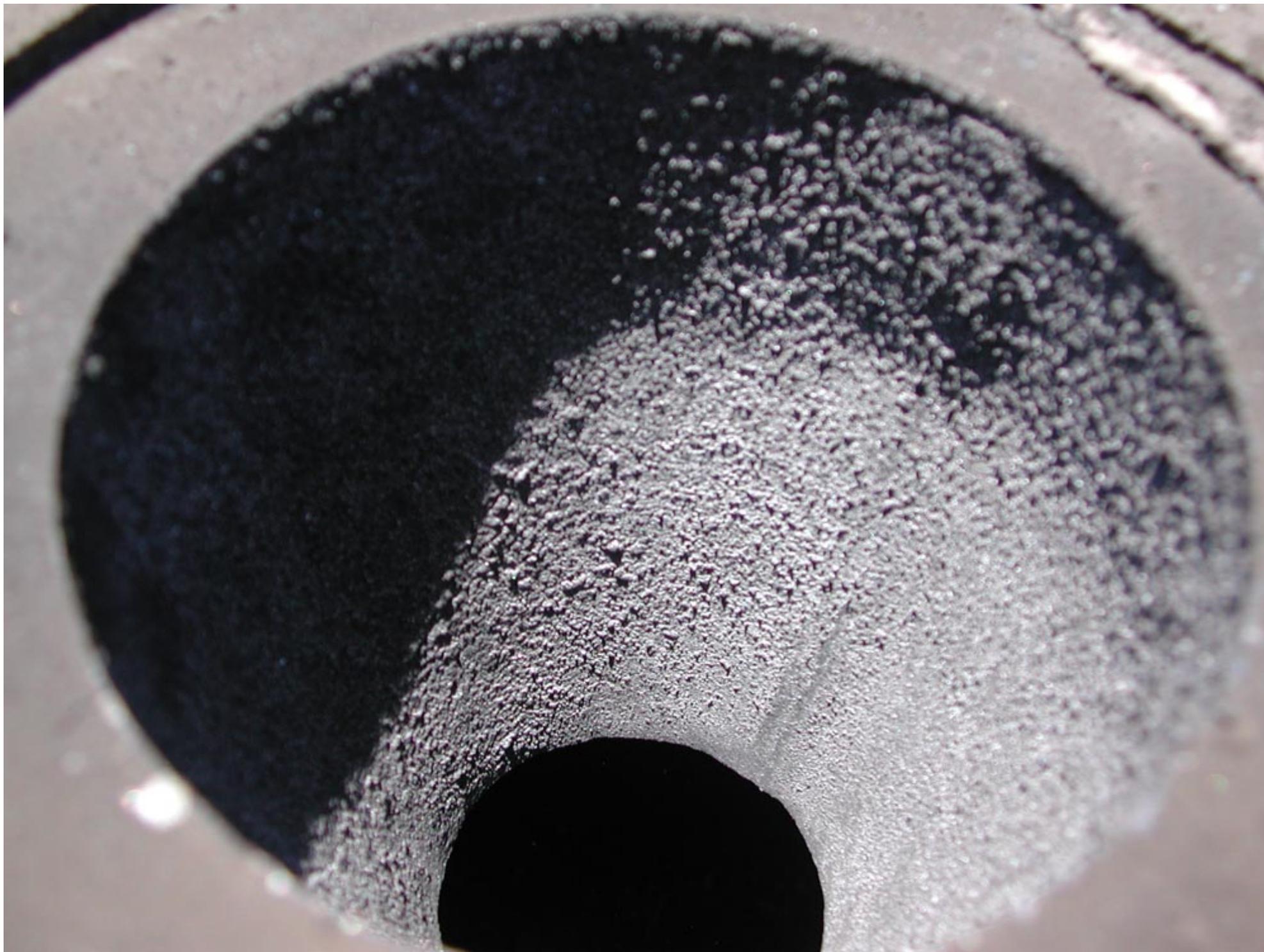












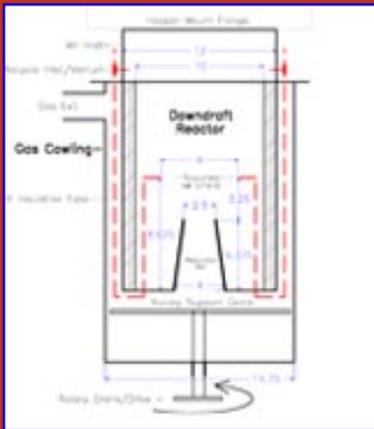








# ALL Power Labs: Tools for Power Hacking



## [Gasification Home:](#)

**The Basics**

**The Science of Gasification**

**Gasifier Types**

**How to Build a Gasifier**

Gasifier Experimenters Kit (GEK)

[Quadrafire \(4 in 1\)](#)

[Gas-can-o-fire](#)

[Cigifier](#)

[GMC truck](#)

Other Designs Online

[overview](#) - [gallery](#) - [reactor options](#)  
- [manufacturing](#) - [FAQ](#) - [test reports](#)  
- [downloads](#) - [purchase](#)

**GEK Test Report  
#1: *Air Preheating  
Configuration (Zero  
Tar)***

## Gasifier System Components

### Technical Resources

[Gasification Workshop \(June, 08\)](#)



The above pictures show a new air preheating scenario for the GEK nozzle and constriction (Imbert) type downdraft reactor. We ran this configuration at the Maker's Faire in San Mateo, CA, May 4-5 to drive a Lister 6/1 diesel genset in dual fuel mode. The

result was a tar free gas over about 10 hours of operation. The fuel was walnut shells at 15% moisture content.

This air preheating system uses heat exchange tubes in the form of stainless steel natural gas lines, 48" in length, 5/8" ID, spiral wrapped around the reactor. When the reactor is bolted down into the gas cowling, these heat exchange tubes fill the circular volume where the product gas rises upwards towards the outlet. The heat exchange tubes are mostly perpendicular to the direction of gas flow, unlike the [previous "J tube" scheme](#). SS natural gas lines are well optimized for repurposing as heat exchange tubes. They are thin and corrugated (thus lots of surface area), easy to bend, non-corrosive and cheap.

Somewhat to our surprise, this aggressive air preheating system resulted in a gas that appeared completely tar free. This is likely the result of higher combustion and reduction zone temps and thus improved tar consumption and conversion. Condensate too was significantly decreased, owing to increased H<sub>2</sub>O conversion in the reduction zone from the higher temps.

Below you can see the clear gas hoses we use for the product gas piping. After one hour of running, there was absolutely no brown or

black discoloration in the tube. I did not have a paper tar test filter rig hooked up at the Faire, but from experience I know this lack of deposition in the clear gas tube equates with a tar level below measurement for typical sample times with the paper filter. The only liquid visible is the typical water condensation, also completely clear.





*(With the GEK I try to use clear gas tubes, filters, condensate vessels and hoppers wherever possible so as to be more transparent and honest about real world performance, and make the processes more visible for learning.)*

The product gas "smoke" was similarly nearly transparent, with only a slight white coloration. Nothing like the usual cream colored smoke. After a full day of running at 1-2" water vac, there was a slight brown tinge in the tubing, but nothing like the usual black stains and soot.

The swirl burner similarly showed an unusually clean gas signature. After half of day of running, the burner had zero soot deposition. The inside of the burner still looked identical to the original raw steel.

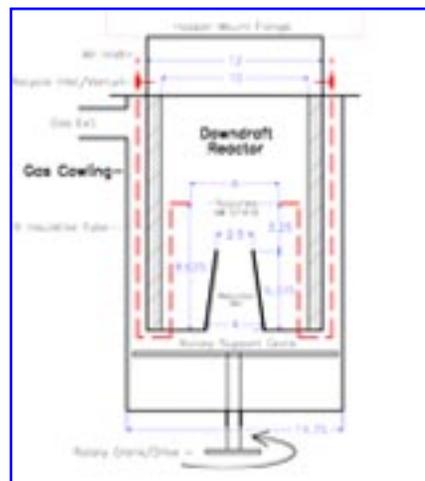




In addition to preheating the air, the heat exchange tubes also cool the product gas. I was surprised to see gas exiting the top of the gas cowling at 150-210F. Yes that is correct, 100C or less. Compare with typical no air preheating or gas cooling configurations which have gas exit temps in the 200-400C range. Hot gas is much more difficult to process downstream than cool gas. Cyclones, filters, plumbing and pumps are all complicated by high temp gas.

This success of this "gas cooling via air preheating" suggests the potential of eliminating the radiator all together. In the next run I'm going to double the length of the air preheating lines, put fins on the cyclone, increase the size of the granular filter, and see if we can do without the radiator (or in other words, incorporate the radiator into the gasifier). Efficiency will

also continue to increase the more we recycle this "waste" heat back into the gasifier.



The internal geometry for this run was the "textbook" dimensions for Swedish inverted V hearth designs for a 2.5" reduction constriction. This is a very small constriction, intended for engines around 5-10hp. I did not do any special nozzle burn path tests or other diagnostic configurations, so i'm sure what I had could be improved upon. The fuel was walnut shells in 1/4 - 1/2 shell form. Moisture was measured at 15%.



In the drawing above you will also see an ejector venturi based tar recycling system. This is built into the GEK downdraft nozzle and constriction reactor, but we were not using it during the current test. The inlets in the pyrolysis zone were capped off so we could test the air preheating alone. A run in the near future will explore and document this tar recycling system.

# ALL Power Labs: Tools for Power Hacking



## [Gasification Home:](#)

[The Basics](#)

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Gasifier Experimenters  
Kit (GEK)

[Quadrafire \(4 in 1\)](#)

[Gas-can-o-fire](#)

[Cigifier](#)

[overview](#) - [gallery](#) - [reactor options](#) - [manufacturing](#) - [FAQ](#) - [test reports](#) - [downloads](#) - [purchase](#)

## GEK Report #2: *Soot on Air Preheating Tubes*

Here are pictures of the air preheating tubes after 15 hours of operation. The air preheating tubes are made from 4' lengths of 5/8" corrugated stainless steel natural gas lines. (Details are in [GEK Report #1](#)). The fuel was halved walnut shells at approximately 15% moisture content.

I was very pleased the relative lack of deposition on the tubes. This is a gasifier after all. Internals are always messy. Here the soot is surprisingly light, and easy to brush off with

[GMC truck](#)

[Other Designs Online](#)

## Gasifier System Components

**Technical Resources**

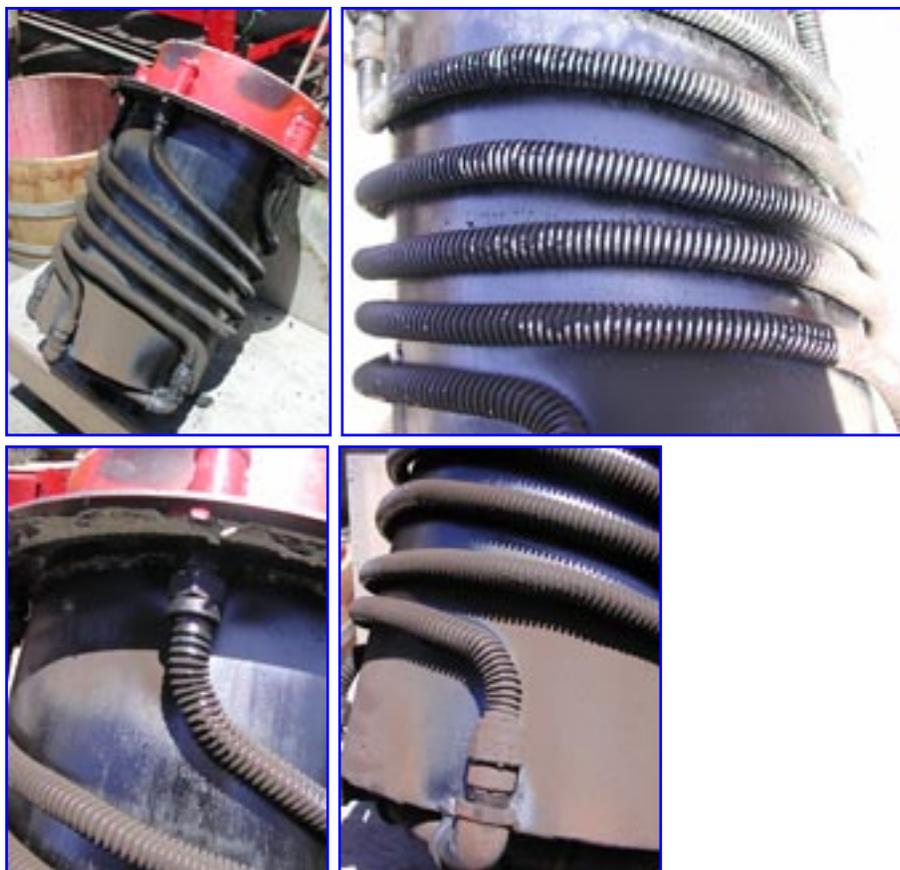
[Gasification Workshop](#)

[\(June, 08\)](#)

your hand. The soot is not the oft encountered tarry black glue. I expected much greater soot and tar deposits given the temp differential between the hot gas exterior and the cold air interior.

Lower parts of the tubes have more particulate deposits. The upper parts are without such, as the long gas rising pathways tends to settle out the particles.

Next task is to run thermocouples down the tubes to get the temperature profile along the whole path.









More pictures [in the gallery](#) under GEK v0.9 .



# ALL Power Labs: Tools for Power Hacking



## [Gasification Home:](#)

**The Basics**

**The Science of Gasification**

**Gasifier Types**

**How to Build a Gasifier**

Gasifier Experimenters Kit (GEK)

[Quadrafire \(4 in 1\)](#)

[Gas-can-o-fire](#)

[Cigifier](#)

[GMC truck](#)

Other Designs Online

[overview](#) - [gallery](#) - [reactor options](#) -  
[manufacturing](#) - [FAQ](#) - [test reports](#) -  
[downloads](#) - [purchase](#)

## GEK Report #3:

### Temperature Profile Data for Air Preheating / Syngas Cooling

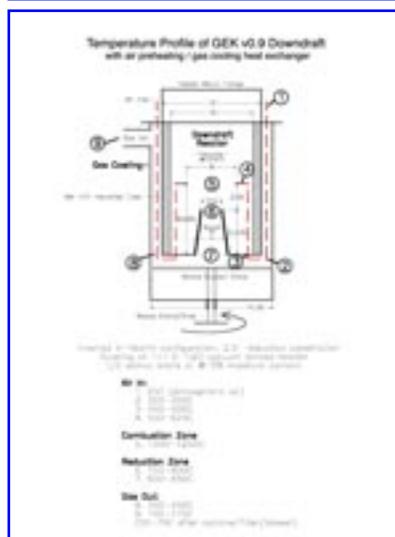
Data is finally in for GEK v0.9 internal reactor temperatures during normal run conditions. The graphics below give measured temps at all critical locations relevant to air preheating, combustion and reduction zones, and syngas cooling. The graphics index these temps to pictures of the GEK reactor, as well as CAD drawings of the same. I suggest you

## Gasifier System Components

### Technical Resources

[Gasification Workshop \(June, 08\)](#)

open both graphics to follow the comments.



### Summary:

*The GEK v0.9 air preheating / gas cooling architecture is raising 25C atmospheric air to @600C by the time the air reaches the nozzles at the combustion zone. In the opposite direction, the incoming air cools the output syngas to 100-175C before it exits the gas cowling.*

*Preaheating the air to 600C significantly reduces thermal load on the combustion zone, which would otherwise have to do the same*

*air "preheating" before oxidation reactions can begin. 600C is above the auto-ignition temperature of most components of pyrolysis gas, so the air entering the combustion zone is already at reaction temperatures without heat input from existing combustion.*

*Eliminating the thermal drag of cool incoming air results in higher temps in the combustion zone, greater tolerance to moisture in the fuel, greater tolerance to high air humidity, and/or increased turndown ratio. It also increases combustion rate, which in the current test resulted in combustion finishing well before the reduction constriction-- suggesting we need to lower the nozzle height from the typical "textbook" dimensions.*

*Using the incoming air to internally cool the syngas greatly reduces the need for post-gasifier cooling. In our case, we've eliminated the external radiator entirely. The cyclone,packed bed filter and blower provide enough extra cooling to drop the final output syngas temp to 50-75C.*

### **Full Report:**

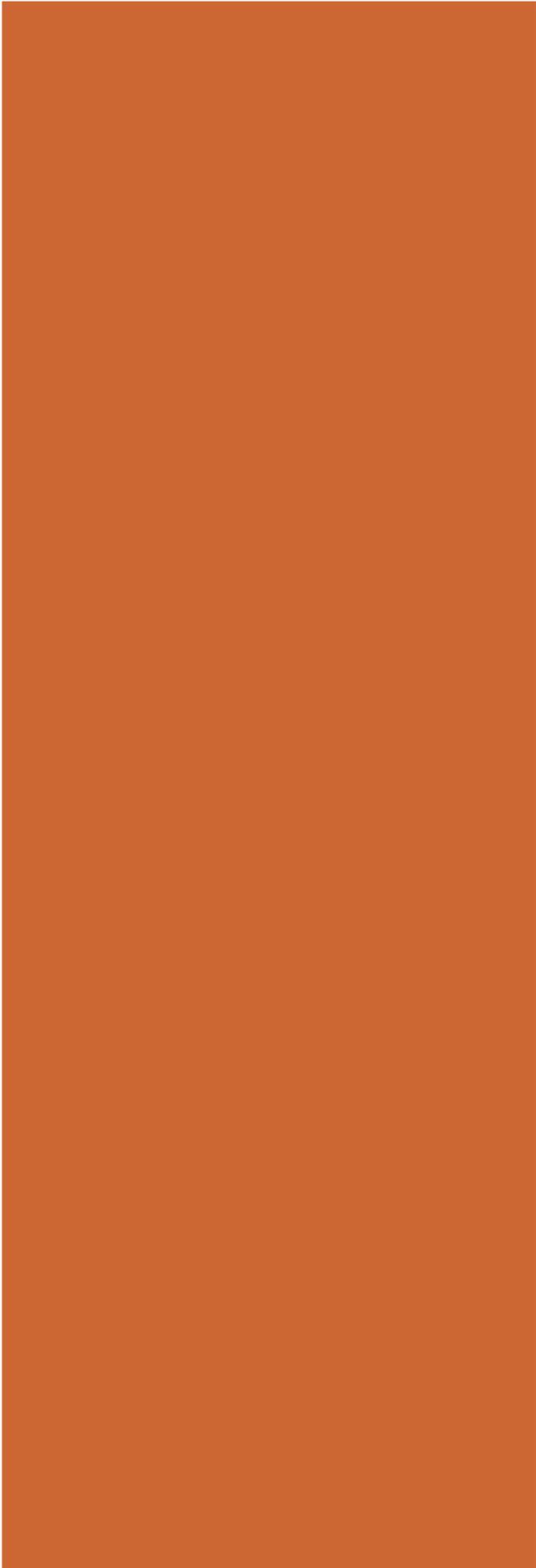
This data was collected and averaged over three separate run sessions of 2-3 hours each, in June and July 2008. The fuel was halved walnut shells at approximately 15% moisture content. The GEK was set up as an inverted V- hearth reduction bell, with 2.5" constriction. The heat exchange lines are 5/8" corrugated SS lines of 4' length. More details on the heat exchange architecture is here: [GEK Report #1](http://www.allpowerlabs.org/gasification/gek/gekreports/report3/report3.html).

The reactor was pulled at a flow rate that experience suggests is about its mid range of operation. This corresponds to 1-1.5" of H<sub>2</sub>O vacuum across the reactor (before the cyclone and filter). We cannot yet quantify this flow rate in volumetric terms, but in experience it has corresponded to running a gasoline genset at around 2kwe. (Apologies for annoying vagueness, we're still trying to acquire a full instrumentation suite)

We had installed 6 type K thermocouples into the GEK to generate the temp data. We were careful to keep TCs in the actual gas streams and not touching pipe or vessel walls. We also tried to weigh the reactor during running so as to measure fuel consumption, but alas, success eluded us.

Here's some pictures of the process, along with the locals mulling over the situation (Bear Kaufmann, Charlie Sellers and Dennis).







Here's what we found . . .

### **Air In: Atmosphere to Nozzles:**

The air preheating lines are raising the incoming air to 450-500C by the point where the air lines penetrate the bottom of the reactor and head upwards to the nozzles. This is adjacent to the base of the reduction bell, where the syngas exiting temp is 600-650C. This is around a 150C temp differential, which is likely about as good as we can hope for in a winding gas-to-gas heat exchanger.

The air temp raises another 100C or so between the reactor bottom and the insides of the nozzles. We measured 550-625C inside

the nozzles. The highest peak was 650C. This temp increase is from heat contributed by the char and ash insulation around the reduction and combustion zones. I'm not clear the degree to which this heat input is an added drag on the combustion and reduction zones, or if it is mostly recovered heat already lost to the insulation. We'll have to measure the insulation temp around the air inlets to figure it out.

Remember, the point of this heat exchange architecture is to start mining heat from the syngas immediately after the reduction zone, only after all thermo-chemical work is completed. Mining heat from the combustion and reduction zone may produce a net zero sum heat budget in the end, but it could still reduce max temps achieved along the path, and thus impact tar conversion. Maintaining acceptable max temps is ultimately more critical than efficiency, given the extreme "inefficiencies" of tar in an engine . . .

### **Combustion Zone:**

Combustion zone temps wandered in the 1000-1250C range. At other times i've seen it drop to 800C and rise to 1300C with extreme pull rates or fuel moisture variations. The moisture of the fuel actually seems to have more impact on combustion zone temp variations than the pull rate (within reasonable limits).

### **Reduction Zone:**

The temp drop between the top and bottom of the reduction bell is not as great as I expected. The constriction at the top of the reduction bell runs around 700-800C. This suggests the combustion has already finished before the

constriction and reduction has been underway for some time. This suggests the significantly preheated air is increasing the combustion rate so the "normal" distance from the nozzles to the reduction constriction for combustion to complete is now too long. Or in other words, we need to lower the nozzles to again place the finish of combustion right at the constriction of the reduction bell. (note the configuration help a simple TC provides).

The bottom of the reduction bell is consistently 600-650C. I was very surprised to see this temp stay steady across a very large range of pull rates. The only way I could get the bottom of the reduction bell above this temp was to overpull the reactor, which pulled the reduction down onto the grate and axially outward, typically burning off the gas cowling paint. I was baffled until I pulled out the Boudouard equilibrium reaction chart and discovered a "knee" in the graph right where my temp was stuck. 600-650C is "knee" in the boudouard reaction rate change, below which the reduction of  $\text{CO}_2$  to  $\text{CO}$  slows to a point which is not terribly relevant.

Clearly there is a wealth of configuration optimization and gas flow rate limits that can be derived simply from knowing the top and bottom temps of the reduction bell. More on this in the next report.

### **Grate to Gas Exit:**

The syngas loses about 200-300C from the bottom of the reduction bell to the edge of the grate at the gas cowling. Temps here at the wall before the gas rises up the gas cowling wandered between 350-450C. I was surprised to see this significant drop just from the reduction bell to the edge of the grate, as this

is all of about 5" of travel. Another 200-250C or so is lost on the rise up to the gas outlet, resulting in 100-175C at the gas cowling outlet. (Post reactor cooling in the cyclone, filter and blower bring the final temp down to 50-75C, but none of this heat is recovered back into the system).

The air inlet temps show nearly the same changes but in the opposite direction. 25C at the air inlet. 300-350 at the bottom of the heat exchange tube spirals, where the grate intersects the gas cowling. 450-500C at the inner grate, next to the reduction bell where the air tubes turn up to penetrate the reactor bottom and go to the nozzles. And again, 550-625C at the nozzles.

Through the entire air in and syngas out path, the differential temp seems to hover around 150C. This does not suggest the heat in the syngas is equal to the thermal sink of the incoming air. I seem to remember the syngas out has about 40% more heat capacity than the incoming air, due mostly to volume differences (can someone clarify the specifics here?). This suggests the syngas is a better air preheater than the incoming air is a syngas cooler. The only reason the syngas out gets as cool as it does is from the added heat lost to the surrounding gas cowling and other surfaces.

This excess of sensible heat in the syngas out vs the air in also suggests the heat exchange system will be relatively tolerant of less-than-optimal designs, and still result in near max possible air temps at the nozzles. To the degree the heat exchange efficiency is improved, there is additional capacity we can use to do other heating work, while still ending at the same temps at the nozzles, and also further cooling the output gas.

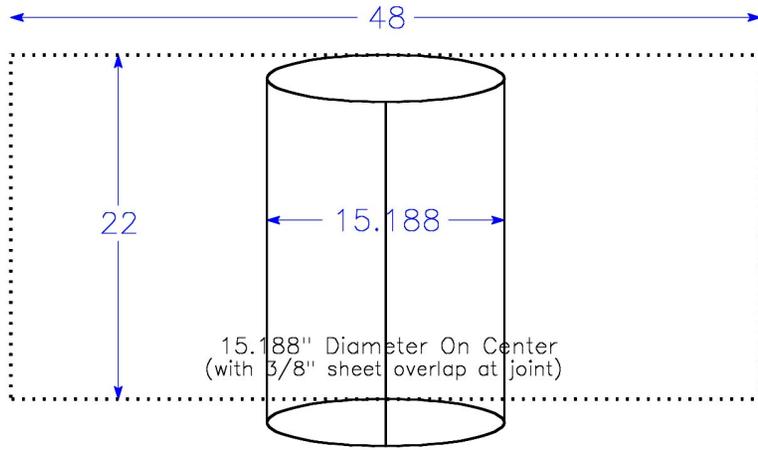
## What's Next:

I'm interested in using this excess heat exchange capacity to support the addition of water/steam, and/or IC exhaust to the incoming air. To the degree we can add h<sub>2</sub>O or CO<sub>2</sub> to the incoming air (while maintaining acceptable temps to consume tars in the combustion zone) our gas quality will go up, while our biomass fuel consumption will go down. Gas will come out slightly cooler too.

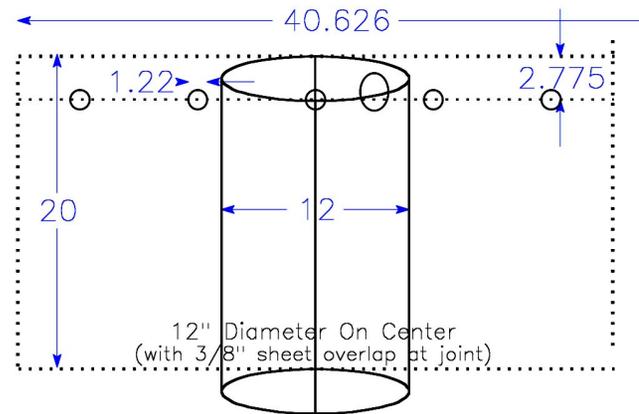
Thus starting with the v1.0 GEK, I increased the SS lines from 4' to 6'-- even though the 4' length as tested seemed to already produce the max incoming air temps one could expect across a small gas-to-gas heat exchanger. The v2.0 run will similarly have 6' heat exchange lines, along with an improved spiral configuration at the bottom of the reactor.

# GEK Vessel Tubes v1.0: Rolled from Flat Sheet

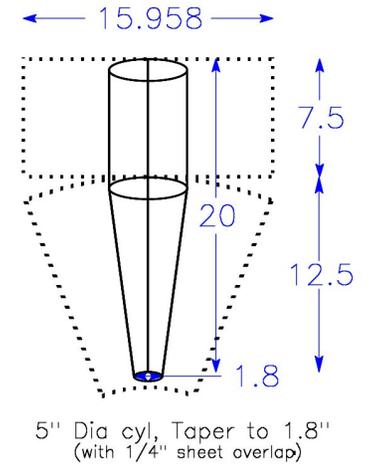
(Cut from 1/16" thick mild steel sheet)



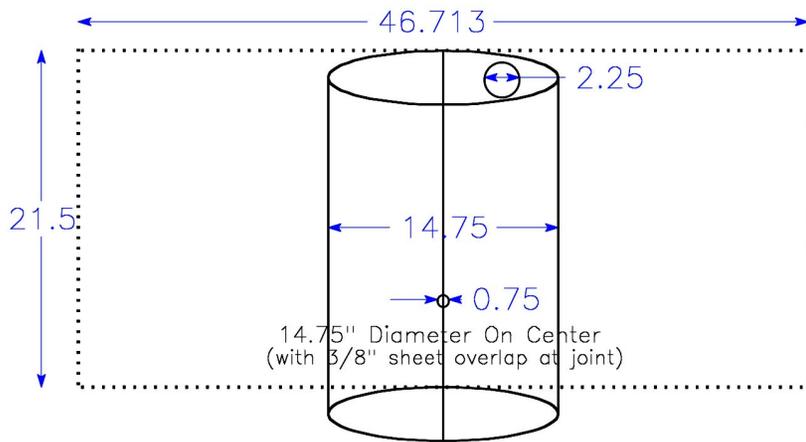
**Hopper**



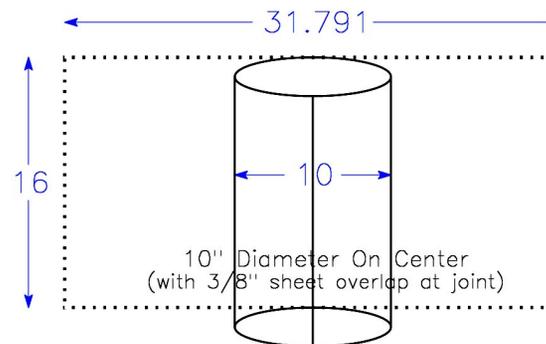
**Downdraft Reactor Outside**



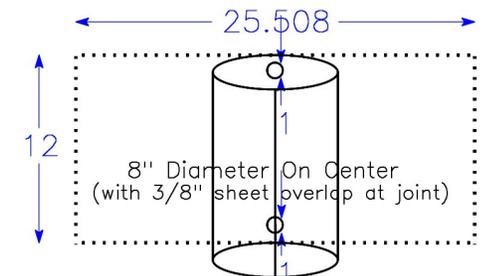
**Cyclone**



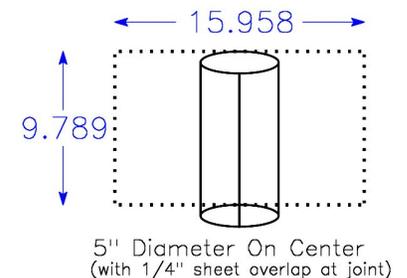
**Gas Cowling**



**Downdraft Reactor Inside/Insulation**



**Packed Bed Filter**



**Swirl Burner**

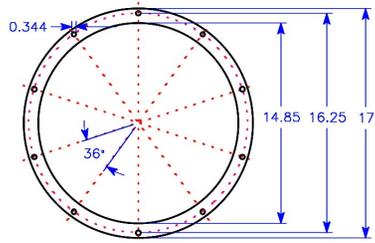
Before building, check for more recent versions at: [www.allpowerlabs.org/gasification/gek](http://www.allpowerlabs.org/gasification/gek)  
ALL Power Labs 1010 Murray Street Berkeley, CA 94710. 8/08. [jimmason@whatiamupto.com](mailto:jimmason@whatiamupto.com)



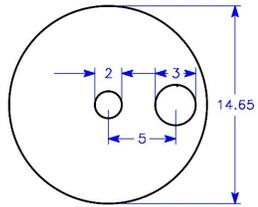
# GEK Flange Rings and End Plates v1.0

(Cut from 1/8" mild steel sheet)

## Gas Cowling

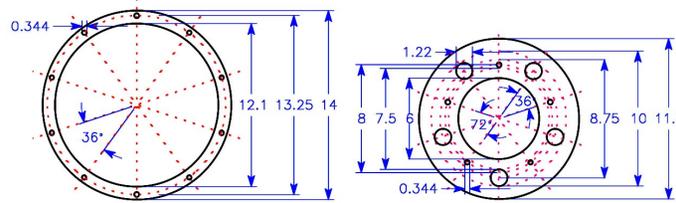


Top Rim Flange



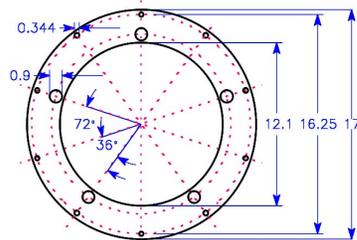
Bottom End Plate  
(with grate rotation, air inlet and ash port holes)

## Downdraft Reactor (nozzle & constriction type)

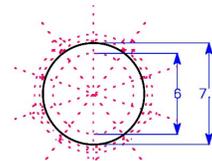


Top Rim Flange

Bottom End Plate

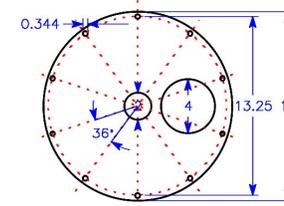


Perimeter Mounting Flange

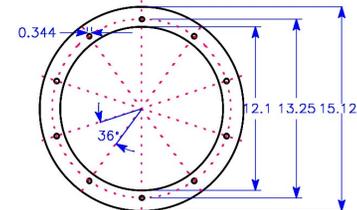


Reduction Bell End Plate  
(cut center to desired size)

## Hopper

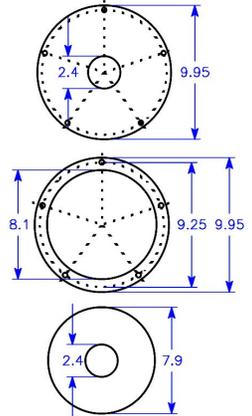


Top Cover for Reactor or Hopper  
(holes for fuel fill and top down air config)

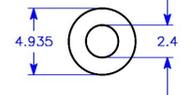


Top & Bottom Flange  
(2 count)

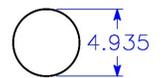
## Filter



## Cyclone



## Burner

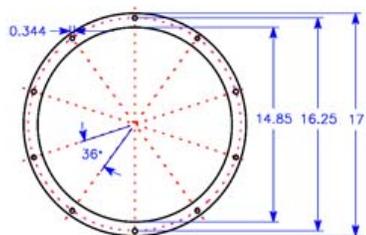


Before building, check for more recent versions at: [www.allpowerlabs.org/gasification/gek](http://www.allpowerlabs.org/gasification/gek)  
ALL Power Labs1010 Murray Street Berkeley, CA 94710. 8/08. [jimmason@whatiamupto.com](mailto:jimmason@whatiamupto.com)

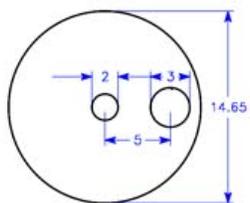
# GEK Flange Rings and End Plates v1.0

(Cut from 1/8" mild steel sheet)

## Gas Cowling

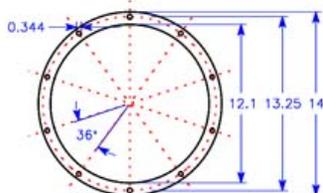


Top Rim Flange

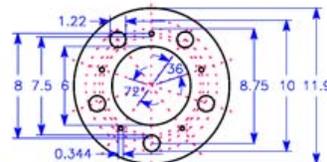


Bottom End Plate  
(with grate rotation, air inlet and ash port holes)

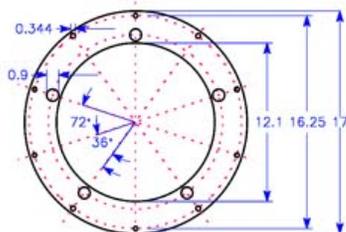
## Downdraft Reactor (nozzle & constriction type)



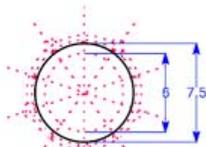
Top Rim Flange



Bottom End Plate

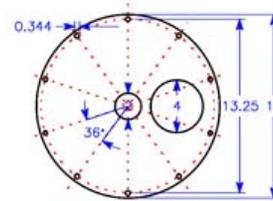


Perimeter Mounting Flange

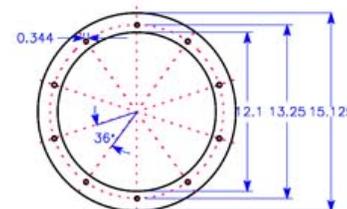


Reduction Bell End Plate  
(cut center to desired size)

## Hopper

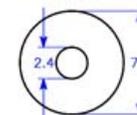
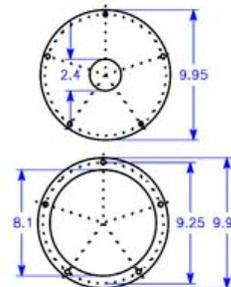


Top Cover for Reactor or Hopper  
(holes for fuel fill and top down air config)

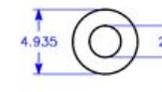


Top & Bottom Flange  
(2 count)

## Filter



## Cyclone



## Burner

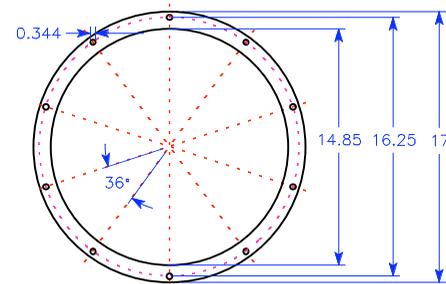


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ALL Power Labs 1010 Murray Street Berkeley, CA 94710. 8/08. [jimmason@whatiamupto.com](mailto:jimmason@whatiamupto.com)

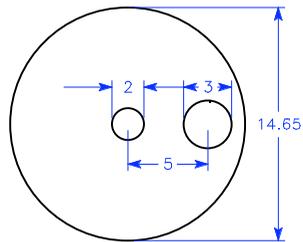
# GEK Flange Rings and End Plates v1.0

(Cut from 1/8" mild steel sheet)

## Gas Cowling

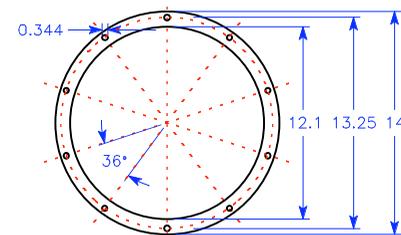


Top Rim Flange

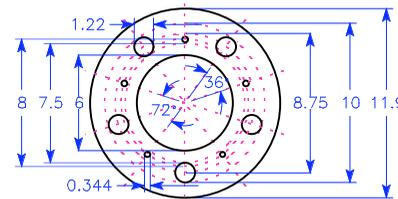


Bottom End Plate  
(with grate rotation, air inlet and ash port holes)

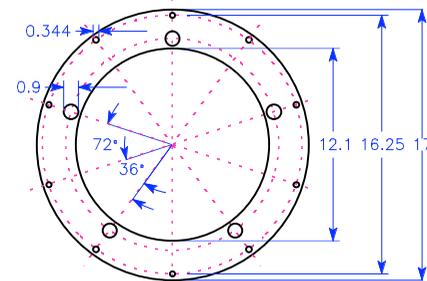
## Downdraft Reactor (nozzle & constriction type)



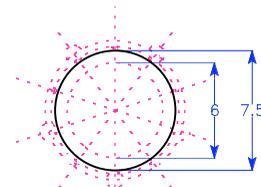
Top Rim Flange



Bottom End Plate

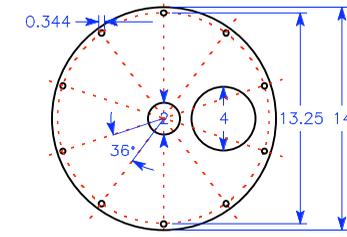


Perimeter  
Mounting Flange

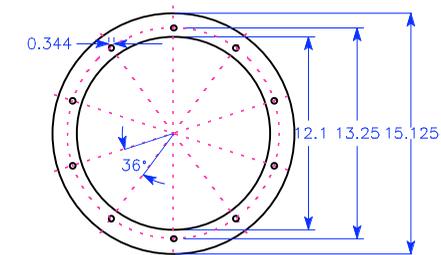


Reduction Bell  
End Plate  
(cut center to  
desired size)

## Hopper

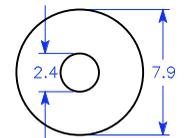
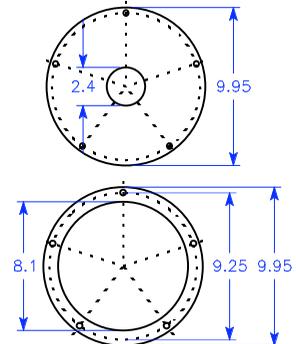


Top Cover for  
Reactor or Hopper  
(holes for fuel fill and  
top down air config)

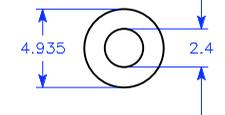


Top & Bottom Flange  
(2 count)

## Filter



## Cyclone



## Burner



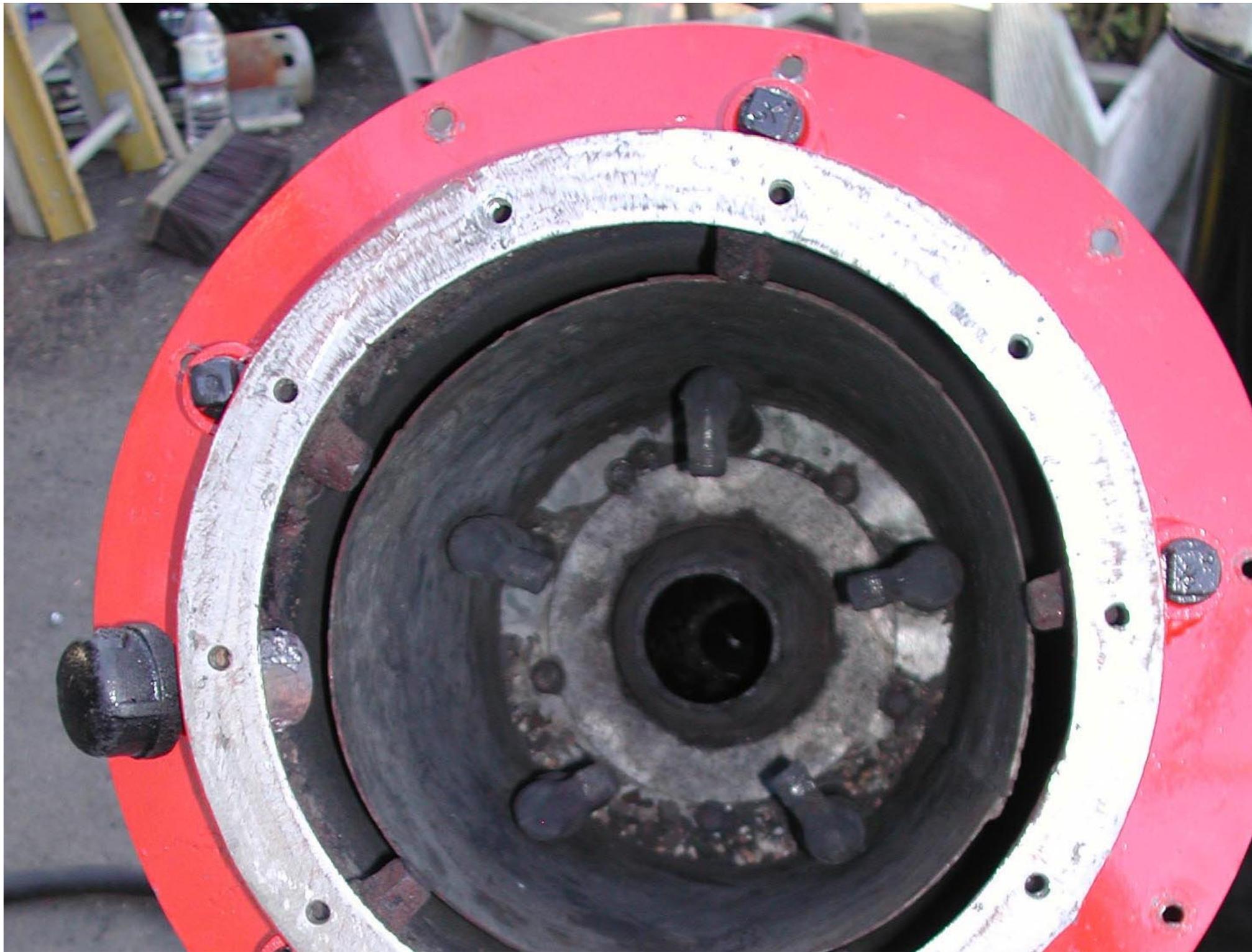
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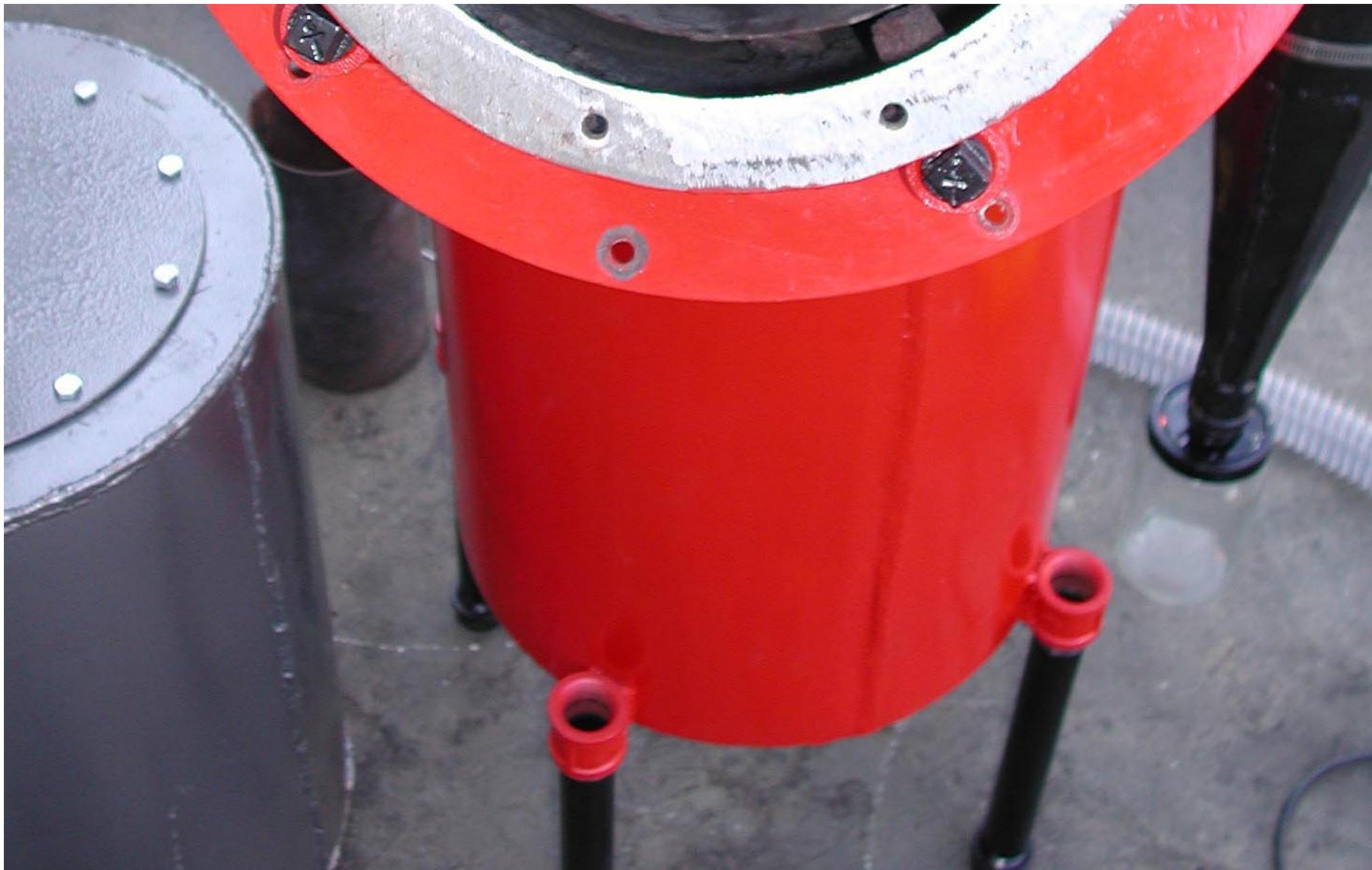
# Gasifier Experimenters Kit

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# Race Kick-off and Vehicle Show Case October 10th, 2008, 8 to Midnight

0 Comments Published October 8th, 2008 in Uncategorized

Escape from Berkeley, Kick-off party and Vehicle Showcase, at the Shipyard Labs **1010 Murray Street** in Berkeley, CA. Entry is a sliding scale five to fifteen, with all proceeds going to the race.

The night before the *Escape from Berkeley* rally commences come gawk and meet the Racers. Lay down your bets, who will win and who will be voted sexiest vehicle. Enjoy, Fired Scottish whiskey by **Jon Sarrigarte**, Orations and evocations by non-other than Dr. Hal and John Hell, and a surprise libation from Flash.

The next morning, Saturday, Oct 11, 2008 at 9:30 we begin the *Escape*. All are welcome to join the as we hold a formal Rally start complete with the singing of the National Anthem by racer Paul J. Travitzky.of the Alabama **Green Team**.

Or join us Along the **route**.

## **Saturday:**

Day 1 Checkpoints

**First** – The Warehouse @ Port Costa Bayfront  
**5 Canyon Lake Drive, Port Costa, CA**

**Second** –Moccasin Powerhouse  
Address: **1 Lakeshore Dr, Moccasin**

**Day 1 Campsite**  
Yosemite Pines RV Resort

**Day 2 Checkpoints**  
First – Tioga Gas Mart  
22 Vista Point Rd, Lee Vining, CA

Second – Keough's Hot Springs  
Resort Address: 800 Keough Hot Springs Rd, Bishop

**Day 2 Campsite**  
The Lone Pine campsite  
701 S Main St. Lone Pine, CA 93545

**Day 3 Checkpoints**  
First – Furnace Creek Steam Engine  
190 Highway, Death Valley, CA

Second – Amargosa Opera House  
Address: 608 Death Valley Junction, Death Valley, CA

**Day 3 Hotel – Sahara Hotel and Casino, Las Vegas**  
Sahara Hotel and Casino  
2535 Las Vegas Blvd. South  
Las Vegas, NV 89109

More info on the race events: <http://www.escapefromberkeley.com>.

See you at the races (by any non-petroleum means).

## Join us along the route

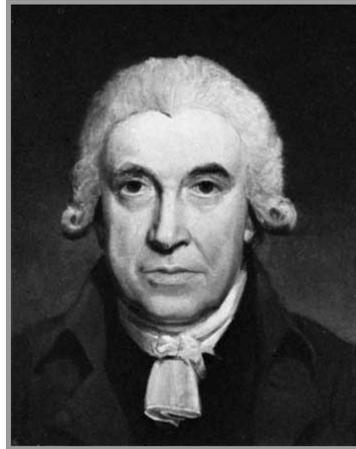
0 Comments Published October 5th, 2008 in Uncategorized

Not racing but still want to be a part of the adventure? Come join us along the route.

[Click here for details.](#)

## James Watt Memorial VIP Dinner - Friday October 10th - SOLD OUT

0 Comments Published October 1st, 2008 in Uncategorized



In the spirit of innovation, Shipyard Labs is hosting an honorary dinner for race participants and VIP benefactors. James Watt was the Scottish inventor who improved the Newcomen steam engine to create the key machine used to jump-start the Industrial Revolution. This dinner is a chance to meet with the rally participants and talk with them one-on-one about their alternative energy exploits. The dinner begins at 5pm and runs until 8. You may purchase a VIP ticket to the dinner via Paypal for \$50.

The dinner will be followed by the vehicle showcase and send-off party beginning at 8pm. The party is open to the public. Shipyard Labs invites you to come and enjoy an exciting evening with the variety of alternative vehicles before they make the mad dash to escape from Berkeley on Saturday morning at 10am.

**Vehicle Showcase Party - (10/10/08) - Shipyard Labs - 1010 Murray St, Berkeley, CA, 94710 - \$5 suggested donation.**  
**Rally Start (10/11/08) - Shipyard Labs - 9am sharp - free and open to the public**

## A 3 Day Competition for Alternately Fueled Vehicles

0 Comments Published September 30th, 2008 in Uncategorized

Latest Press Release:

**A 3 Day Competition for Alternately Fueled Vehicles**  
Escape From Berkeley - a Road Rally from Berkeley to Las Vegas

**Berkeley, CA** - (September 25, 2008) – Shipyard Labs is sponsoring an event to “Escape from Berkeley (by any non-petroleum means necessary)”, a road rally of alternatively powered vehicles from Berkeley, California to Las Vegas, Nevada. The rally challenges contestants to start their engines on anything other than petroleum, and by any means necessary, having the vehicles show up at the Sahara in Las Vegas three days later using only fuels and power scavenged along the route.

Contestants cannot begin with more than the equivalent of a gallon of fuel, nor purchase it along the way. Rally organizers expect a mash-up of “Mad Max meets the DARPA Grand Challenge.” Cash prizes and awards for a variety of areas: the rally time winner, most difficult

Escape From Berkeley (by any non-petroleum means necessary)

engineering problem attempted, worst idea actually made to kind of work, sexiest vehicle on the road, and smallest carbon footprint between Berkeley and Vegas

Currently, Racers David Bransby and Wayne Keith of Springville, Ala., are on a nationwide tour in their Dodge Dakota bio-truck to raise public awareness about renewable energy. For more information about this team and the other racers visit the main event site [www.escapefromberkeley.com](http://www.escapefromberkeley.com).

The rally kicks-off the festivities with a VIP dinner and vehicle showcase October 10th 5pm to 12am at Shipyard Labs, 1010 Murray Street, in Berkeley, CA. Teams will show case their vehicles to the public. The rally starts October 11th at 10 am with a National Anthem send-off by Racer Paul J. Travitzky. The event will culminate with an awards ceremony in Las Vegas, NV October 13th. A panel of Judges, which includes Burning Man organizer Michael Michael, futurist Paul Saffo, Internet Archive founder Brewster Kahle, and senior editor at Reason magazine Brian Doherty, will judge who gets the top prize.

For more information about Escape from Berkeley contact Jessica Hobbs [jess@escapefromberkeley.com](mailto:jess@escapefromberkeley.com).

###

## The Green Team in the News

0 Comments Published September 24th, 2008 in Uncategorized



T-CO Alternative Fuels has featured Green Team members Wayne Keith and David Bransby in their latest newscast. [Read the story here](#) to learn more about the history of Wayne's bio-truck. Be sure to watch the video where Wayne and David explain the mechanics of the truck and give a tour of the gasifier. Also read about them on [Auburn University Newsmakers](#).

## Prisoners Of Petroleum - Mother Earth News Blog

0 Comments Published September 24th, 2008 in Uncategorized



Contestant Jack McCornack has written about the rally in his blog for Mother Earth News in Oregon. Jack will be racing a likeness of the Lotus Seven featured in the '60's TV show "The Prisoner." [Read the whole blog post here](#). Stayed tuned for more updates.

## Vehicle Showcase & Send-off Party OCTOBER 10th

0 Comments Published September 21st, 2008 in Uncategorized

The night before the rally begins, October 10th, Shipyard Labs will be hosting a vehicle showcase and party that is open to the public. All the vehicles in the rally will be present and gearing up for the race, so this is a great time to experience a piece of the event without traveling the route. Party starts at 8pm and goes until 12. [Directions here](#)

## The Route

0 Comments Published September 19th, 2008 in Uncategorized

[Click here](#) to view a scrollable and sizable Google map of the route.

## Interested in being part of this unique event?

0 Comments Published September 18th, 2008 in Uncategorized

# Volunteer for Escape From Berkeley!

We are looking for volunteers to help us in all areas of the race events:

### **Pre Race**

- Friday October 10th - Vehicle Showcase & Send-off Party 8-12pm at Shipyard Labs
- Saturday October 11th: Race Starting Ceremony 10am at Shipyard Labs

### **On the road – Experience the Race while it happens**

- Checkpoint monitors
- Camp hosts
- Road support
- Las Vegas
- Reception committee

-Awards ceremony

All enthusiasts' welcome.

Contact:

Jess  
jess@jesshobbs.com

Jake  
jake@escapefromberkeley.com  
**Shipyards Labs Open Shop Weekends**

-September 20&21st  
-September 27&28th

The next two weekends will be open shop weekends at Shipyards Labs. The rally is coming up quickly so the shop should be very active. These are excellent times to drop by if you are interested in volunteering. Come on over to learn more about the race.

Also visit the [Volunteer](#) page for information about campsites and checkpoints along the route.

## Escape From Berkeley at "How Berkeley Can You Be" Festival

0 Comments Published September 17th, 2008 in Events

Come drop by and visit us at the upcoming How Berkeley Can You Be Festival on September 28th. Its "the worlds zaniest parade followed by an all-day festival in the park." It promises to be a good time. Come and learn more about road rallies and alternative energy in the context of a Berkeley-wide green event. [Click here for directions and more information.](#)

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Epic Arts in partnership with The University Ave Association proudly presents the 13th Annual

# HOW BERKELEY CAN YOU BE!?

**FREE!**

**SUNDAY SEPTEMBER 28<sup>th</sup>, 2008**

**PARADE 11am-1pm : University Ave**  
**FESTIVAL Noon-5pm : Civic Center Park**

ArtCar Fest + Music + Dance + Floats + Arts & Crafts  
Kids Stage + International Foods + Beer Garden & More!

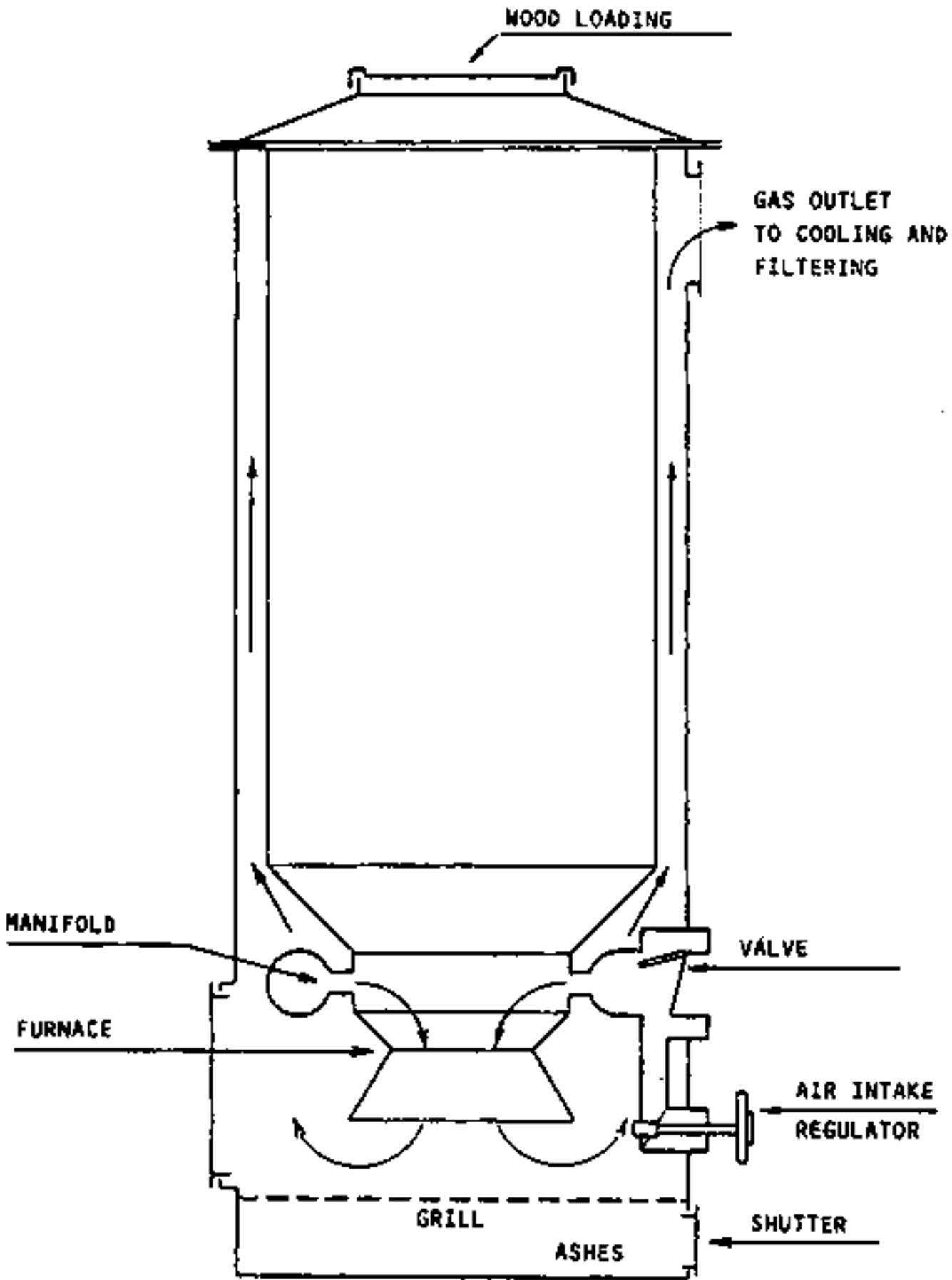
Live Music Featuring:  
**SILA & THE AFROFUNK EXPERIENCE + STEVE PILE BAND**  
**WAYWARD MONKS + EVIL EYE BELLYDANCE**

[www.HowBerkeleyCanYouBe.com](http://www.HowBerkeleyCanYouBe.com)

October 10th -  
SOLD OUT

- A 3 Day Competition for Alternatively Fueled Vehicles
- The Green Team in the News
- Prisoners Of Petroleum - Mother Earth News Blog
- Vehicle Showcase & Send-off Party OCTOBER 10th
- The Route
- Interested in being part of this unique event?
- Escape From Berkeley at "How Berkeley Can You Be" Festival





**Table 5-2. Imbert Nozzle and Hearth Diameters**

| $d_r/d_h$ | $d_h$<br>mm | $d_r$<br>mm | $d_r'$<br>mm | $h$<br>mm | $H$<br>mm | $R$<br>mm | $A$<br>No. | $d_m$<br>mm | $\frac{A_m \times 100}{A_h}$ | $\frac{d_r}{d_h}$ | $\frac{h}{d_h}$ | Range of Gas Output |                  | Maximum Wood Consumption | Air Blast Velocity |
|-----------|-------------|-------------|--------------|-----------|-----------|-----------|------------|-------------|------------------------------|-------------------|-----------------|---------------------|------------------|--------------------------|--------------------|
|           |             |             |              |           |           |           |            |             |                              |                   |                 | max.<br>$Nm^3/h$    | min.<br>$Nm^3/h$ | kg/h                     | $V_m$<br>m/s       |
| 268/60    | 60          | 268         | 150          | 80        | 256       | 100       | 5          | 7.5         | 7.8                          | 4.5               | 1.33            | 30                  | 4                | 14                       | 22.4               |
| 268/80    | 80          | 268         | 176          | 95        | 256       | 100       | 5          | 9.0         | 6.4                          | 3.3               | 1.19            | 44                  | 5                | 21                       | 23.0               |
| 268/100   | 100         | 268         | 202          | 100       | 256       | 100       | 5          | 10.5        | 5.5                          | 2.7               | 1.00            | 63                  | 8                | 30                       | 24.2               |
| 268/120   | 120         | 268         | 216          | 110       | 256       | 100       | 5          | 12.0        | 5.0                          | 2.2               | 0.92            | 90                  | 12               | 42                       | 26.0               |
| 300/100   | 100         | 300         | 208          | 100       | 275       | 115       | 5          | 10.5        | 5.5                          | 3.0               | 1.00            | 77                  | 10               | 36                       | 29.4               |
| 300/115   | 115         | 300         | 228          | 105       | 275       | 115       | 5          | 11.5        | 5.0                          | 2.6               | 0.92            | 95                  | 12               | 45                       | 30.3               |
| 300/130   | 130         | 300         | 248          | 110       | 275       | 115       | 5          | 12.5        | 4.6                          | 2.3               | 0.85            | 115                 | 15               | 55                       | 31.5               |
| 300/150   | 150         | 300         | 258          | 120       | 275       | 115       | 5          | 14.0        | 4.4                          | 2.0               | 0.80            | 140                 | 18               | 67                       | 30.0               |
| 400/130   | 130         | 400         | 258          | 110       | 370       | 155       | 7          | 10.5        | 4.6                          | 3.1               | 0.85            | 120                 | 17               | 57                       | 32.6               |
| 400/150   | 135         | 400         | 258          | 120       | 370       | 155       | 7          | 12.0        | 4.5                          | 2.7               | 0.80            | 150                 | 21               | 71                       | 32.6               |
| 400/175   | 175         | 400         | 308          | 130       | 370       | 155       | 7          | 13.5        | 4.2                          | 2.3               | 0.74            | 190                 | 26               | 90                       | 31.4               |
| 400/200   | 200         | 400         | 318          | 145       | 370       | 153       | 7          | 16.0        | 3.9                          | 2.0               | 0.73            | 230                 | 33               | 110                      | 31.2               |

Variables not given in figure are defined as follows:

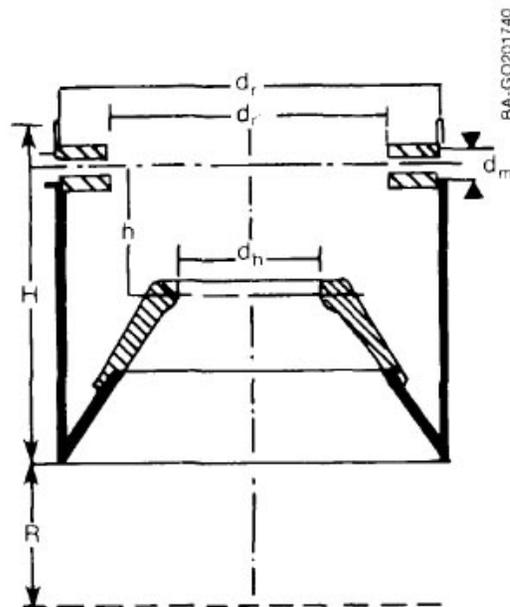
$d_m$  = inner diameter of the tuyere.

$A_m$  = sum of cross sectional areas of the air jet openings in the tuyeres.

$A_h$  = cross sectional area of the throat.

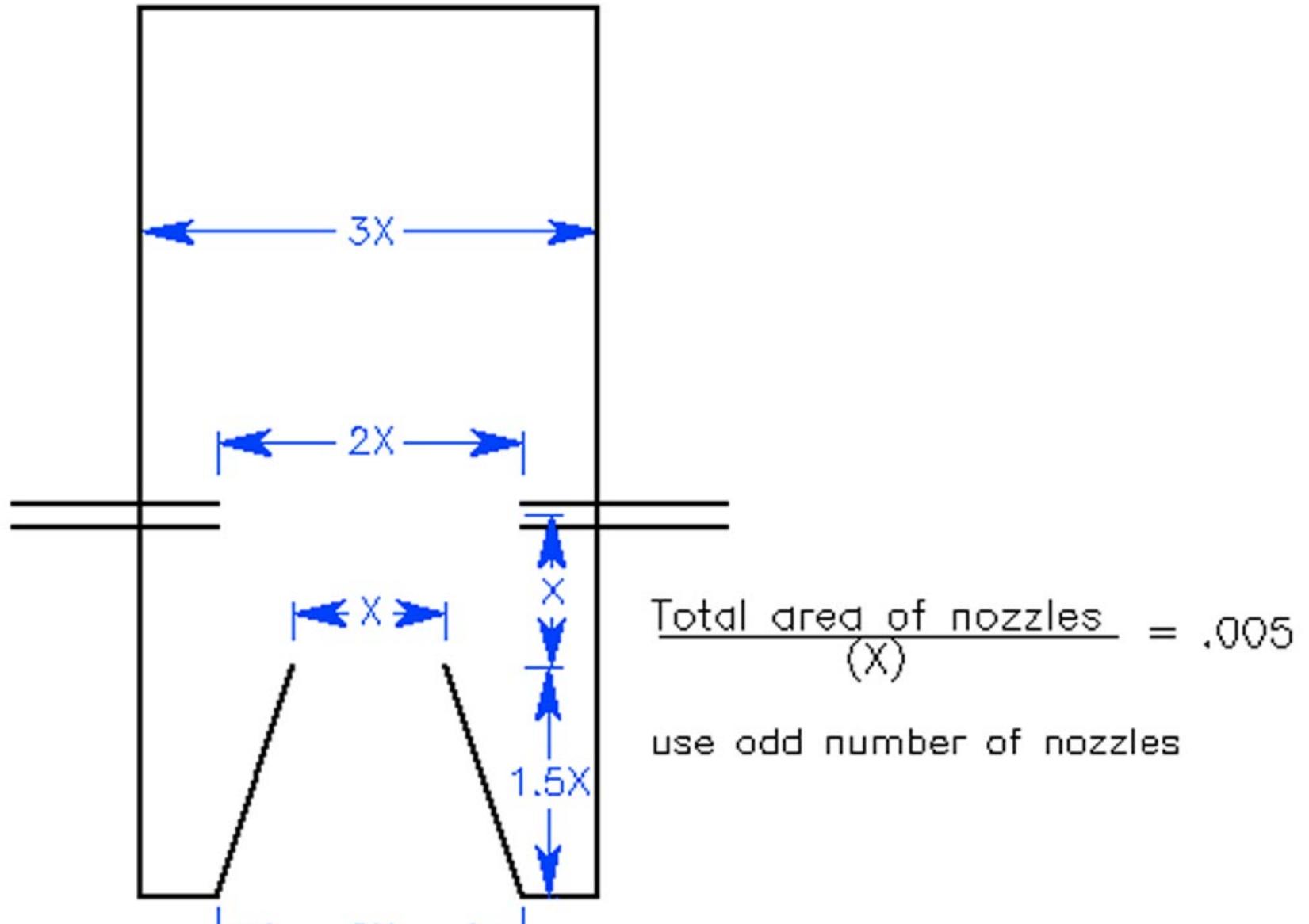
$A$  = number of tuyeres.

Source: Kaupp 1984a, Table 5; Fig. 75.



# General Proportions for Inverted V Hearth Downdraft Gasifier

*(see charts for more detailed dimensions and variations)*





*ALL Power Labs June 16, 2008*

## Fire Tube Dimensions for Stratified Downdraft / Open Core Gasifier

(from FEMA Simplified Wood Gas Generator: LaFontaine, Zimmerman, p. 74, Table 2-2)

---

| Inside diameter<br>(inches) | Minimum<br>length<br>(inches) | Engine power<br>(horsepower) | Typical engine<br>displacement<br>(cubic inches) |
|-----------------------------|-------------------------------|------------------------------|--|
| 2 <sup>a</sup>              | 16                            | 5                            | 10   |
| 4 <sup>a</sup>              | 16                            | 15                           | 30   |
| 6                           | 16                            | 30                           | 60   |
| 7                           | 18                            | 40                           | 80   |
| 8                           | 20                            | 50                           | 100  |
| 9                           | 22                            | 65                           | 130  |
| 10                          | 24                            | 80                           | 160  |
| 11                          | 26                            | 100                          | 200  |
| 12                          | 28                            | 120                          | 240  |
| 13                          | 30                            | 140                          | 280  |
| 14                          | 32                            | 160                          | 320  |

---

<sup>a</sup>A fire tube with an inside diameter of less than 6 in. would create bridging problems with wood chips and blocks. If the engine is rated at or below 15 horsepower, use a 6-in. minimum fire tube diameter and create a throat restriction in the bottom of the tube corresponding to the diameter entered in the above table.

**Table 1.10. Combustion characteristics of fuels\*** (See also Tables 1.7, 1.9, 2.1, 2.12, and 3.1)

| Fuel                                      | Minimum ignition temp, F/C | Calculated flame temperature, † F/C |                         | Flammability limits % fuel gas by volume |                   | Maximum flame velocity, fps and m/s |                   | % Theoretical air for max. flame velocity |
|---|----------------------------|-------------------------------------|-------------------------|--|-------------------|-------------------------------------|-------------------|---|
|   |                            | in air                              | in O <sub>2</sub>       | lower                                    | upper             | in air                              | in O <sub>2</sub> |   |
| Acetylene, C <sub>2</sub> H <sub>2</sub>  | 581 <sup>c</sup> /305      | 4770/2632                           | 5630/3110               | 2.5                                      | 81.0              | 8.75/2.67                           | —                 | 83  |
| Blast furnace gas                         | —                          | 2650/1454                           | —                       | 35.0 <sup>h</sup>                        | 73.5              | —                                   | —                 | —   |
| Butane, commercial                        | 896/480                    | 3583/1973                           | —                       | 1.86                                     | 8.41              | 2.85/0.87                           | —                 | —   |
| Butane, n-C <sub>4</sub> H <sub>10</sub>  | 761/405                    | 3583/1973                           | —                       | 1.86                                     | 8.41              | 1.3/0.40                            | —                 | 97  |
| Carbon monoxide, CO                       | 1128 <sup>c</sup> /609     | 3542 <sup>h</sup> /1950             | —                       | 12.5 <sup>f</sup>                        | 74.2 <sup>f</sup> | 1.7/0.52                            | —                 | 55  |
| Carbureted water gas                      | —                          | 3700/2038                           | 5050/2788               | 6.4                                      | 37.7              | 2.15/0.66                           | —                 | 90  |
| Coke oven gas                             | —                          | 3610/1988                           | —                       | 4.4 <sup>f</sup>                         | 34.0 <sup>f</sup> | 2.30/0.70                           | —                 | 90  |
| Ethane, C <sub>2</sub> H <sub>6</sub>     | 882 <sup>c</sup> /472      | 3540/1949                           | —                       | 3.0                                      | 12.5              | 1.56/0.48                           | —                 | 98  |
| Gasoline                                  | 536 <sup>f</sup> /280      | —                                   | —                       | 1.4                                      | 7.6               | —                                   | —                 | —   |
| Hydrogen, H <sub>2</sub>                  | 1062 <sup>c</sup> /572     | 4010/2045                           | 5385/2974               | 4.0                                      | 74.2              | 9.3/2.83                            | —                 | 57  |
| Hydrogen sulfide, H <sub>2</sub> S        | 558 <sup>f</sup> /292      | —                                   | —                       | 4.3                                      | 45.5              | —                                   | —                 | —   |
| Mapp gas, C <sub>3</sub> H <sub>4</sub> ‡ | 850/455                    | —                                   | 5301/2927               | 3.4                                      | 10.8              | —                                   | 15.4/4.69         | —   |
| Methane, CH <sub>4</sub>                  | 1170 <sup>c</sup> /632     | 3484/1918                           | —                       | 5.0                                      | 15.0              | 1.48 <sup>a</sup> /0.45             | 14.76/4.50        | 90  |
| Methanol, CH <sub>3</sub> OH‡             | 725/385                    | 3460/1904                           | —                       | 6.7                                      | 36.0              | —                                   | 1.6/0.49          | —   |
| Natural gas                               | —                          | 3525 <sup>g</sup> /1941             | 4790 <sup>g</sup> /2643 | 4.3                                      | 15.0              | 1.00/0.30                           | 15.2/4.63         | 100                                       |
| Producer gas (See Part 3)                 | —                          | 3010/1654                           | —                       | 17.0 <sup>f</sup>                        | 73.7              | 0.85/0.26                           | —                 | 90  |
| Propane, C <sub>3</sub> H <sub>8</sub>    | 871/466                    | 3573/1967                           | 5130/2832               | 2.1                                      | 10.1              | 1.52/0.46                           | 12.2/3.72         | 94  |
| Propane, commercial                       | 932/500                    | 3573/1967                           | —                       | 2.37                                     | 9.50              | 2.78/0.85                           | —                 | —   |
| Propylene, C <sub>3</sub> H <sub>6</sub>  | —                          | —                                   | 5240/2893               | —  | —                 | —                                   | —                 | —   |
| Town gas (Br. coal) <sup>d</sup>          | 700/370                    | 3710/2045                           | —                       | 4.8‡                                     | 31.0              | —                                   | —                 | —   |

\* For combustion with air at standard temperature and pressure. These flame temperatures are calculated for 100% theoretical air, dissociation considered. Unless otherwise noted, data is from Reference 1.i.

† Flame temperatures are theoretical—calculated for stoichiometric ratio, dissociation considered.

‡ From private communications.

Small letters refer to references at end of Part 1.

# the Algae Lab

## at The Shipyard in Berkeley, CA

The Lab

Algae

People

Workshops

Volunteer

## Home

---

It's a fact. Food, fuel, fertilizer, fresh water, and arable land-- all are running out.

But there is a crop that can grow in salt water, on true waste land, creating all the products we need by eating greenhouse gases and water water. And can grow 100x faster than conventional crops.

Algae! A truly green crop for a sustainable future.

### **We are the Shipyard algae lab community.**

We have created the world's first community algae lab for the development of open-source, DIY-oriented algae technology, to facilitate the co-operative pursuit of this new form of agriculture -- and we invite *you* to come learn how to raise algae and transform them into exciting products!

Whether you are looking for a job in the exploding algae biofuels field, or thinking about creating your own farm, we can help you get up to speed!

We have created an independent, non-profit algae laboratory for teaching and research using low-cost, widely-available materials, and we would love to teach you how! Get on board with this exciting, expanding field that's truly "green"!

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[Hands-on Weekend Algaculture Workshop](#)

October 18-19, 2008

[Video from our  
August 10th Lab Opening!](#)



# Gasifier Experimenters Kit

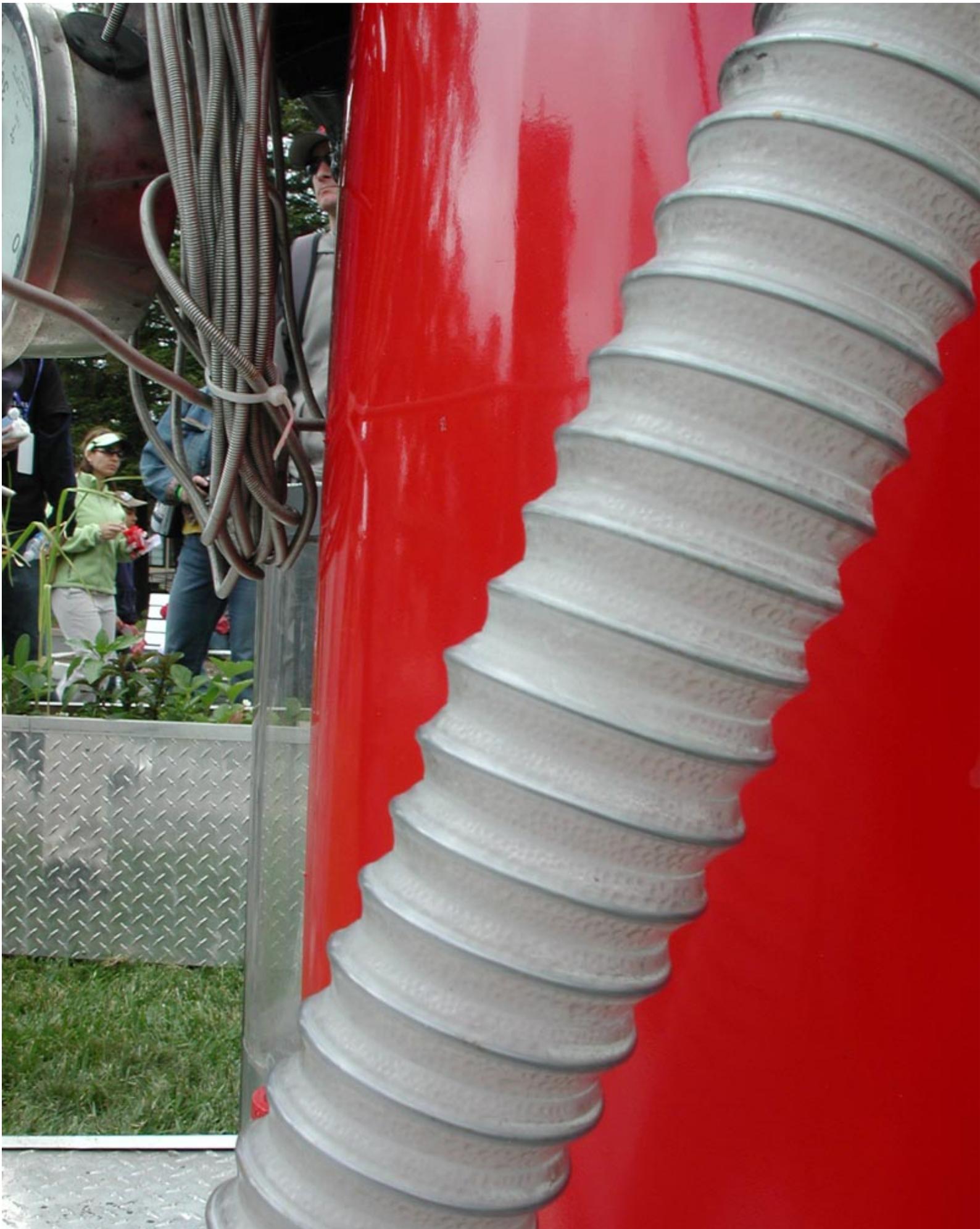
- [Index](#)
- [Previous](#)
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© Jim Mason



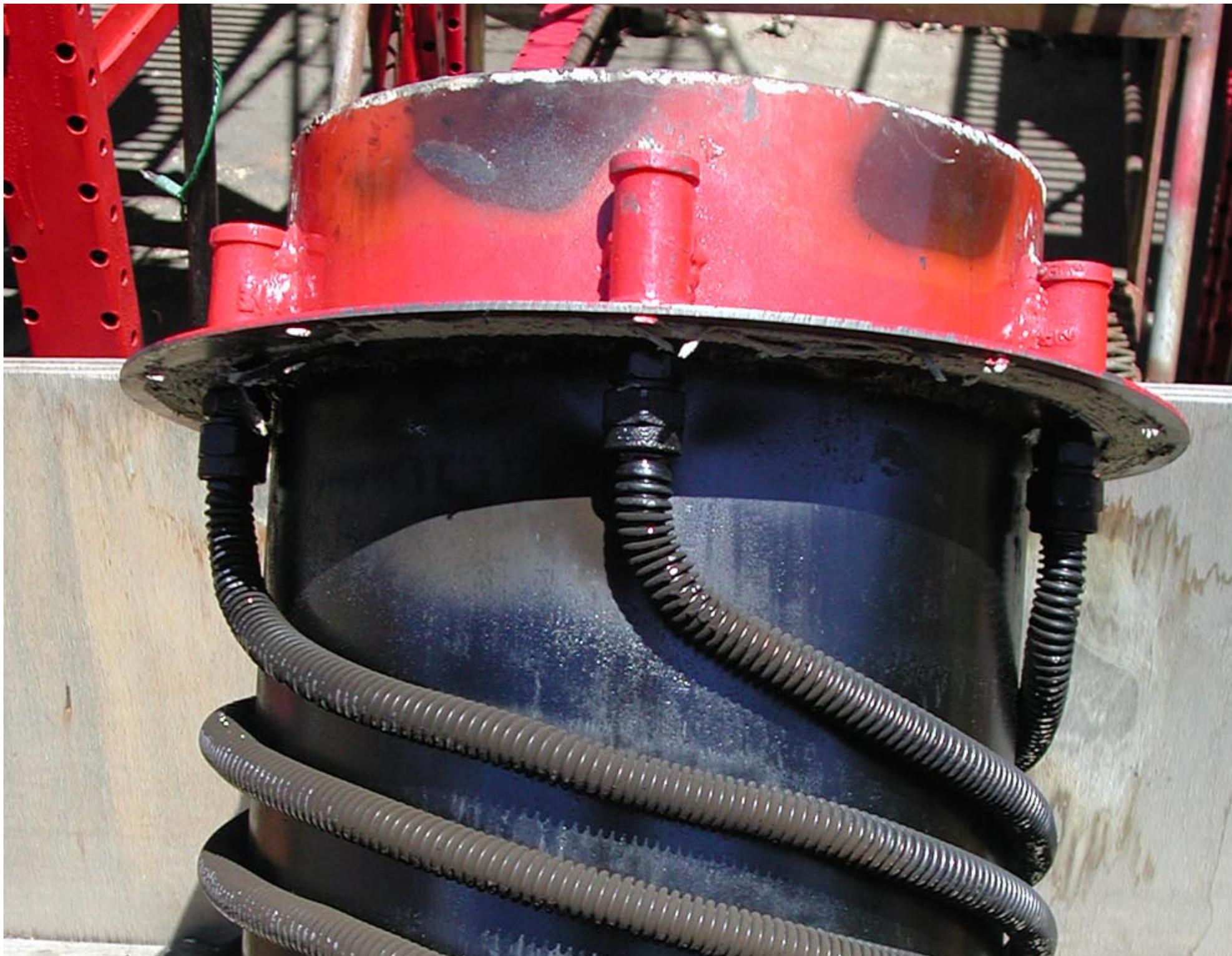


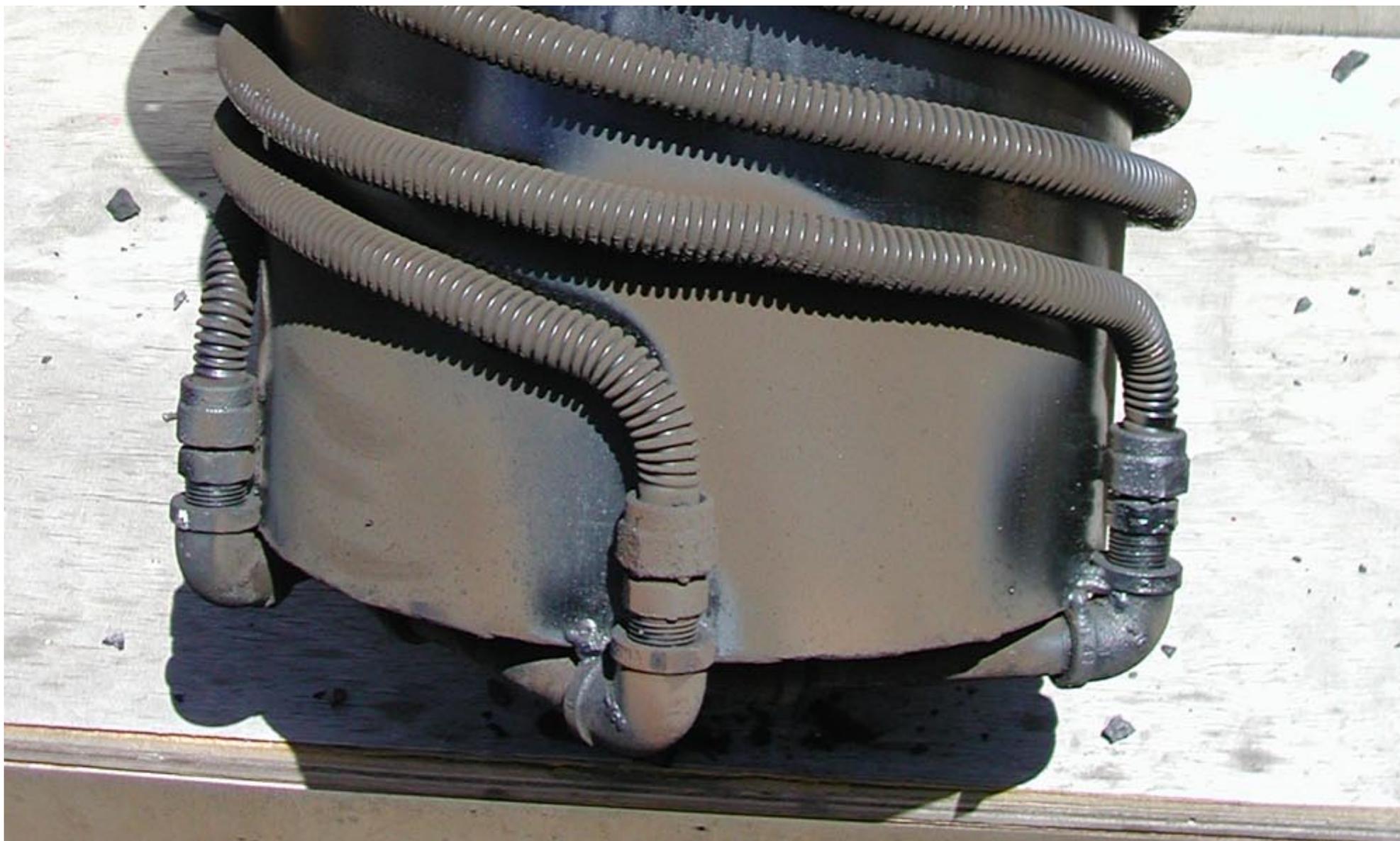




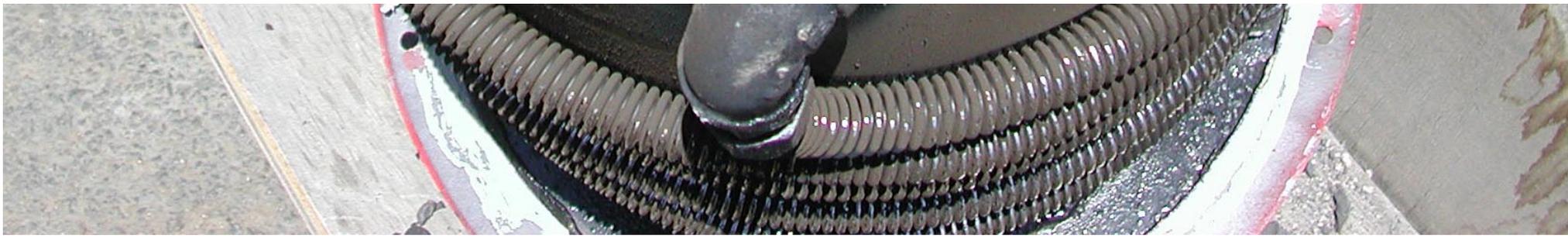




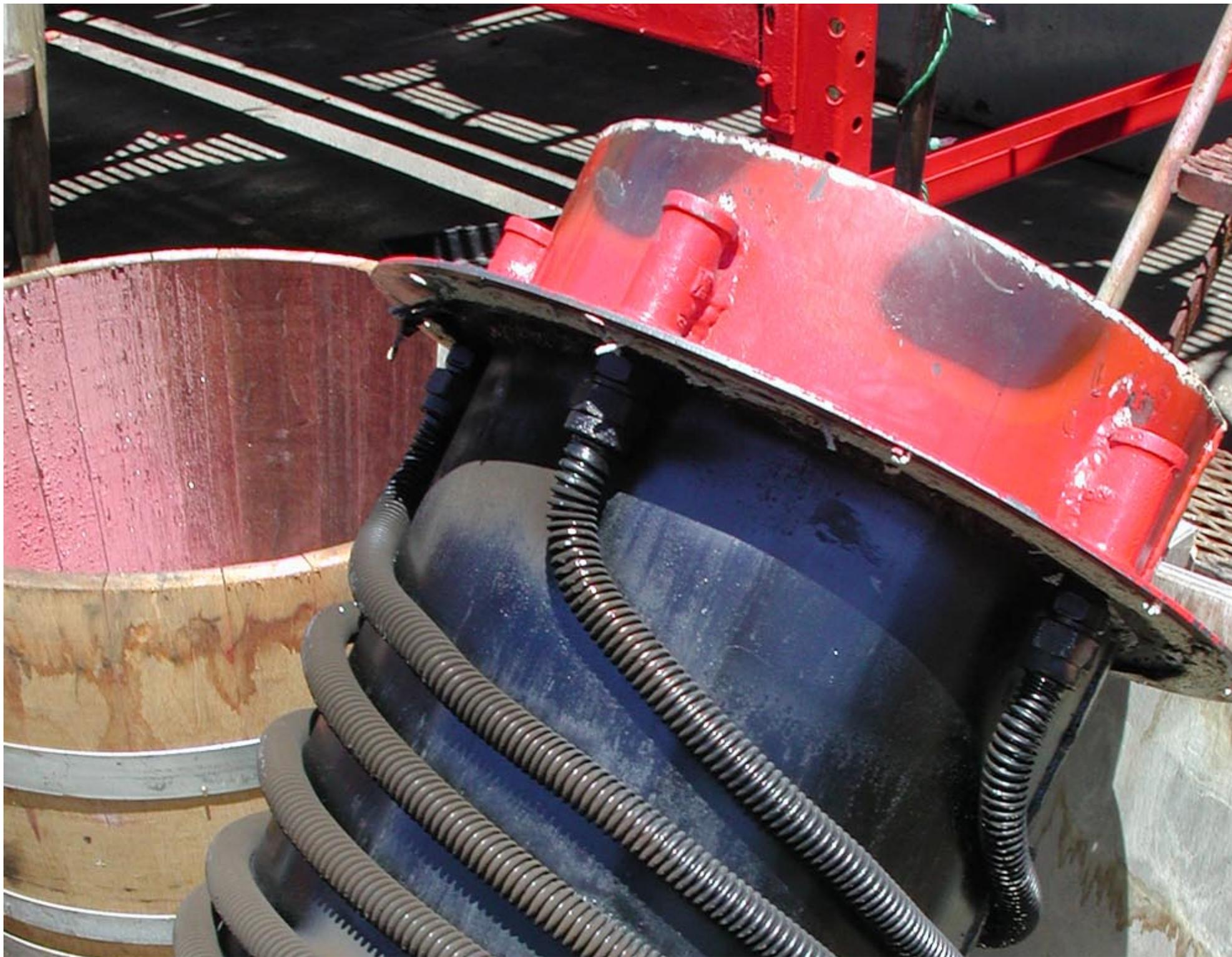


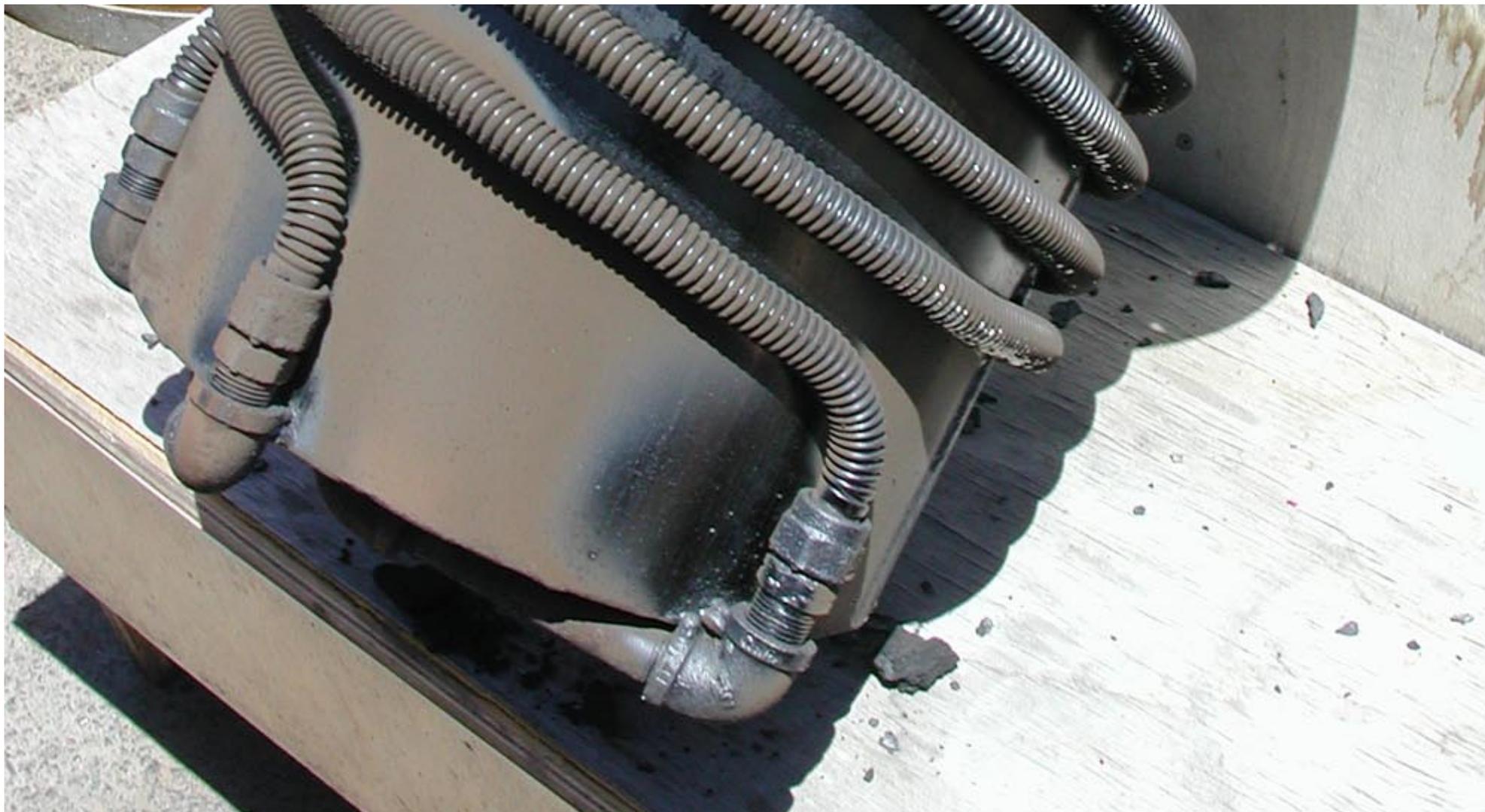








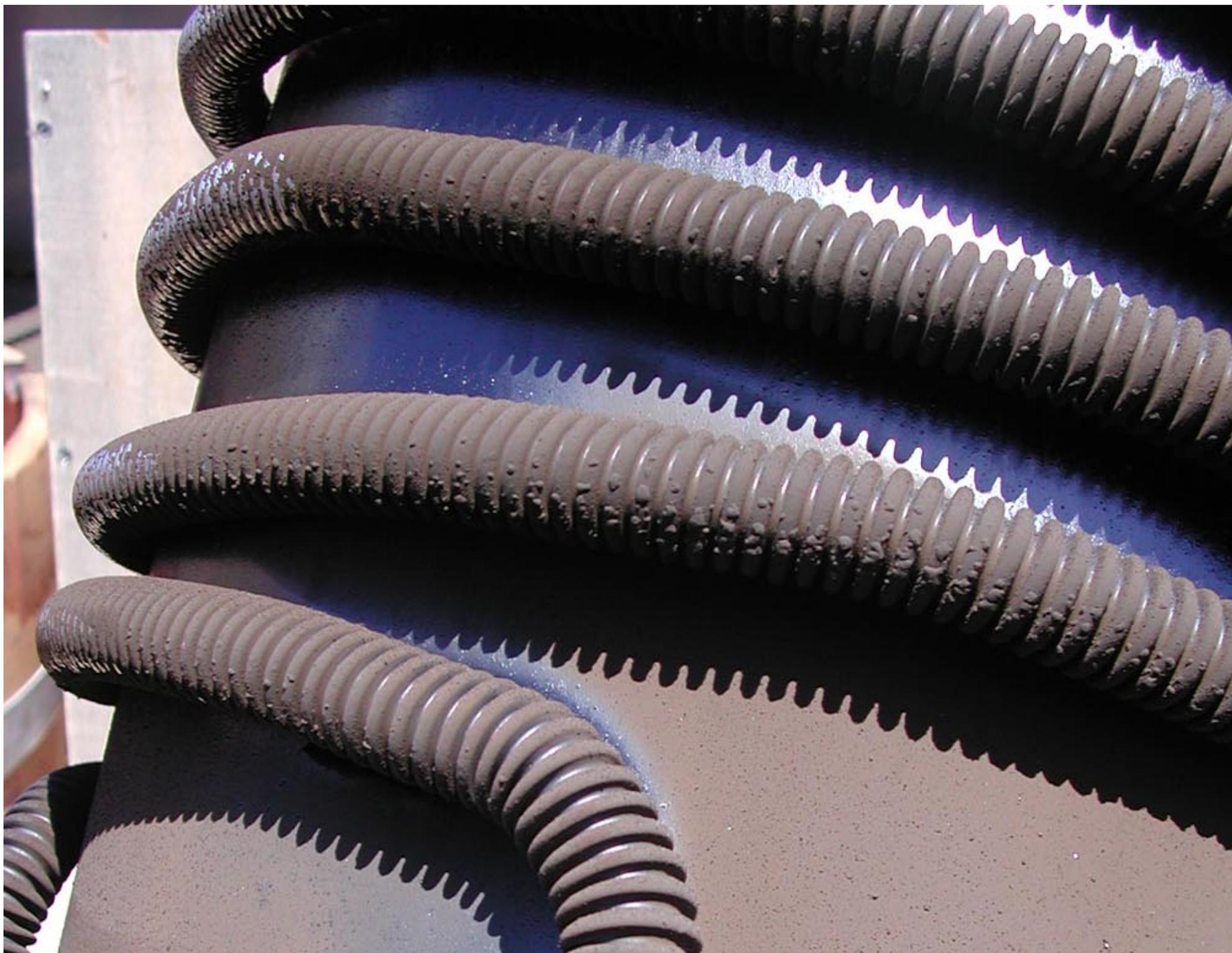






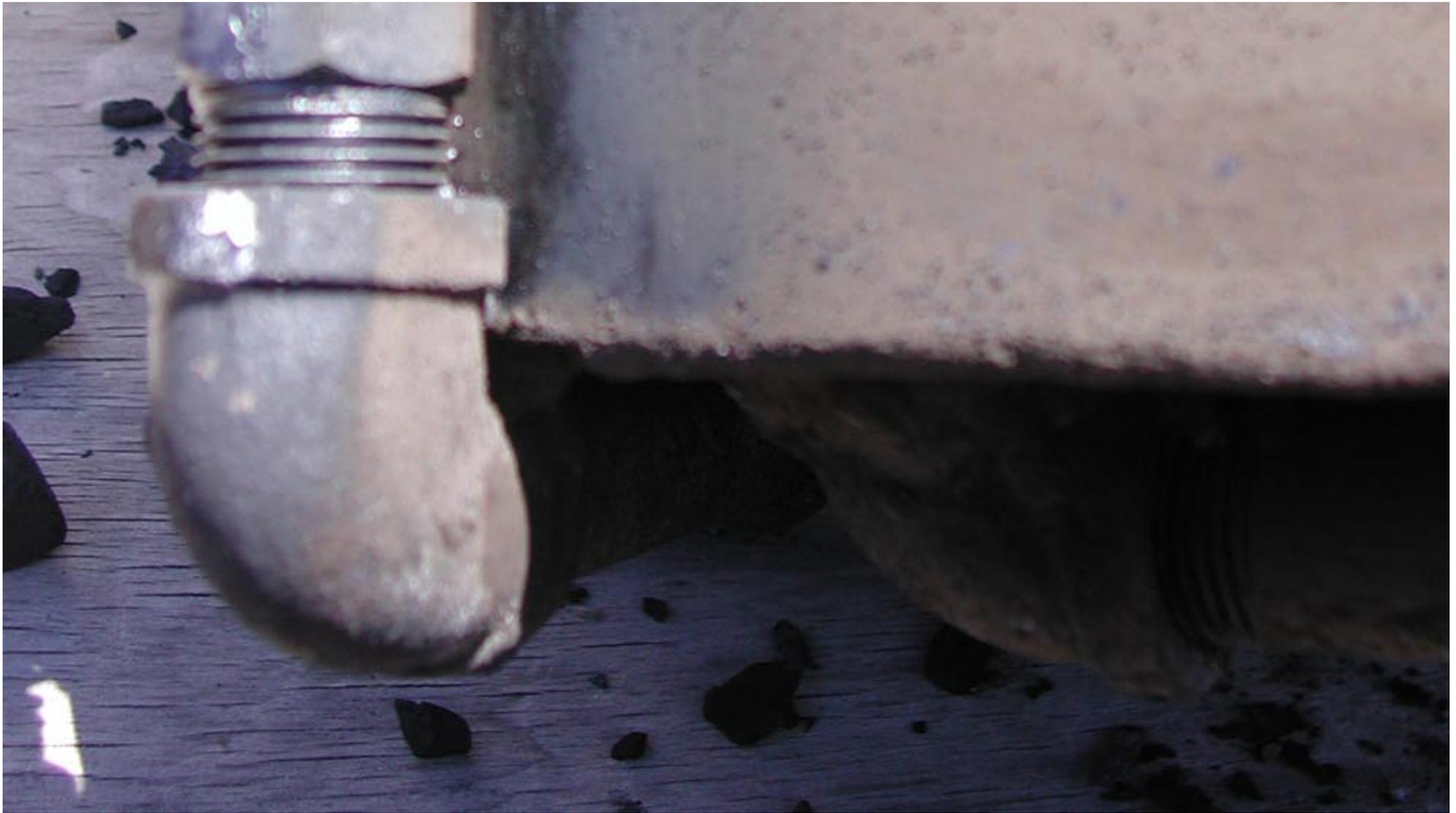


















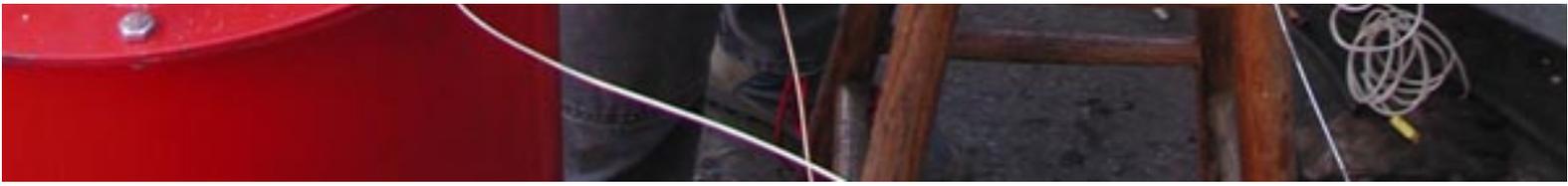












## Temperature Profile of GEK v0.9 Downdraft with air preheating / gas cooling heat exchanger

Inverted V-Hearth configuration, 2.5" reduction constriction  
Running at 1-1.5" H<sub>2</sub>O vacuum across reactor  
1/2 walnut shells at @15% moisture content

### Air In:

1. 25C (atmospheric air)
2. 300-350C
3. 450-500C
4. 550-625C

### Combustion Zone

5. 1000-1250C

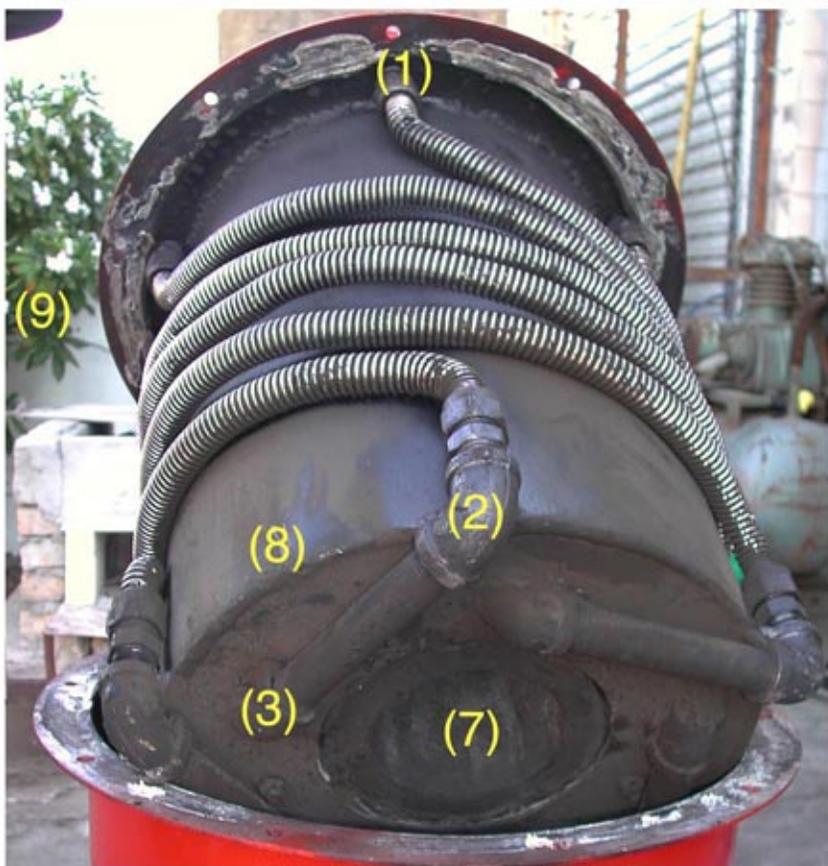
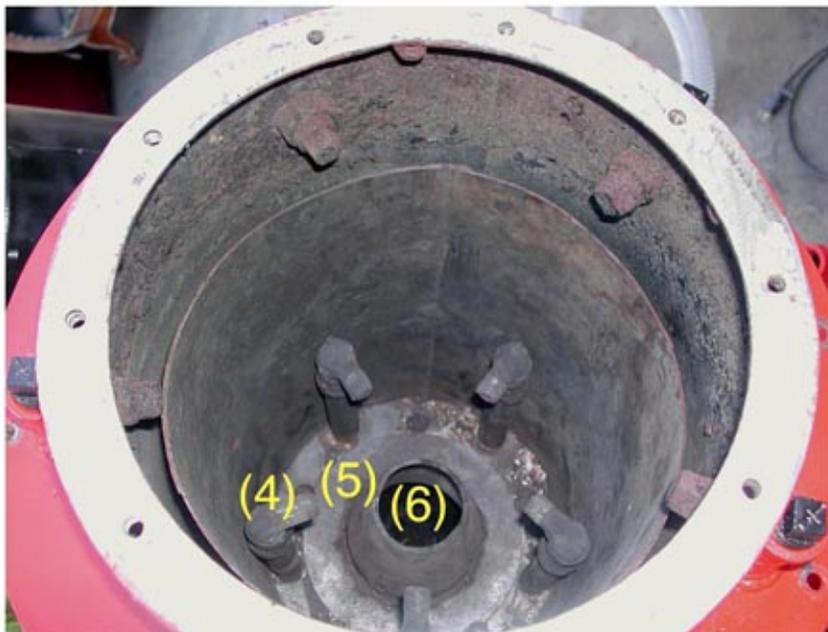
### Reduction Zone

6. 700-800C
7. 600-650C

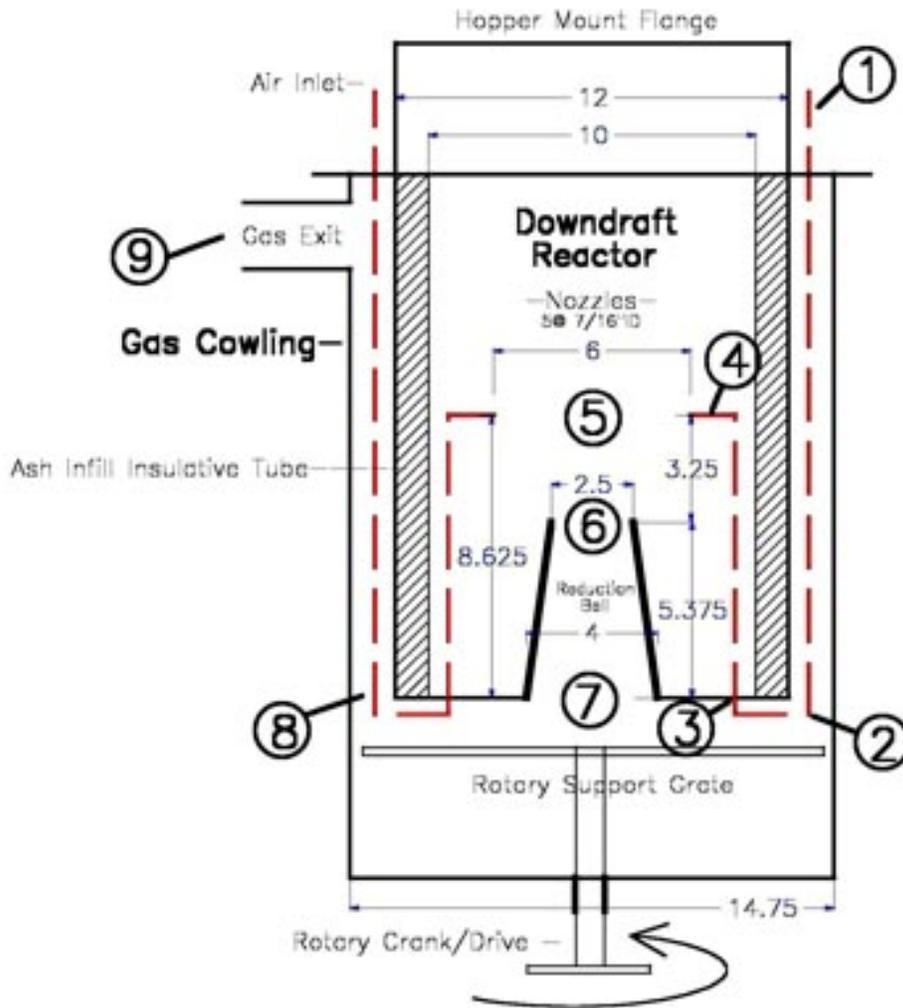
### Gas Out:

8. 350-450C
9. 100-175C

(50-75C after cyclone/filter/blower)



## Temperature Profile of GEK v0.9 Downdraft with air preheating / gas cooling heat exchanger



Inverted V-Hearth configuration, 2.5" reduction constriction  
Running at 1-1.5" H<sub>2</sub>O vacuum across reactor  
1/2 walnut shells at @15% moisture content

### Air In:

1. 25C (atmospheric air)
2. 300-350C
3. 450-500C
4. 550-625C

### Combustion Zone

5. 1000-1250C

### Reduction Zone

6. 700-800C
7. 600-650C

### Gas Out:

8. 350-450C

**Gas Out:**

8. 350–450C

9. 100–175C

(50–75C after cyclone/filter/blower)











# Gasification NYE 2006

- 1
- 2
- 3
- *Next*

gasifier  
v1.0



© Jess Hobbs 2006

*Sept, 08. See updated gasifier at: [Gasifier Experimenters Kit \(GEK\)](#)*

## Gasified 5kw generator: coffee, sawdust, wood pellets, cardboard and other solid biomass to electricity.

The photos below are of the V2.0 gasifier I made from an junk air compressor double tank, and a variety of other obtainium around the shop. I am using this as a learning rig, with no intended end use other than learning about gasifiers through building them.

The plan is to build small versions of each of the main 4 types of gasifiers on the same frame, of approximately the same size, allowing for easy comparison between the types. Currently there is an updraft gasifier on the left (grateless design) and a stratified downdraft on the right. In the coming weeks there wil be a cross-draft and fluidized bed added to the same fame. In these pictures, we are running the downdraft version on the right. Pictures from the previous updraft one (V1.0) are [findable here](#). The previous one generated gas for an air burst type flamethower.

The goal with these units is very quick iterative building, using only junk at hand and a few readily findable parts at home depot. My rule was i could only use things i already had around the shop, or could expect to find at the local auto junkyard, or on the shelves of home depot. No McMaster Carr orders. No fully integrated heat recycling embedded processor temp and O2 sensor metering and and feedback modulation. That will come later . . .

Thus I started with a junk 2x air compressor tank and welded various plumbing fittings into it for the gas inlets and outlets. The grate in the downdraft is cut from a chappati flipper stainless steel spatula I bought at local Indian spice store (that was cheating, i know, but it was perfect).

The "cyclone" is a 10 gal metal bucket that was borrowed from the local gas station. I've used a hammer smashed flex exhaust pipe to try to get a little cyclone circulation without having to fabricate the taper. The filter in the top is from a shop vac.

The cooler/condensor is a car radiator.

The piping is a combination of flex exhaust pipe, hydraulic hose, home vacuum tubing, and duct tape.

The fan is a small shop vac run on a variac (light dimmer) so i can alter the gas flow to see the related effects.

The generator is a standard generac type 5kw briggs and stratten type gas generator. The grinder in the pictures below is running off it while on woodgas.

The woodgas carb is the existing briggs and stratton carburetor, with a ball valve restrictor added to the air intake of the carburetor. Adjusting the resistance on the air intake allows varying the vacuum on the gasifier and thus gas:air mixture until it is proper (about 1:1). The existing butterfly plate in the carburetor continues to be the throttle, with the existing generator governor controlling engine speed.

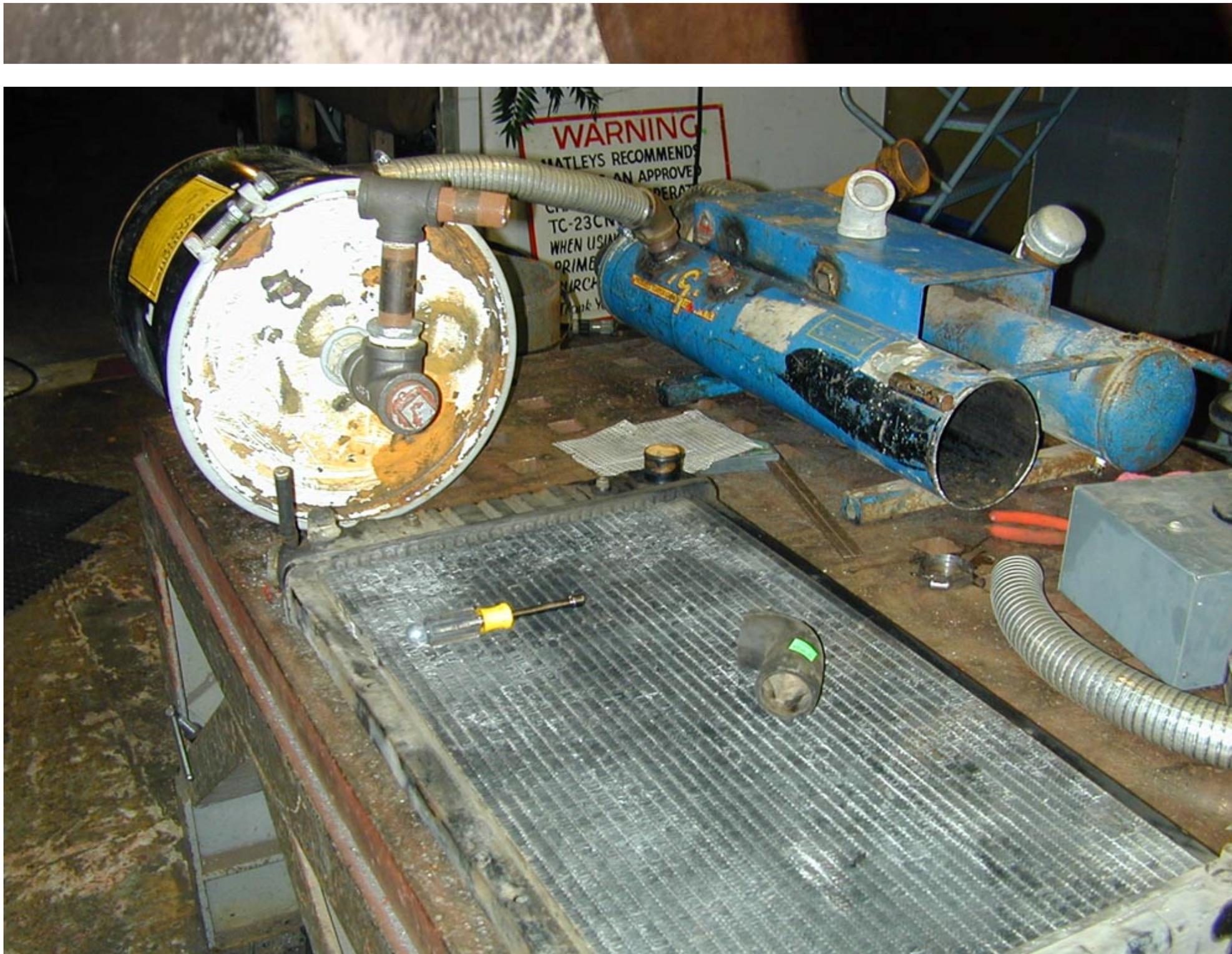
The unit is started on gasoline with the regular carburetor, then the fuel cock is shut off. As the engine runs out of gas, the air restrictor ball valve is adjusted to start pulling gas from the gasifier. The transition is fast and a little rough, but can be smoothed out by keeping the choke about half way shut..

The gasifier is prestarted and wamed up with the shop vac.

These are pictures are not great, but there will be more soon.

Pictures from V1.0, which was run on NYE 06/07, are [findable here](#).



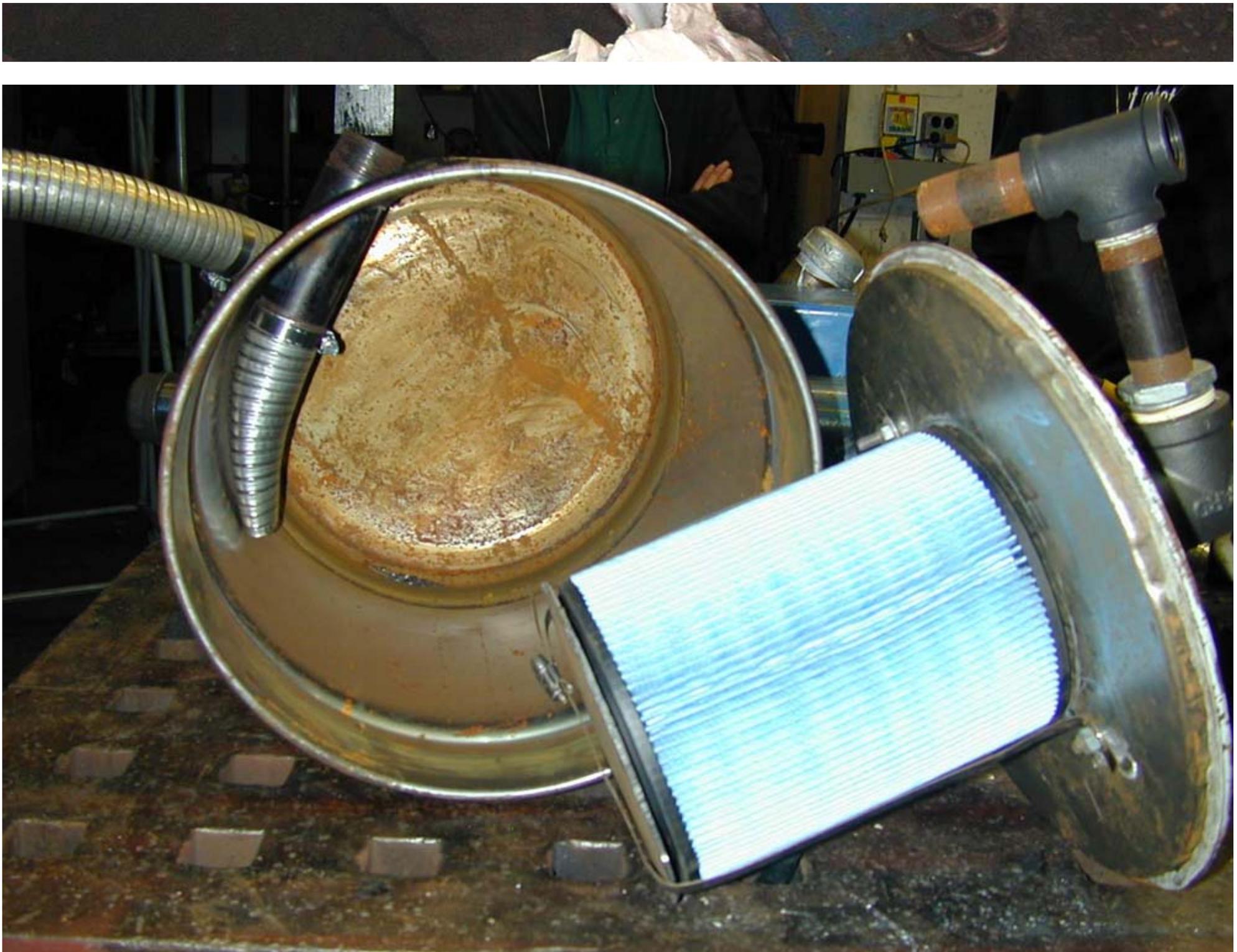


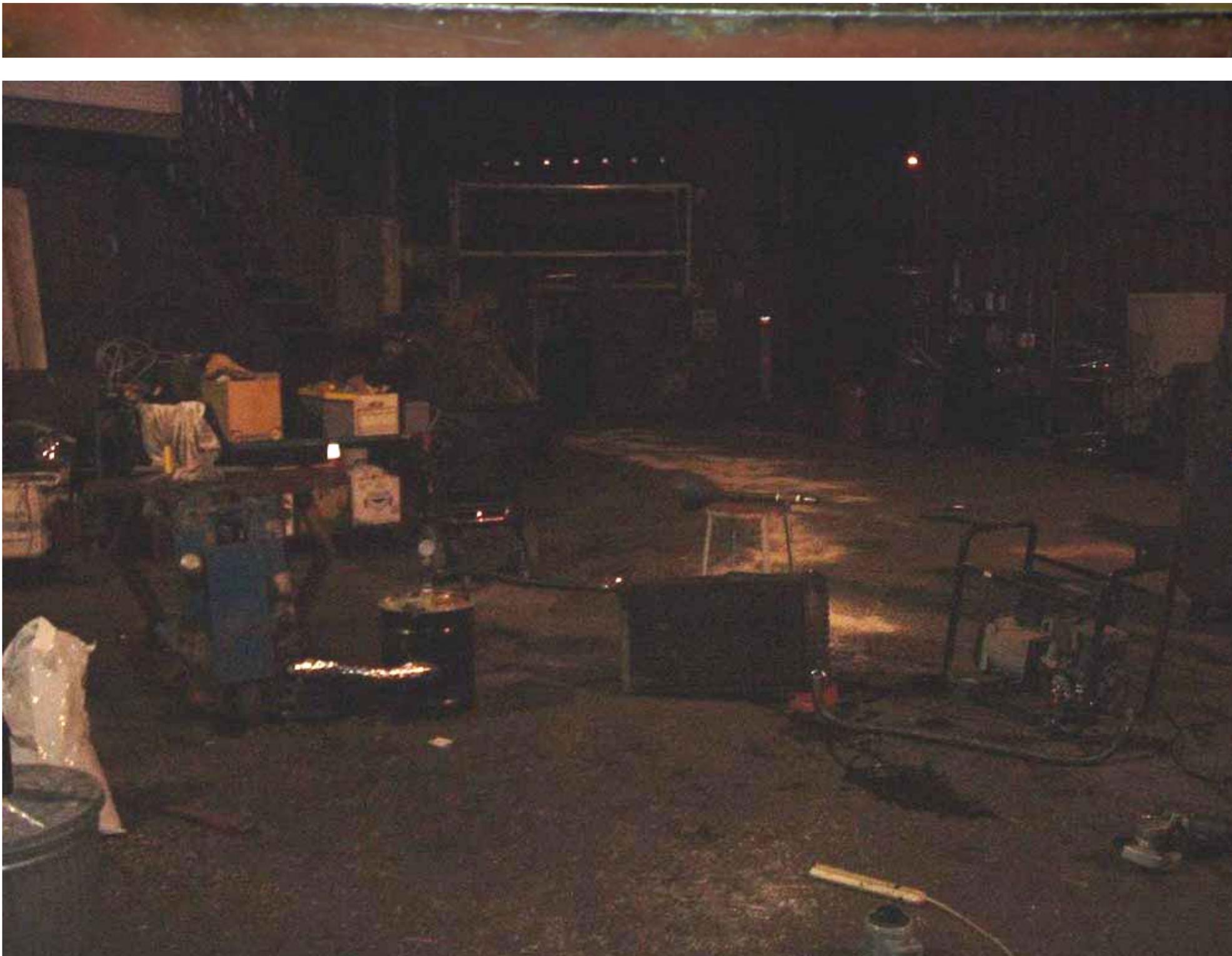






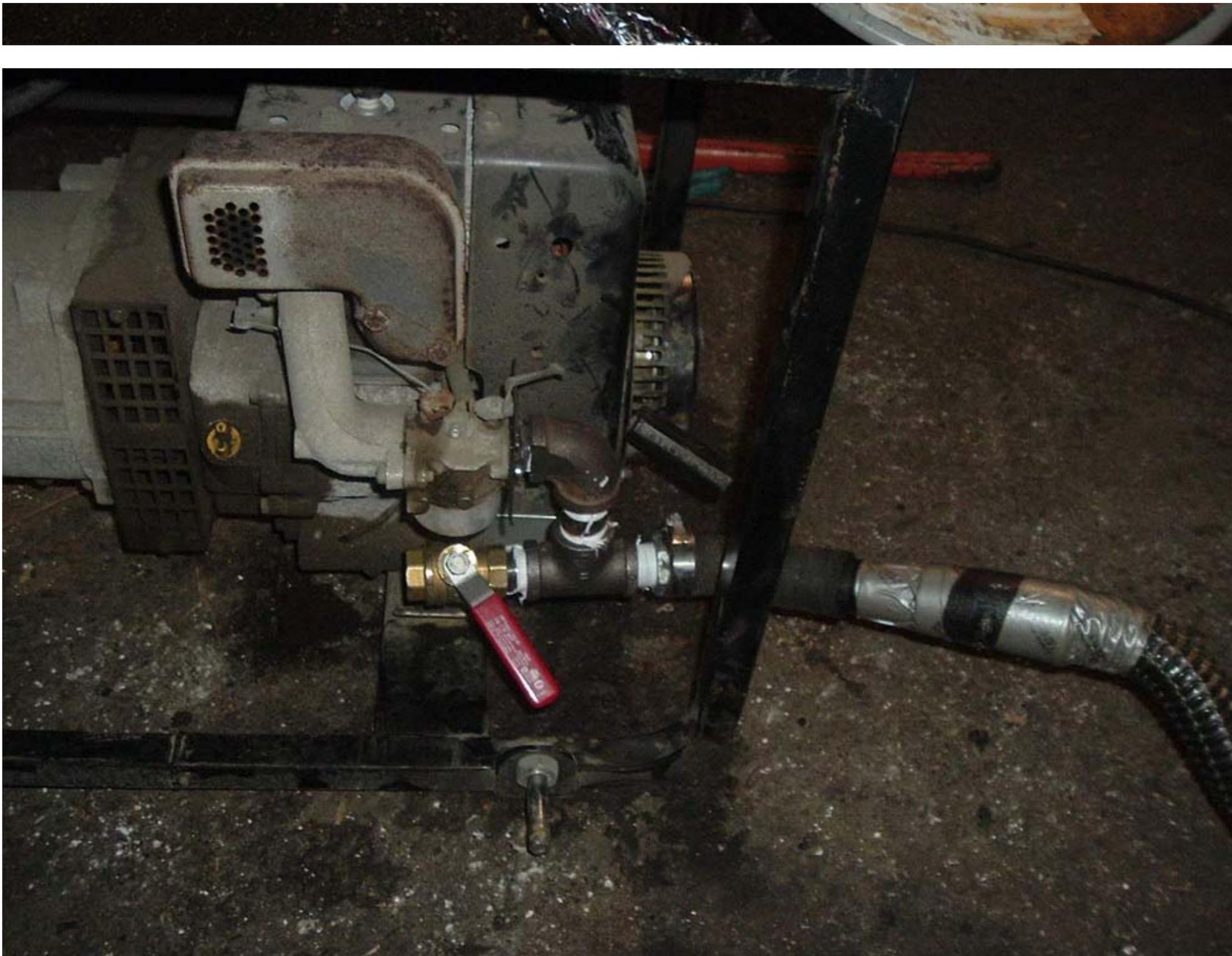
















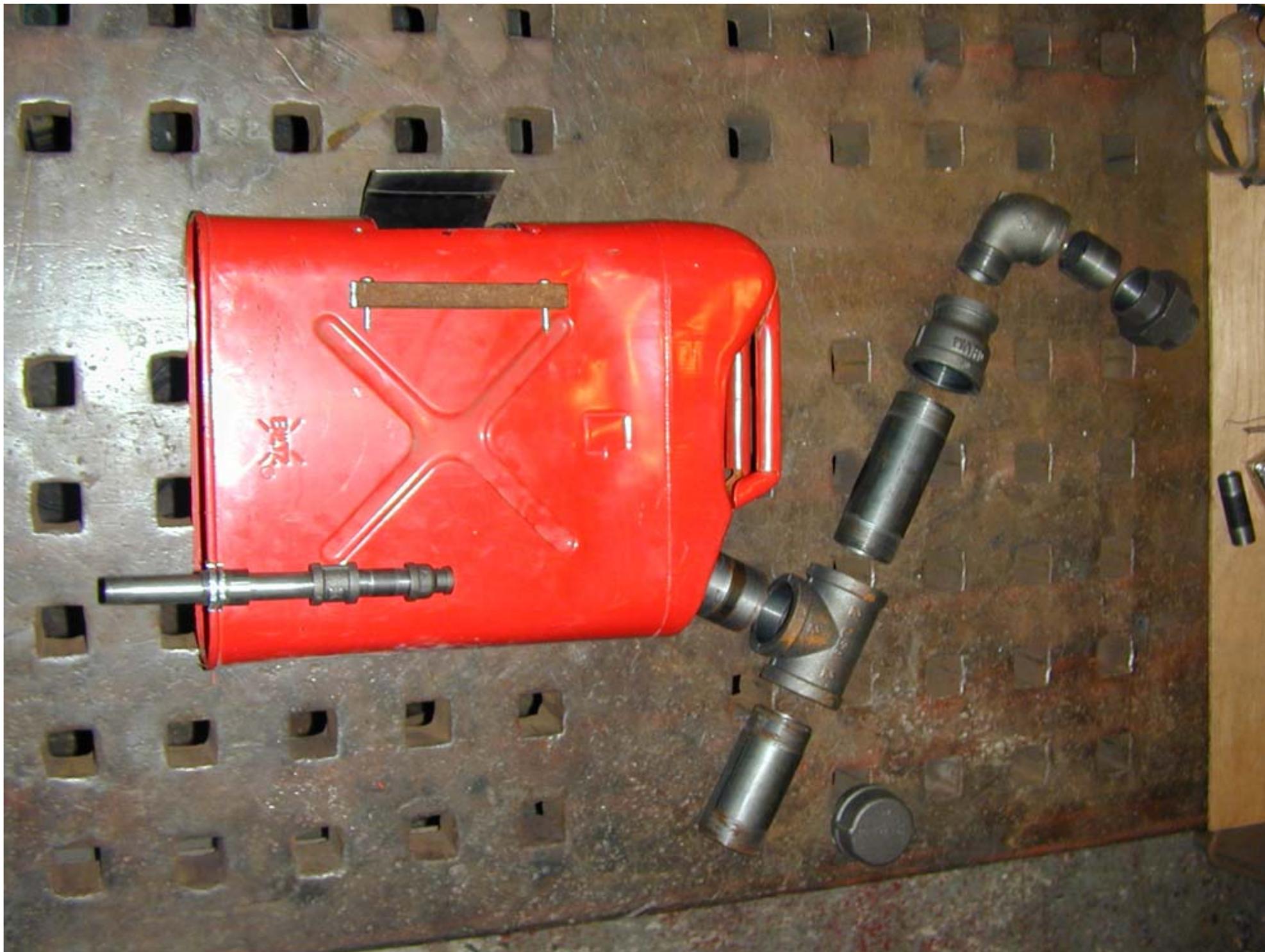


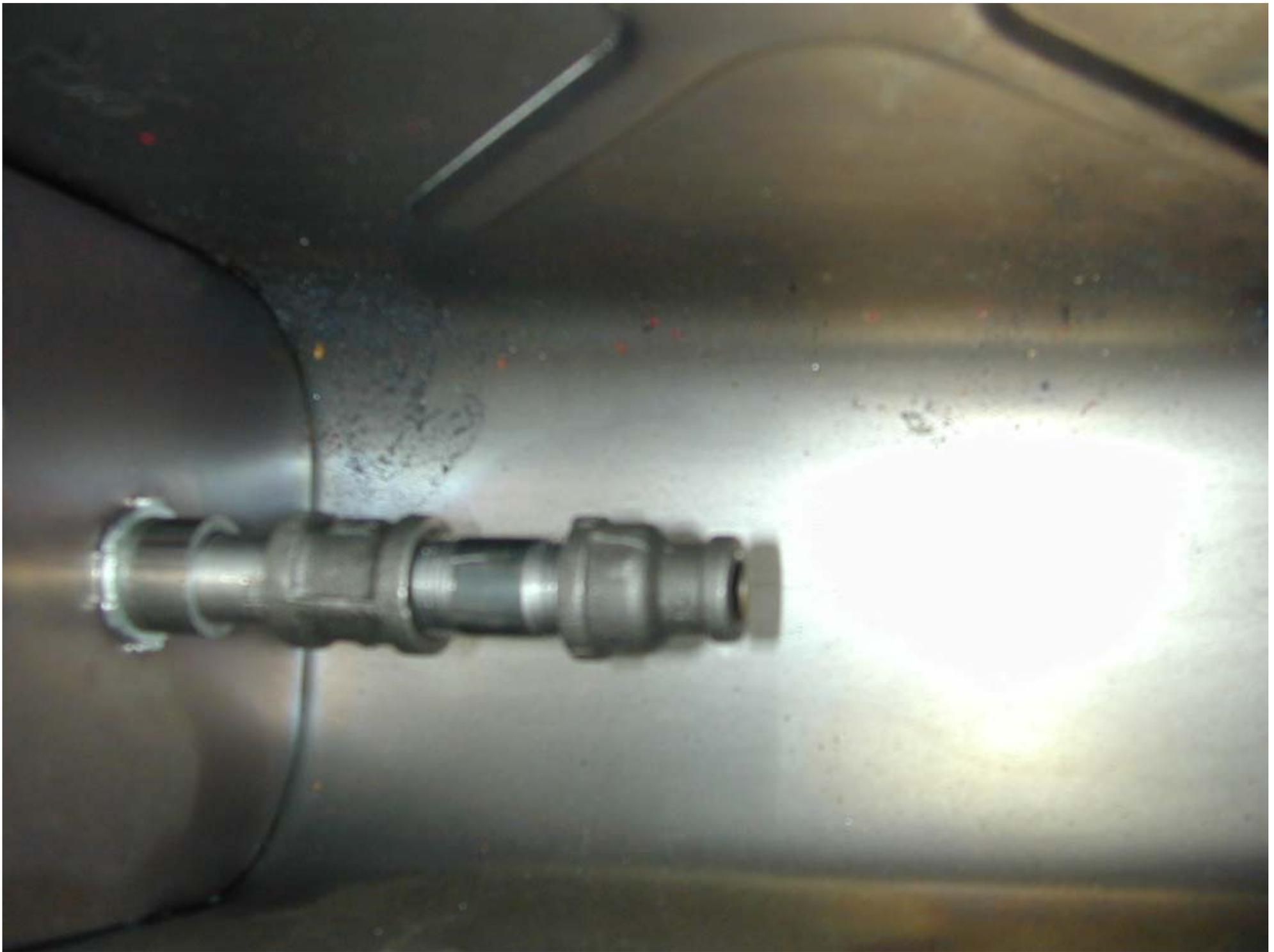






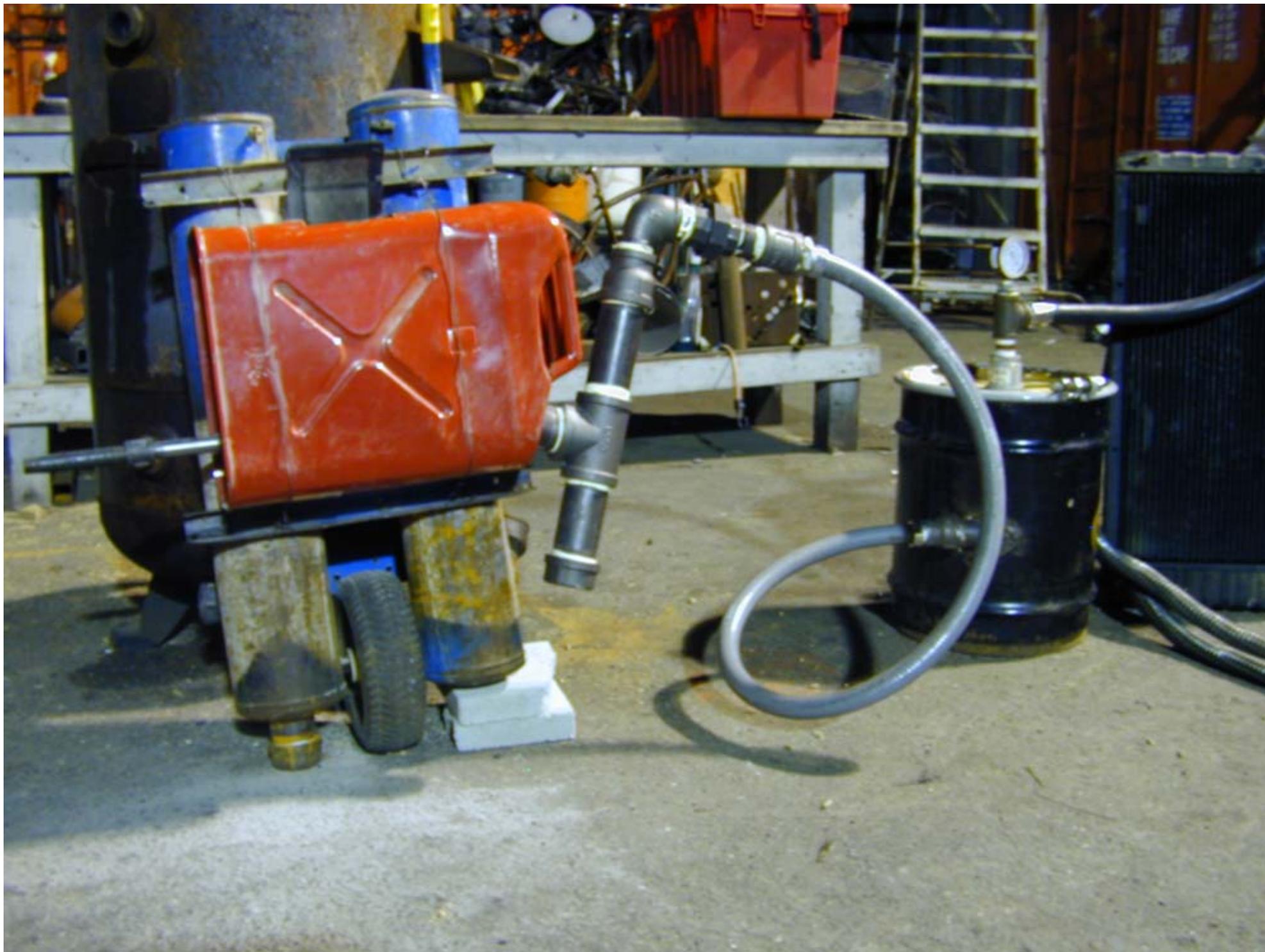






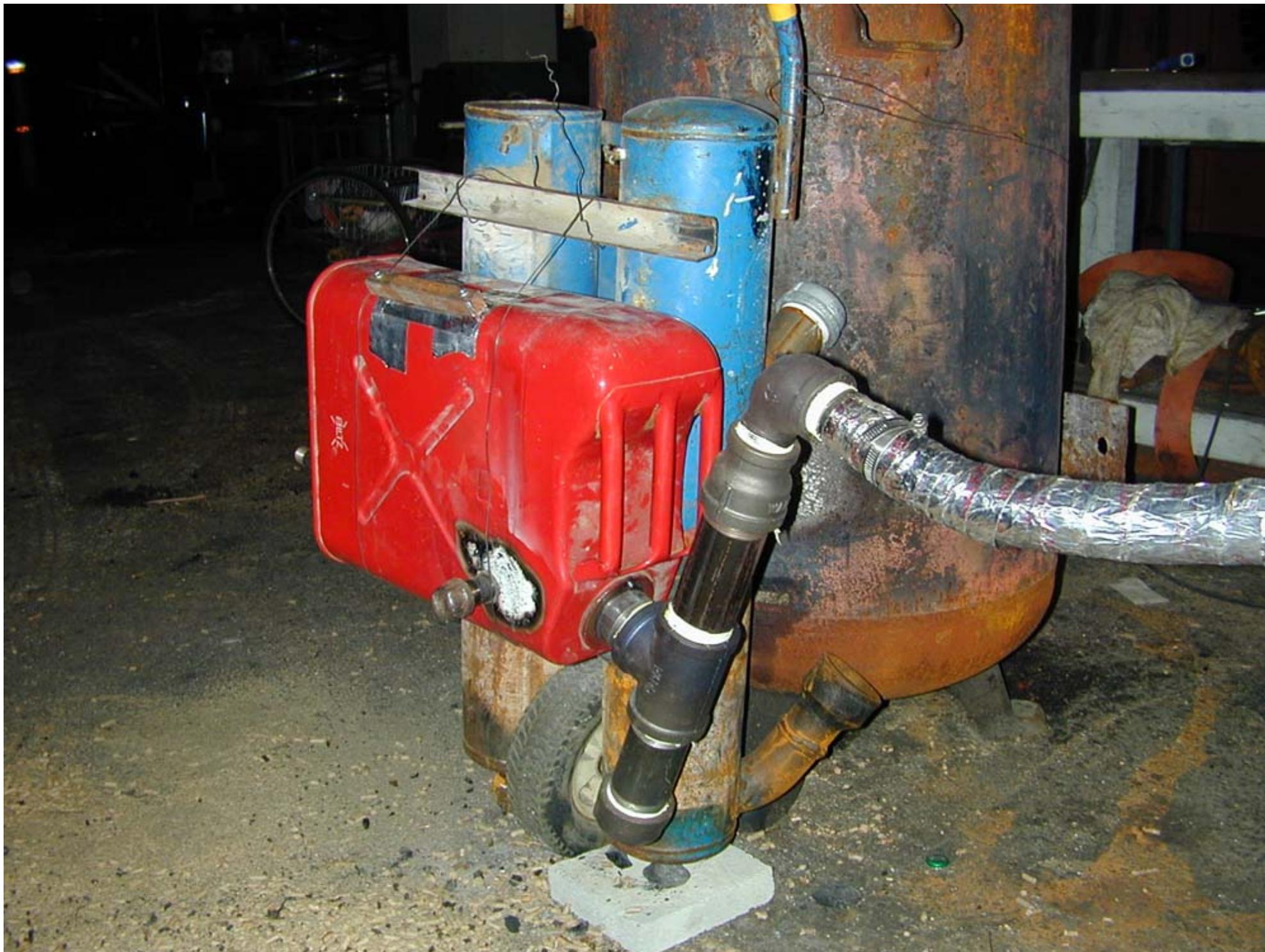




































Sept, 08. See updated gasifier at: [Gasifier Experimenters Kit \(GEK\)](#)

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### The Basics

- How it works
- History (and Future)
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### The Science of Gasification

- Four Core Processes
- How a Match Burns
- Product Gas/Char Variability

# Fuel from Waste Biomass: *Experiments in Pyrolysis, Gasification and Combustion*

Gasification is the general term used for processes where heat is used to transform solid biomass into a "natural gas like" flammable fuel. Through gasification, we can take nearly any solid biomass waste and convert it into a clean burning, carbon neutral, gaseous fuel. Whether starting with wood scraps or coffee grounds, municipal trash or junk tires, the end product is a flexible gaseous fuel you can burn in your gasoline engine, cooking stove, heating furnace and/or flamethrower. Apply a little additional effort and various liquid and solid fuels are possible too.

Sound impossible?

Biomass Fuel  
Variability  
Terra Preta

## **Gasifier Types**

4 Problems, 1000

Solutions

Updraft

Downdraft

Crossdraft

Fluidized Bed

Top Lit Updraft

(TLUD)

Entrained Flow

Kalle

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## **Full Gasifier Systems**

What is Needed

Particulate Filtering

Coolers/Radiators

Well, over one million vehicles in Europe ran onboard gasifiers during WWII to make fuel from wood and charcoal, as gasoline and diesel were rationed and/or unavailable. Long before there was biodiesel and ethanol, we actually succeeded in a large-scale, alternative fuels redeployment. That redeployment was made possible by the gasification of waste biomass, using simple gasifiers about as complex as a traditional wood stove.

Gasifiers are easily reproduced (and improved) today by DIY enthusiasts, using simple hammer and wrench technology. The goal of this site is to show you how to do it.

But a small warning before you start. . .

Those who venture into the realms of pyrolysis, gasification and combustion, seldom re-emerge unscattered (if they ever re-emerge at all). For soon after the heat is applied, the LEGO box of organic chemistry always unwraps itself, and pieces start falling out all over the floor. Through we are given only three easy pieces with which to work, (carbon, hydrogen and oxygen), the potential "solutions" to the puzzle are near limitless. Most soon find themselves deep in wondering about the elegance of the carbon based energy system, as well as the many ways in which a gasifier can be designed to transact the puzzle pieces towards a multitude of desired end products.

May the reassembly be for you, as deeply revealing of the larger biological and energy systems around us, as it has been for me.

Overview

Carburetors

Plumbing

Engine Modifications

Fuel Pre-processing

## **Technical Resources**

Gas Charts

Flow and Sizing

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Sizing Calculator

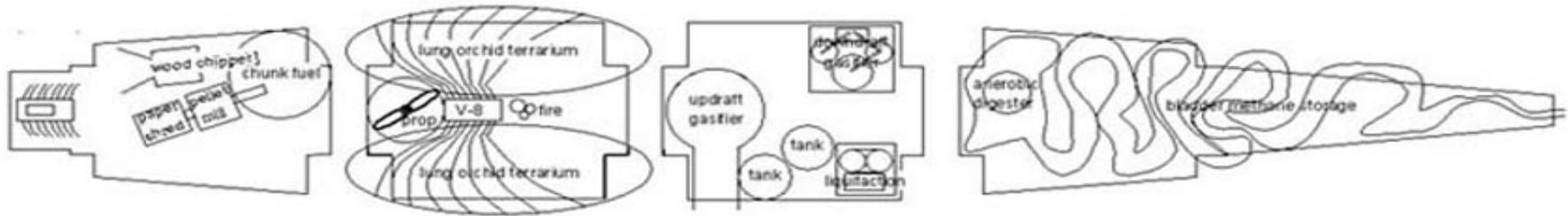
Test Equipment

etc

etc

Links





## The Mechabolic Hypothesis: Cyborg Speculations in Machine Metabolism

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(the mechabolic hypothesis started from a series of email exchanges in the fall and winter of 06. excerpts from the conversation are copied below.)

Sent: 9/21/06

From jim mason

To: xxxxxxxx

Subject: a thesis?

### Philosophy

[Motivation](#)

[Mechabolic Hypothesis](#)

. . . which begs a thesis i have been playing with for a couple months. i think you might find it curious. here's the gist.

### Logistics

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the more i play with all the biomass based fuel things and their related combustion machines, the more i'm realizing all this as the third leg of the grand artificial life project of replicating ourselves: the other two being mechanical robotics and AI as digital machine intelligence/cognition.

this bio immitative metabolic project is seldom called out as such, but it is the core project of the history of development of heat engines, and the various fuels that have been used to power them. all of which are ultimately solar radiation endothermically sprung into cabrohydrates/hydrocarbons, which are then unspring exothermically through oxidation back to heat and co2. which then is restructured back into biomass again through photosynthesis.

whether food or fuel, animals or engines, it is the same chemical process, partaking of the same inputs, exhaling the same exhausts. fuel, machines and fire as the synthetic forms of food, body and respiration. hmmm . . . sounds like an up and coming burning man theme, minus the green-meanie thing . . .

oddly, the early part of the history of immitating the animal respiration with mechanical heat engines was fed with mostly biomass sources- from whale oil to veg oil to wood manufactured gaseous fuels to sweage digested methane. only very late in the project did underground petro based stuff become viable and so densely sourced that all the rest was soon forgotten, and its bio immitative origins concealed. which oddly, is all that is reappearing currently as we have found various issues with petro sourced hydrocarbons and are working to reorient our machines of artifical respiration towards other sources of oxidation ready input.

so somewhere in all of this, the project to save the world seems to be some sort of artistic mashup of the man/machine metabolic/pyro soup with the general aesthetic and pleasures of 50/60s gearhead hotrod culture. and big fire art of course, fed with esoteric organic fuels. biotech not as a medical idiom or project of physical flesh syn architecture, but as a play and creative engagement with the sensual pleasures of mechanical metabolism, fire and noise, as manifested through the v-8 and its fuel/food preps.

all in all, this alt energy thing really shouldn't be a hippie ludditite green narrative of sin and renunciation of consumption, but rather a geek hack project of manipulating artificial life machines and their variable bio/syn fuels. a lego code hack of organic chemistry. ingesting municipal trash, tires, wood waste and agricultural debris to produce the usual heat to mechanical energy to electrical energy that has fueled most of the gig for the last century, but mostly invisibly, and without much concern for the larger cycles in which this energy exchange partakes.

i'm finding the positive artificial life play with the wild diversity of carbon transactions, reckoned through big machines and fire, to be vastly more interesting than any environmental narrative of guilt and sin i've yet to hear. that all this should be drag racing and open source code hacking in the service of creative play, self-expression and general competitive customization, done in social ground up

collaboration, rather than all that it is currently.

thus the all power network and a gasifier fueled edsel bonnevillie land speed record attempt and 1600gal of matthew barney vasoline powering a container camp squat art space in berkeley.

you see anything here?

do you think any of this has legs?

j

-----

9.21.06

later restatement of the above

i'm starting to see all this alt fuel thing as really an artificial life endeavor. the third leg of the grand arc engineering project of replicating and elaborating the human animal. but a third leg we oddly never call out as such.

mechanical engineering has broadly been the replication and expansion of the physical body. artificial intelligence the replication and expansion of cognition. with both now together as robotics. seems that heat engines and their varied fuel preparations are the artificial metabolic system that powers all this. without metabolism through oxidative respiration, there is no life. nor is there heat to mechanical energy to electrical energy, which powers all industrial process. this oxidative metabolism is what powers all bio physical and cognitive entities. but the synthetic forms of this metabolism are largely ignored as a major challenge of artificial life endeavors.

i'm starting to see power engineering as nothing other than the replication and expansion of the organic chemistry of life. all biomass based energy work is imitative of the natural transactions around carbon and hydrogen, ultimately fueled by solar radiation. petroleum was an easy way to ignore it and just input ready made products from ancient and dense underground sources (which were at one time solar energy packed and stored into the form of carbohydrates). sustainable biomass sources require engagement with

contemporary carbon and solar transactions- whether through their forms of photosynthesis to carbohydrates to animal respiration, or through the gasifier/digestor preparations of hydrocarbons to combustion to mechanical energy to electrical energy.

somehow i think there is art here. but haven't quite figured it out yet. though i think it looks something like this . . .

here's a musing from the shipyard list today about such that i though you might enjoy.

-----  
from the shipyard list:  
subject: scented fuels  
date: today

continuing on the idea of "fuel is food" for the metabolic needs of our artificial life machines. ingesting the same hydrocarbons/carbohydrates that we do, exhaling the same  $\text{CO}_2$  and  $\text{H}_2\text{O}$  as we do. all of which goes round and round in the fabulous organic chemistry of life. with solar radiation providing the power to endothermically restructure the C and H into better sprung forms, so we can "burn" it again, exhaling heat and  $\text{CO}_2$  and  $\text{H}_2\text{O}$  again. reminding us yet again that the world is on fire. and man and machine burn through largely the same respiratory process, through largely the same chemical transformations. (the gasifier being the stomach in all this. the v-8 being the lungs and blood.)

but as we don't treat our "energy needs" as a raw energy problem, but rather as the creative idiom of "cuisine" in all its forms, whereby we find sensual pleasure, sociality, relationship to land and distant cultures, etc etc, it seems that we should show our machines the same respect, and enjoy the pleasures of better fuels with them, instead of suffering with the junk we usually feed them. that as we power ourselves with pleasure, we should also power our machines with pleasure. we could all eat gruel and live. but who does? no one.

therefore it seems there is an opportunity in the biodiesel industry to sell scented fuels. fuel alcohols as well.

imagine that when you were buying your biodiesel, you had a choice of "indian", "thai", "italian", "sushi", etc. that you could choose the oil base of the fuel you were buying, and have to pay differently depending on what it was, and how pleasant it is to smell while you are driving. instead of different octane grades, you have choices of smell. with all the jokes and play that follows.

smell is one of the few direct sensory returns from fuel, other than ones in the imagination (which maybe are mostly of interest to me), so smell seems the place to differentiate them.

the smell industry is giant. the car customization industry is giant. as soon as there is opportunity for vanity and distinguishing oneself through customization, people will pay. and in doing so often pursue things of greater quality and creativity in the process.

which is the critical turn we need to make with fuels.

fuel should not be an invisible need fulfillment problem. a zero sum game of solving a problem so we can forget about it, only concerned with economic optimization. but rather relearning it as an expressive medium, whereby we can get past zero and into other areas of interest with it. pleasure, play, learning, humor, community, etc.

and thereby release fuels from their raw btu/\$ calculus, and open them into a realm where much more than btus are being transacted. when was the last time you saw food in the market costed by the calorie? i've never seen a food label that said, "these noodles are 10cal/cent." which is essentially how we label the food for our mechanical animals.

it seems to me that the personal meaning and opportunities of fuel for our machines are as rich as food for ourselves- which long ago left the realm of raw starch and burned meat.

but currently there is no where to buy such "otherwise" distinguished fuels. hmmm . . .

j

-----

Sent: 12/20  
From: Nesdon booth  
Subject: Re: the mechabolic project

Maybe it will need to be scaled back, but I really think the idea of trying to make energy policy more comprehensible by modeling it as metabolism is truly inspired. I look at the way we cut our power consumption in the yard when the pEEfomatic was installed, and how that feedback of systems that we normally keep invisible is a powerful interpretive tool to understand and control them. And this project which models machine energy conversion as biologic metabolism anabolism and catabolism is just such a tool.

...

It is Gaia theory that I imagine in all this. Gaia gets a bit of a bum rap from the scientific community as it was so quickly taken up by the oobie doers, and Lovelock hit the metaphor of one global cell a bit too hard. But his idea for Gaia came out of his work for the Viking Mars Landers. He worked on ways to distinguish between biological and geological chemical processes. It is interesting that the results from Viking are still ambiguous.

His central epiphany was that our atmosphere is extremely unstable chemically, and by all rights should have evolved to very stable atmospheres like Mars and Venus both have. But ice cores and other data all suggest that our atmosphere has been incredibly stable over a very long period, in fact more stable than many of the important inputs, such as insolation, which vary in both short and long term trends would suggest. His inevitable and I think correct conclusion was that collectively, life on earth has coevolved with the soil and the atmosphere to form a homeostatic system whereby crucial compounds are maintained at optimum levels for the continuation of life. This is surprisingly analogous to what living things in fact do within their tissues. It does look very much like the global ecosystem functions in many ways like a single large organism.

He suggested a thought experiment he called Daisy World, whereby populations of daisies (good old asteraceas) with white and black individuals might evolve to vary the proportion of white to black to compensate for the historic change in insolation (a star's output grows steadily over time, up to a point) by altering the albedo (more black and more heat is absorbed, more white and more heat is reflected) and thereby maintaining a constant pro-daisy local temperature.

In unfathomably complex ways we all collaborate (I think the soil bacteria and phytoplankton still have a little edge on us, but not for long) to make this world inhabitable. All of the engines we have built, we have built essentially as cyborgs, to augment our natural human functions. Since they are all conceived in this anthropomorphic process, and then must function within this lifelike global ecosystem, they are fairly literally part of the metabolic functions of Gaia.

That's why I think this Mech-A-Bolic thing is such a damned good idea. I'm not sure how to make it doable. I will certainly put my rhetorical shoulder against the Borg wheel and help however else I can.

Nesdon

---

Sent: 12/20/06  
From: jim mason  
Subject: the cyborg gaia idea

also remember, the system being suggested in all this is not really a single animal organism, but the larger marco-metabolism of solar energy and co2 through photosynthesis to carbohydrates to heat, motion and exhalation of co2 back into the atmosphere, so that solar radiation can start it again. a giant planetary system of power conversion, driven by the sun.

that is the larger metabolism of interest here. with our industrial machines and fuel preps, we are still rather fragmented in all this. we have the respiration part down near perfect. but our carbohydrate/hydrocarbon preps are a complete mess, as in we take them out of the ground, and don't deal with any contemporary photosynthesis.

and to the degree that we are trying to harvest solar to run this synthetic macro-metabolic machine, we are trying to use pv, which is equally fragmenting of hte larger system. yes, pv is great, but it has little imaginative potential when trying to get our minds around the larger system.

and in absolute terms, the more i read on this, the more i see that the biomass based inputs into our existing MASSIVE infrastructure of synthetic respiratory machines, is what is going to make the biggest dent in all this. not the silver bullet. but likely the most important comonent that can change. well, that and nuclear. all projections for pv are not impressive. about 90% of current energy use on the planet is petro based. yes, even hydro and nuclear is that small. all this petro fuel is burned in machines of synthetic respiration that can already use biofuels with very minor modifications.

---

1.27.06  
From: jim mason

Subject: GMO

the more i listen to the energy debate, the more i hear two strains of cultural bias. one is "go back to nature", which all the associated ludditeism and wishes for a non-consumist, non-stuff based life, and the other is "go forward to artificial life", which is arguing the good of GMO, active hacking of the biosphere, and general technical solutions.

nesdon's previous post about the corollary of the gaia hypothesis, that we are collaborators in the atmosphere, and it has evolved with us. not just humans. but all life. all organic life is part of the larger biosphere organism.

it seems to me that humans, as fundamentally tool making creatures, have made synthetic metabolic machines of such size at this point that we have injected a new type of species into this biosphere. i don't think we can go back to a pre mechanized time. our machines are us. and as we had the power to mess up the atmosphere through them, we also have the power to fix the problems with them. but NOT by returning it to how it was. but rather, by hacking to get to the desired end state.

i'm starting to called this the "mechabolic hypotheis". that global metabolism is now primarily a cyborg entity, as we need to more thoughtfully operate our machines of mechanical metabolism within it.

given thus, we should look around for greenhouse gas mitigating gestures. the one i'm seeing as the biggest lever is methane. methane is like 4x or 5x the effect as co2. if we could reduce methane faster than we are adding problematic co2 from non contemporary sources, we could get to a statis we like better.

the biggest source of methane is all the rotting stuff on the planet, made worse by biodegradable consumer products, and worse of all, hippies composting things. all organic matter put into the ground in these manners, rots and produces large amounts of methane (ch4).

it would be vastly better if we collected up all the waste biomass and "burned" it through thoughtful gasification, mining its energy as it is returning back to the atmosphere as co2, all the while generating a high carbon ash that is a vastly better fertilizer than just organic

mulch. this is the terra preta soils in the aztec amazon.  
charcoalized soils. also why things grow so well on volcanos in hawaii.

interestingly, such a char/ash out of gasifiers would allow us to use an already existing global infrasture for carbon sequestration. it is called agriculture.

redistribute the char/ash as fertilizer, burying it in the ground, where it is now out of the atmosphere.

there would be some balance in here where you are reutrning enough better char/ash as fertilizer to replenish the soil, while mining all of its energy that wouldl have otherwise been lost when it just rotted into the ground.

given all this, i believe i can make a sound argument that a systemic approach to gasification is a carbon NEGATIVE energy system. and one that produces heat, power, fuels and fertilizer in the process.

is this bullshit? i think this argument is correct.

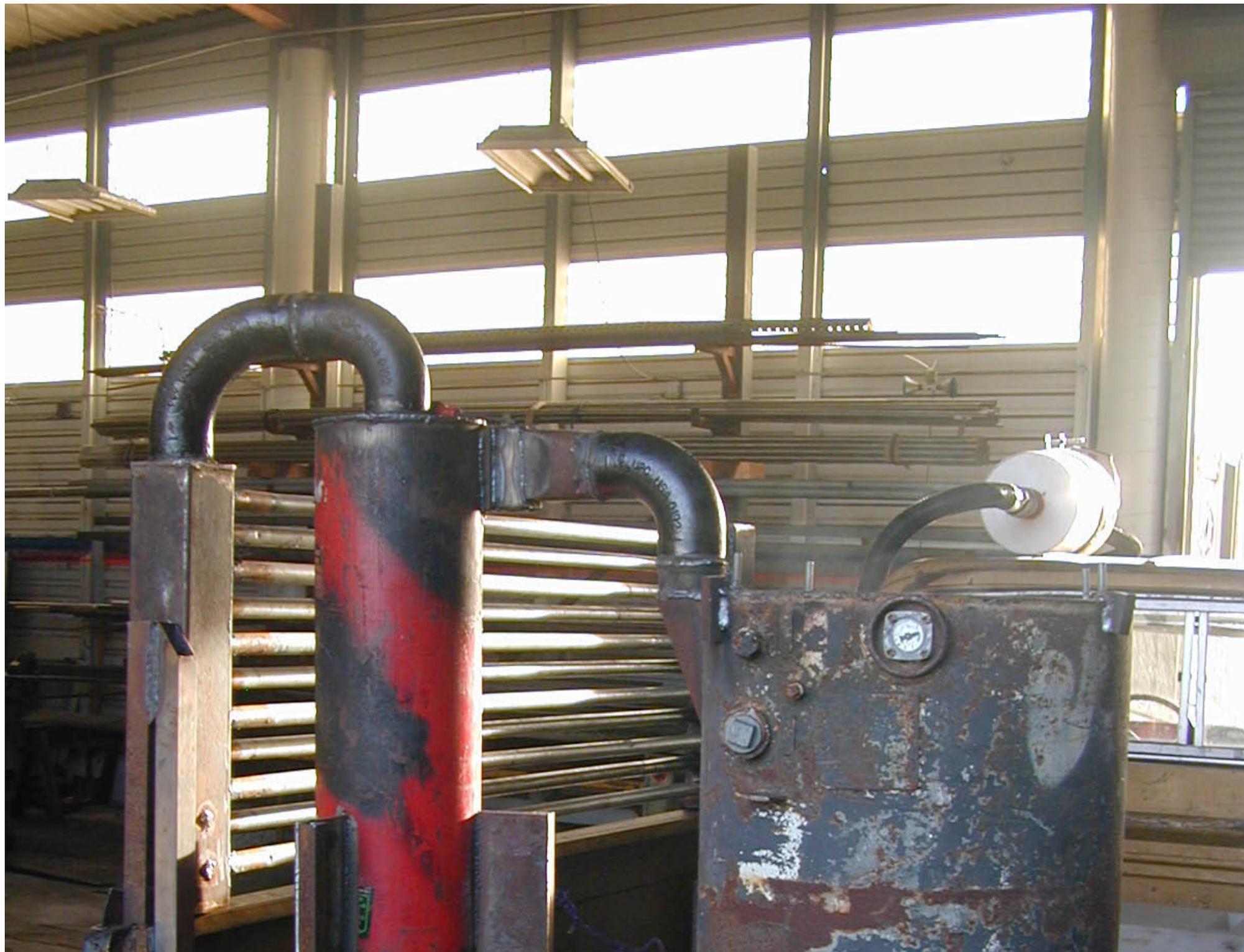
can someone help me see where it is wrong?

j



















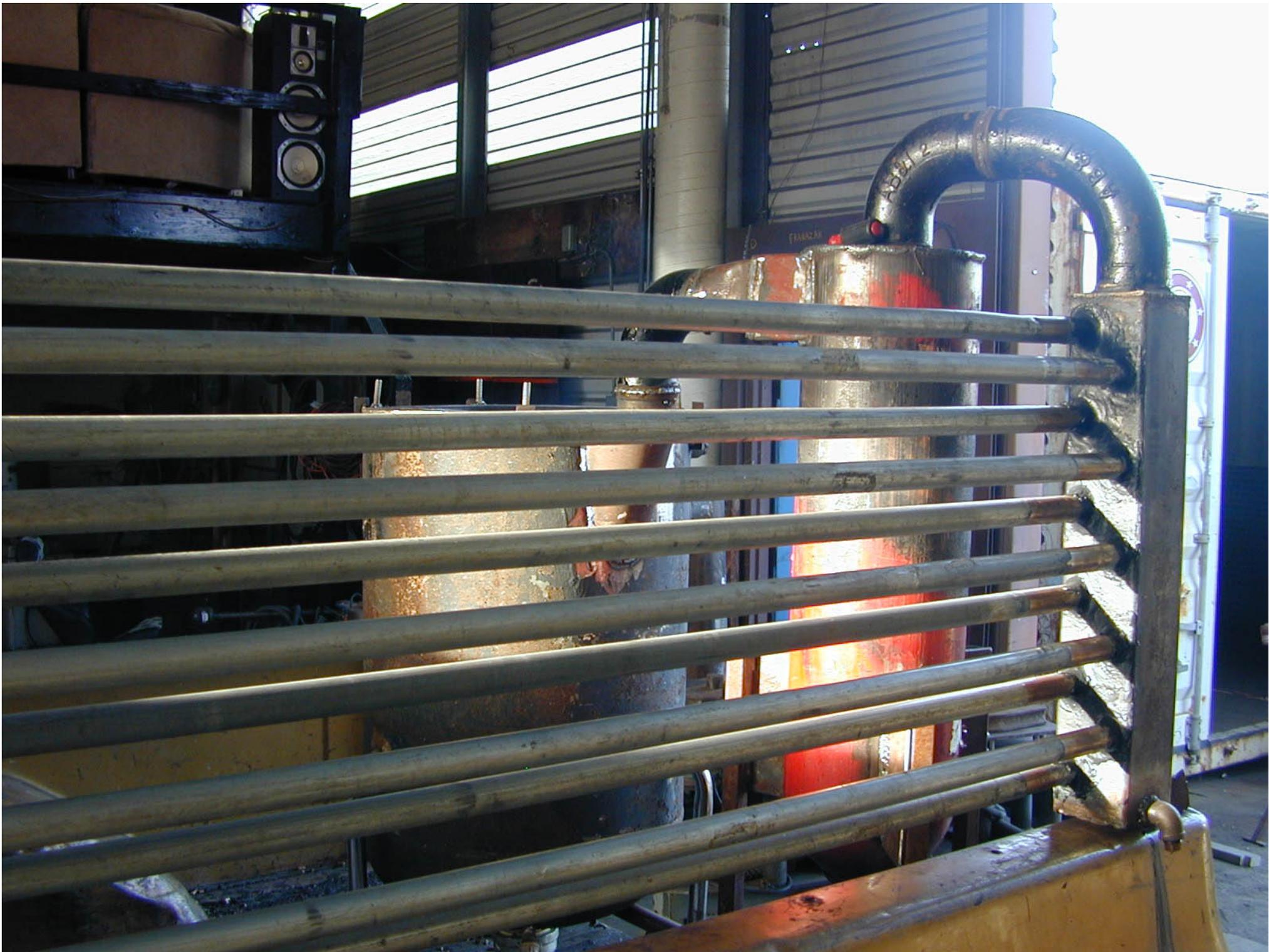




















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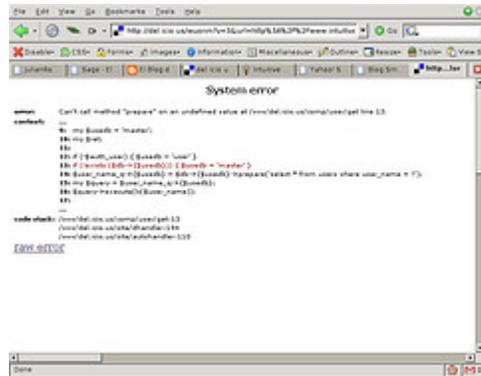


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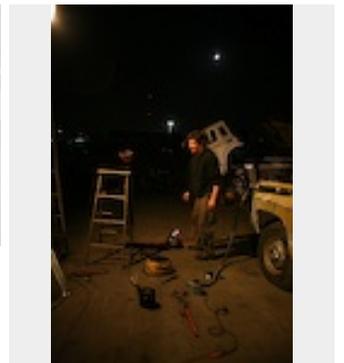
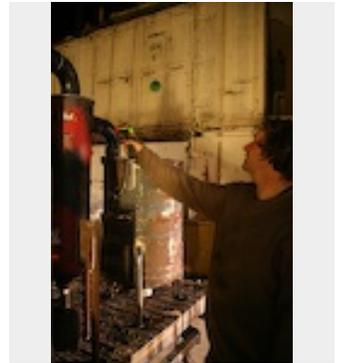
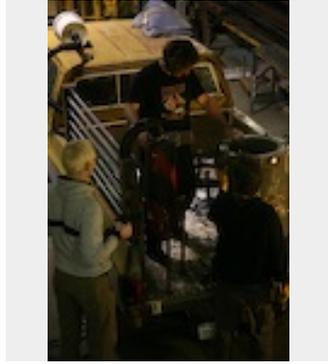
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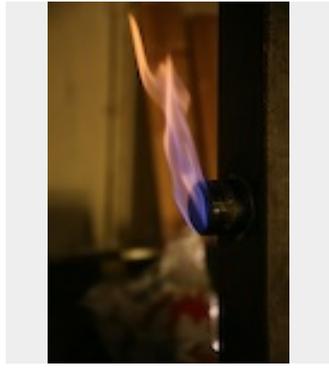
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# This is a low density gas it won't explode

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- 2
- *Next*





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and F. P. Zimmerman, Oak Ridge National laboratory, Energy  
Division FEMA Interagency Agreement Number: EMW-84-E-  
1737 Work Unit: 3521 D

for:

Federal Emergency Management Agency Washington, D.C. 20472

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Prepared by:

Oak Ridge National laboratory Oak Ridge, Tennessee 37831-6285  
for the U.S. Department of Energy

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---

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Sept, 08. See updated gasifier at: [Gasifier Experimenters Kit \(GEK\)](#)

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**The Basics**

How it works

History (and  
Future)

Biomass as Solar  
Energy

Pathways of  
Biomass

Conversion

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**The Science of  
Gasification**

# Power Exchange Gasification Workshops

Next workshop: Friday and Saturday,  
May 4 and 5

*Gasification Lecture and Demo: Friday 7:30-9*

*Build Day: Saturday 10am - 6pm*

Cost: \$50-100 (sliding scale)



Four Core  
Processes  
How a Match Burns  
Product Gas/Char  
Variability  
Biomass Fuel  
Variability  
Terra Preta

We are holding a series of workshops this spring and summer to experiment with DIY gasification. The workshops are formally in support of the Mechabolic art project for Burnig Man 07 (<http://whatiamupto.com/mechabolic/index.html>), but we invite anyone with interest in pyrolysis and gasification to join us. The workshops start with a talk presenting the science behind gasification, along with a summary of its design and social history: past, present and future. The following day is a 8 hour build day to convert a vehicle or other combustion device to woodgas operation. We welcome your vehicle, lawnmower, generator, etc for conversion.

### **Gasifier Types**

4 Problems, 1000  
Solutions  
Updraft  
Downdraft  
Crossdraft  
Fluidized Bed  
Top Lit Updraft  
(TLUD)  
Entrained Flow  
Kalle  
Mason

The pictures and report from the first gasification workshop are here: <http://whatiamupto.com/gasification/woodgastruck.html>

The workshops intend to enable the conversion to woodgas of various artcars and fire effects for the Burning Man event, with fuel being processed and distributed by the Mechabolic installation. Our goal is 10-20 vehicles running woodgas in one place, fed by fuelstocks prepared from various wastes at the event. Our feedstock will be primarily coffee grounds, dpw waste wood, cafe paper cups, non-white paper trash, junkartwood, etc. A parallel terra preta biochar agricultural effort locally to Gerlach, Nevada will sequester some amount of carbon and ash from the proceedings as fertilizer, for an ultimately carbon negative system intervention.

### **Demos and**

### **Experiments**

[Quadrafier \(4 in 1\)](#)

[Gas-can-o-fire](#)

[Cigifier](#)

Toilet

[GMC truck](#)

So if you are interested in converting a vehicle, generator, pulsejet, flamethrower or other combustion based device to run on solid waste biomass, and leave less greenhouse gas airborne at the end than when you started, we have the workshop for you.

Here are the dates for upcoming workshops.

### **How to Build a Gasifier**

One Minute  
Designs  
One Hour Designs  
One Day Designs  
One Weekend  
Designs  
Design Your Own  
Sizing Calculator

may 5th  
may 26th  
june 16th  
june 30th

### **Participants in workshop #1.**

Jim Mason, Jessica Hobbs, Chicken John, Phil Glau, Alec Plauche, Les Young, Bruce Arneson, Steve Nelson, Roger Carr, Eric L. Forsman,

Other Designs  
Online

Kiko Almund, Dov Jelen, Caroline Miller, Chris Schardt, Patrick  
Buckley, Dann Davis, Darrel Licks,

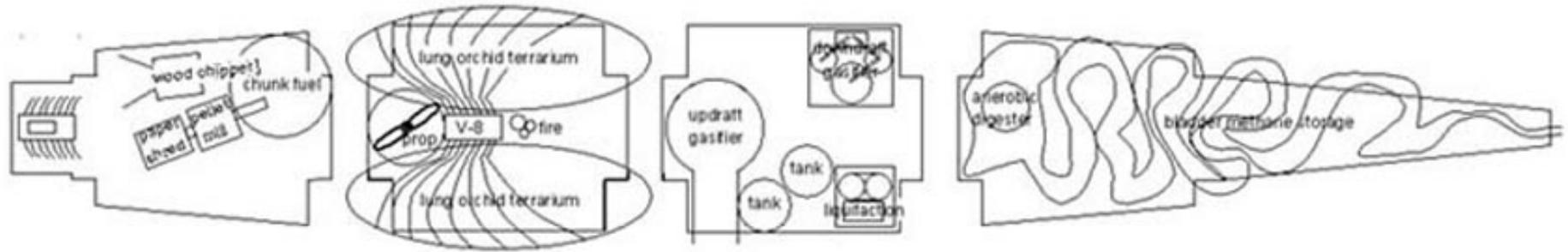
## **Full Gasifier Systems**

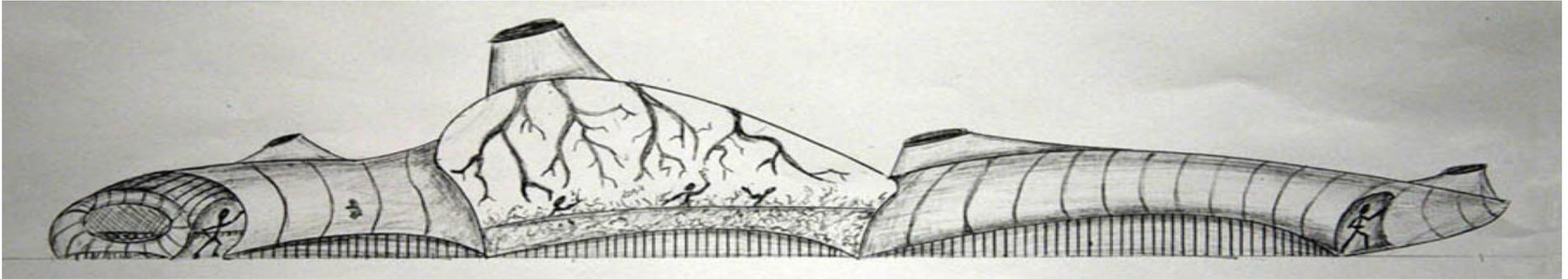
What is Needed  
Particulate Filtering  
Coolers/Radiators  
Carburetors  
Plumbing  
Engine  
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Fuel Pre-processing

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# The Mechabolic:

## *Cyborg Speculations in Machine Metabolism*

A large-scale installation exploring the bio-imitative nature of our synthetic "metabolic machines", and their related hydrocarbon based fuels/foods

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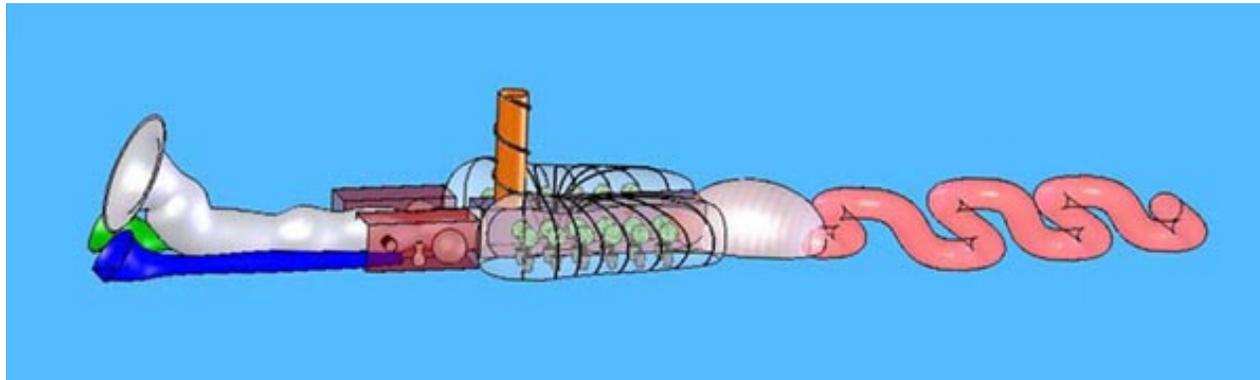
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### Principals:

*Jim Mason, Chicken John, Dann Davis, Michael Christian*

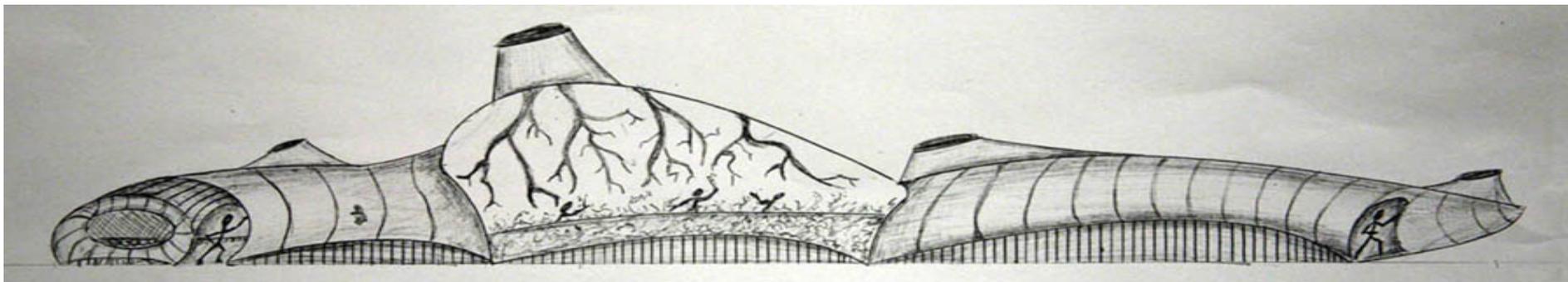
### Main Collaborators and Sub-Project Leaders:

*Dov Jelen, Kiko Almund, Jess Hobbs, Brandi Hugo,  
Peef Sadow, Darrel Licks, Peter Durand, Jae Rhim Lee*

### Project Management:

*Babalou*





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*The sculpture:*

The Mechabolic project is a large-scale bio-imitative installation of hydrocarbon based fuel production, transformation and consumption. Our goal is to create a fantastical, bio-machine hybrid environment --a burlesque of the "synthetic metabolism" of machines-- recasting internal combustion engines and petroleum fuels as their parallel animal organs and plant generated carbohydrate foods.

As a physical sculpture, the Mechabolic will take the form of an exploded assembly of digestive and respiratory organs, laid out across the desert floor, and mashed up with their associated mechanical metabolic machines (i.e. internal combustion engines, refining gasifiers, anaerobic digesters, liquefiers, process tanks, condensation towers, etc.). All features and functions will be rendered in the aesthetics of human anatomical illustration meets blown V-8 hot rod fetishism.

The Mechabolic will encase these hybrid bio-machine organs in a giant "dinosaur slug" trash scavenging creature- a creature which slithers across the desert in search of waste biomass trash to feed/fuel itself. All ingested trash will be converted to clean biomass foods/fuels using the simple technologies of gasification, anaerobic digestion and Fischer Tropsch liquification. The Mechabolic will re-ingest the resulting foods/fuels to power its own locomotion as well as as a variety of high altitude fire effects.

*Interactivity:*

The Mechabolic invites participants to walk through the innards of an exploded metabolic animal and contribute their waste paper, wood, coffee grounds and food compost to the fuel

making effort. Participants can watch all fuel/food processing through transparent process tanks and plumbing, as well as handle the feed and fuels at various points in the "refining" process. All in all, a fun house walk-through journey of machine digestion and respiration -- from mouth to anus, oil well to gas tank, trash dumpster to carburetor plenum-- with all the interstitial fun and mysteries of organic chemistry implied therein.

The Mechabolic creature will also function as an odd sort of biological "gas station" in the middle of the desert, collecting, processing and dispensing biomass fuels to power "woodgas" converted art cars. The proposed project includes a series of monthly workshops this spring and summer to convert vehicle engines and generators to "woodgas" operation. These "Power Exchange" workshops will teach the building of simplified downdraft gasifiers, as [recently demonstrated](#) at the Shipyard, which produce a synthetic "natural gas-like" fuel from any solid waste biomass- a gaseous fuel that will run in any gas or diesel engine.

As such, the Mechabolic intends to become a future vision of the ubiquitous "pump n' munch" road side gas station/diner. But in this iteration, a fuel/food stop where artcars congregate to fill up on coffee grounds, chipped wood and pelletized trash, while people stroll through fuel making biological organs, and lounge in a rather unlikely V-8 powered, fire spewing, carbon sequestering, lung shaped terrarium- filled with orchids, ferns, terra preta bio-char, and you.

#### *The Mechabolic Hypothesis:*

Our intention with the Mechabolic is recast combustion machines and their related petroleum fuels --the foundations of our industrial energy economy-- as somewhat of a veiled project of artificial life. Where usually a dry technical problem is seen, we want to suggest that what is really at issue here is the the "third leg" of the grand human engineering project of replicating ourselves.

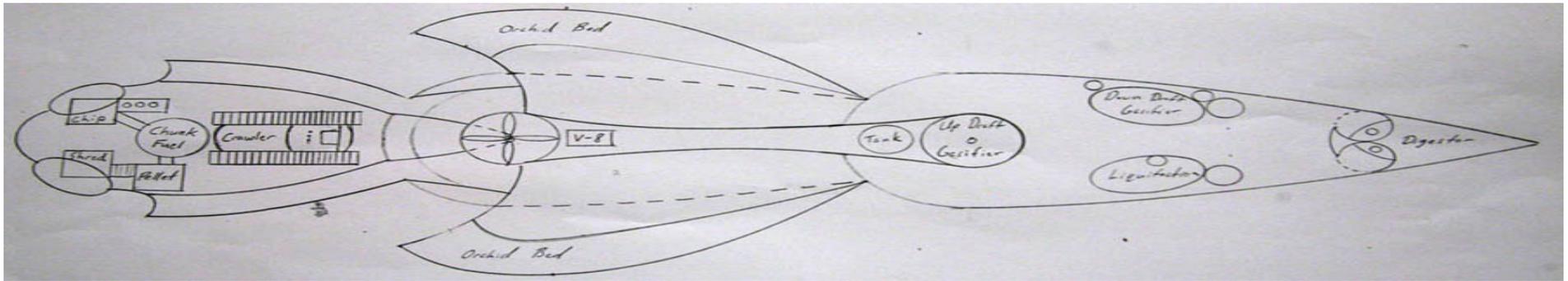
Artificial life is usually reckoned as a problem with two basic challenges- one physical and one cognitive. Mechanical engineering has broadly been the replication and expansion of the capabilities of the physical body. Computer science and AI the replication and expansion of our perceptual and cognitive abilities. What usually goes unmentioned is the similarly bio-imitative energy systems we synthesize to power our synthetic creatures. This metabolic artificial life project is seldom called out as such, but it is the core endeavor in the history of heat engine development, as well as the many fuels that have been refined and fought over to power them.

The biological metabolism of life is symbiotic relationship between sun, plants, animals, and atmosphere, with all combined together in a virtuous circle of photosynthesis and oxidative respiration. Curiously, 90% of the human produced energy on the planet follows from a similar bio-imitative project of metabolic artificial life, using synthetically refined "solar energy"

hydrocarbons and various forms of heat engines to respire them. Our current problem follows largely from feeding our mechanical animals with foods/fuels derived from the prehistoric solar energy (petroleum products), and not their contemporary sun derived parallels (terrestrial biomass).

The evolution of our artificial life machines, and particularly synthetic metabolic systems, has now progressed to a point where they are no longer trivial participants in the larger biosphere and atmosphere. Though Gaia has really been a cyborg entity since the beginnings of wide spread human agriculture, the fundamental cyborg nature of Gaia can no longer be ignored. We are not likely to go backwards to a light food/fuel footprint. Rather, we are likely to go forward with more thoughtful forms of synthetic metabolism- ones which more reasonably collaborate with and positively contribute to a progressively cyborg earth/atmosphere system.

This bio-imitative nature of our industrial metabolic machines, as well their intimate participation in the macro-carbon cycle of biological life, we are terming the "Mechabolic Hypothesis". We hope that recasting the energy economy in the terms of biological metabolism will highlight its systemic nature, as well as the great flexibility available in nearly all parts of the system.



## The Mechabolic: Technology of Gasification

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Gasification is the general term used for processes where heat is applied to transform solid biomass into a "natural gas like" gaseous fuel. Through gasification, we can take nearly any solid biomass waste and convert it into a clean burning, carbon neutral, flammable fuel. Whether starting with wood scraps or coffee grounds, municipal trash or junk tires, pistachio nut shells or avocado pits, the end product is a flexible gaseous fuel you can burn in your gasoline engine, cooking stove, heating furnace and/or flamethrower. Apply a little additional effort through liquefaction technologies like Fischer-Tropsch or other catalyst based processes, and methanol, ethylene, and diesel are possible too a modest complexity.

Sound impossible?

Well, over 1,000,000 vehicles in Europe ran onboard gasifiers during WWII to make fuel from wood, as gasoline and diesel were rationed and/or unavailable. Long before there was biodiesel and SVO, we actually succeeded in a large-scale, alternative fuels redeployment. That redeployment was made possible by the gasification of waste biomass, using simple gasifiers about as complex as a traditional wood stove. Gasifiers are easily reproduced (and improved) today by DIY enthusiasts, using simple hammer and wrench technology. (see [www.woodgas.com](http://www.woodgas.com) and <http://en.wikipedia.org/wiki/Gasification> for more background info).

The Mechabolic project intends to reintroduce this technology for contemporary DIY enthusiasts, with improvements in design following from the many sensing and embedded control potentials that were not available during the previous "woodgas" deployment. We intend for this "artistic deployment" to seque into a growing collection of usable wood gas converted cars and other machines for off playa purposes. In fact, we are currently in the process of converting Ritual Café on Valencia street to run entirely on its own coffee grounds waste. Coffee in: electricity, heat and gaseous fuel out. (our [current DIY gasification efforts are here](#) and [here](#)

I started reading and experimenting in gasification a little over a year ago and have already shown the ease with which basic units can be made to run internal combustion engines and fire effects. In the process, I have found gasification to be an unusually rich alt energy technology. By far the most rich and flexible in its applications that I have found to date. Its conceptual, technical, social, visual and logistical realities are nearly always expansive, evocative and strong tonics for most imaginations that engage it.

Gasification is a unique artistic opportunity for fire artists as it is really a form of partial or staged combustion. In gasification the usually unnoticed serial steps and kinetics of "fire" are controlled and pulled apart, revealing a multiplicity of forms and processes. Where before we just saw fine burning, a knowledge of gasification soon has one seeing the infinitely configurable LEGO system of organic chemistry, refereed by that hard and always unbribable taskmaster, thermodynamics.

In the crucible of fire, with the tools of gasification, we are invited to play with the raw elements from which all life and natural metabolic/energy systems are made. Oddly, we are given only three measely pieces with which to work (C, H and O; carbon, hydrogen and oxygen). But with this small collection of pieces, and thoughtful thermal, pressure and catalyst interventions, we can start with nearly any organic matter, and make nearly any end hydrocarbon/carbohydrate we desire.

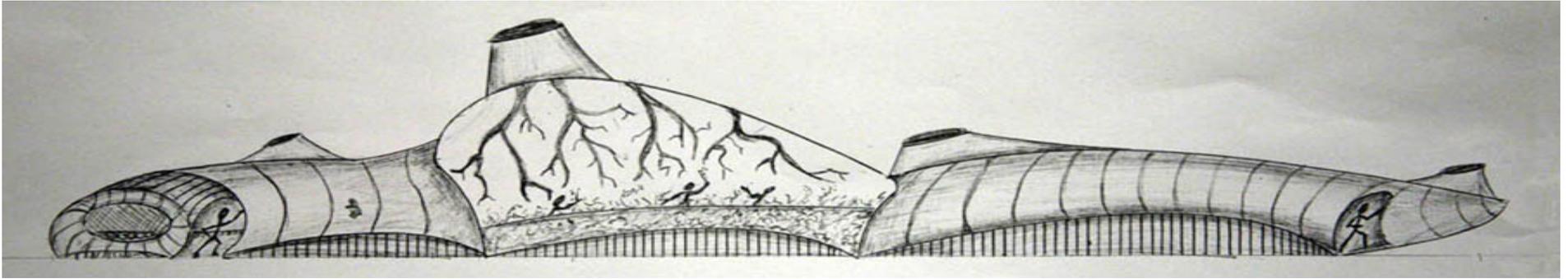
As such, I found gasification to be a tremendously attractive idiom and technology just begging for exploration and creative manifestation by our ever expanding circle of DIY junkyard fabricator pyros. Gasification is uniquely suited to the fire interests and gearhead skill set generally found around Burning Man. In time, I believe it will emerge as the main idiom through which Burning Man can contribute something burning man related to the larger environmental conversation.

"Gasification: Burning our way to a better tomorrow"

After exploring nearly all the known options for power generation and conversion over the last five years, for me gasification has emerged as the most interesting and flexible way to "burn things" in an environmentally thoughtful manner. And with the recent combination of gasification with Terra Preta Bio Char agriculture, gasification has emerged as the ONLY current alt energy technology that can create a carbon NEGATIVE footprint. (see "Physical Specifics" section for details). The proposed Mechabolic project will be using gasifier based Terra Preta carbon sequestration process to fertilize the orchids and other plants in the "lung terrariums".

(for a more technical discussion, [see here](#))





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The Mechabolic creature will be a large sculpture of mixed materials, environments and processes. The sculpture will be much a walkthrough stage set and fun house interactive experience, as it is a discrete object for aesthetic and sensual consideration.

We expect it to measure somewhere around 120 feet in length, 20 feet in width and 15-25 feet tall. The sections of the body will be premade on skids and containerized, with the superstructure formed through a combination of hoop and stretched cloth construction, as well as transparent inflatables. Various cantankerous machines, stainless steel tank processors, clear process plumbing, V-8 dragster engines, wood chippers, fleshy surfaces, flowers, storage bladders, etc etc etc, will fill out the spaces. A weird fantastical mash up of hot rod chrome fetishism with exploded innards, insides made outsides, fleshy biological anatomy.

The current plan is to make the creature mobile, but we are also considering doing it as a stationary installation. The original notion was a stationary installation, but Dann Davis and Michael Christian, the leaders of the creature conceptualization, design and building, really want to make it move. This does make sense, of course, as scavenging animals move to their food, not have their food brought to them. Details on the locomotion scenario are at the end below in a separate section.

Whether we make it mobile or stationary in the end, the basic assembly of organs and materials to make the superstructure remain the same, so we are not formally committing to one of the other quite yet. The main difference, obviously, is that the mobile version will need a much more complicated floor/belly, and related locomotion system. The materials and budget items that relate to the locomotion are easily separated from the current proposal if we eventually decide against the moving version.

The creature is divided into 3 separate section, roughly cooresponding to the head/neck, chest, and abdomen. The biological organs and processes in each of these body cavities informs the arrangement of fuel processing and combustion equipment in the creature. The creature is

exploring the machine parallels to BOTH digest and respiration, with some added allusions to the plant and microbial worlds that are related to each.

The technologies we are engaging towards these ends are gasification, anerobic digestion and terra preta bio char sequestration. Gasification processes the dry biomass to fuel. Digestion processes the wet biomass to fuel. And terra preta uses the byproduct of each to sequester carbon as a soil enhancing fertilizer. The combination will allow us to convert various types of trash at the event into fuel for both mobility and fire effects, and do so ultimately do so in a carbon NEGATIVE footprint. (for more information on newly developing scenarios of terra preta, see the [summary here](#). A longer [academic paper is here](#).)

Solid waste biomass in dry form is available on the playa as waste wood (both participant and dpw), paper trash (both participant and project), coffee grounds from the center café, and surely more we have yet to realize. Wet waste biomass is most likely food scrap from both camps and the commissary. We will not be digesting or contending the poo in the Johnny on the Spots. Human manure take about one month to digest, so it is not possible over the period of the event to do too much with it.

Here's the specifics of the three main "cavities".

**1. Head:** fuel/food preparation and standardization (i.e. chewing). Machines will include a wood chipper, paper shredder and pellet mill and wet food mascerator. The products of these processed waste streams will be conveyed to the abdomen by clear transport pipes and/or conveyer belts. The chipped and pelleted dry biomass will be stored in a "fuel pile" and made available for art cars with wood gas conversions.

**2. Chest-** The chest will re-render the "Breathing/Burning" of carbohydrates/hydrocarbons to carbon dioxide through a double lung V-8 engine inflatable orchid terrarium, large scale vertical fire effect with V-8 driven wind slip stream, and bio char fertilizer/sequestration.

The "terrariums" somewhat mix the respiration of plants, (inhaling carbon dioxide and exhaling oxygen) with animal respiration (inhaling oxygen and exhaling carbon dioxide). The lungs are wrapped around the center blown V-8 hot rod motor, with the dragster style exhaust "zoomies" wrapping around the lungs like ribs and/or blood vessels. Additional "blue blood vessels" will branch off the ceiling in the terrariums, with the main trunk going to the intake of the V-8. With the exhaust zoomies in red and the intake "blood vessels" in blue, the central V-8 will "breathe" with the aesthetics of its biological parallel.

The "terrariums" will be enterable environments, where participants can wander and relax, enjoying a collection of orchids and ferns, set over a floor of black biochar.

The V-8 driven propeller, cowling and wind stream will extend out the top of the creature using a

somewhat flexible steel and fabric sock. This is the "trachea", where the engine and pyro effect respire the made fuel into a swirling vortex of exhalation- which we might call the "throat of fire". Fire effects in the throat of fire will include typical ICP-type pressurized liquid flamethrowers, and continuous and burst flow gaseous fuels.

**3. Abdomen-** The abdomen will contain the gasification, liquefaction and digestion processors to make fuel for both the onboard engines as well as all fire effects. The Mechabolic will only "burn" fuel it makes from trash at the event. Zero purchased petroleum products will be used.

Real time gaseous fuel production for the engines and liquefaction processes will happen via a downdraft gasifier. This will be skidded with the associated cyclone filter, cooling unit and dry gas filter.

A second and much larger updraft gasifier will make gaseous fuel for the wind slip stream fire effect. This will burn with a clean blue flame, in a manner similar to the images here, but at much larger scale.

A third skid will hold various process tanks to support Fischer Tropsch liquefaction of the gasifier gas to a mixed gasoline/diesel product fuel. We are choosing to use the FT process, as do many DIY liquefaction efforts, as it is the only liquefaction process that can operate at atmospheric pressures, thus avoiding the difficulty and safety issues of negotiating fuel transactions under both pressure and heat.

A fourth skid will hold the anaerobic digester and inflatable bladder storage, wound into an intestine like shape. Waste wet biomass food scrapes, unlike manures, allow for fast digestion processes, going from solid to methane gas in one to two days. The product gas will fuel the central fire effects, as well as an "eternal flame" at the anus of the creature.

All these components will be modular and containerized, so the resulting "sculpture" is made reasonably easy for transport and show in future venues. A major goal of this project is to exit out the end with a collection of containerized alt fuel "demonstration units", ready for storage, transport and "roll right off the trailer" use in future contexts, both art and engineering.

### **Locomotion Scenarios:**

Ideally we want the Mechabolic to move so as to "scavenge" for its food/fuel. Early designs considered building the creature as a sort of wheeled train, but the amount of axles, wheels, linkages, drive shafts, bearings, etc etc to do as such is daunting. the vehicle undercarriage alone could easily take up too much of the project time and effort.

So currently we are exploring the possibility of just giving it a flat belly and making it slither. Or in

other words, drag it, REALLY really slow, using a track caterpillar tractor built into the front of the mechabolic animal to pull it.

This would be rather interesting we think. No one has yet built anything between a stationary installation and an art car on the playa to date. No really slow moving objects that are neither stationary installation nor large rolling people conveyance, but rather a barely moving object with no visible wheels or discernable movement.

It would be a tolerable amount of work to make a snake scale belly sort of thing out of tiled sheet steel. 4' x 8' sheets, all nearly identical, each with a hole in the front and an attach pin at the back. Then lay them out tiled and overlapped, from front to back. The lip overlap at the front of each one, as well as the tremendously large surface area would give plenty of flotation. ([see here](#)) Or do the belly as three larger plates, corresponding to the three "cavities" of the creature, and form them with radii at the joints so the creature can turn. ([see here](#))

Either form would not dig into the playa, given the huge flotation surface. The pressure on the playa would actually be much less than wheeled vehicles. And as the floor is solid and the beast is moving in inches per minute, not miles per hour, there would be almost zero dust. Also, stepping on and off the mechabolic would have no vertical elevation change, which would be interesting. The digestive/respirative "walk through" would be on the belly on the ground essentially.

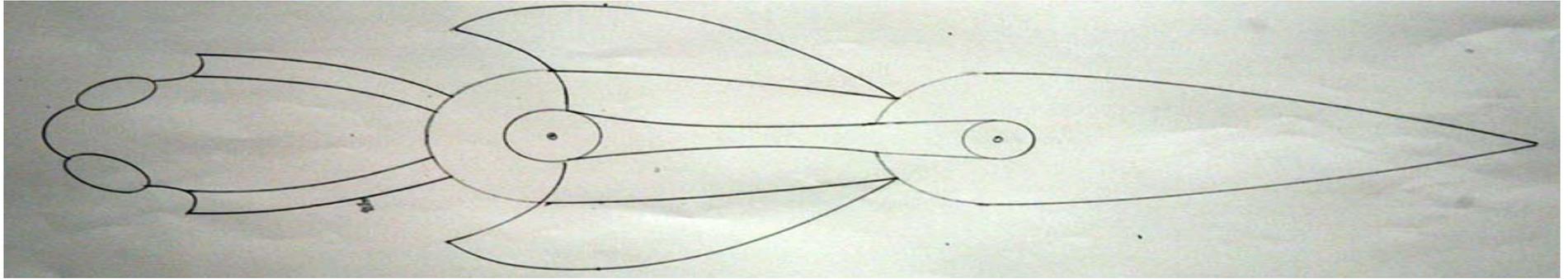
Maybe we could come up with a path for it to follow over the week. Make about one playa crossing each day, so it is "installed" somewhere different each night. Maybe do a winding path from keyhole to trash fence, leaving a "slime trail" behind it, in the shape of a gigantic "small intestine". Well actually, that wouldn't work, as the trail would disappear in minutes from foot traffic. But still, it would kinda work.

I can slide a 20,000lb container building with my big forklift, riding only on sharp corners. So a tracked Caterpillar D-6 or so would surely pull 30,000 lbs of perfectly flat steel and sculptural curiosities across the playa. But quantitative modeling, as well as on site testing early in the project, would surely be needed before committing to this scenario and planning/building accordingly.

So in summary, it would be great if we could make it move, as animals move to scavenge for their food. But such is not a prerequisite for the project to be successful. The project can work well in either a stationary or mobile form. We can discuss and develop each scenario in more detail as we progress here.







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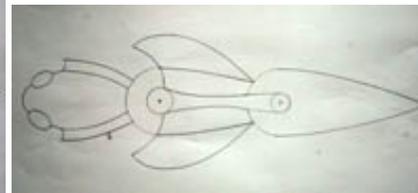
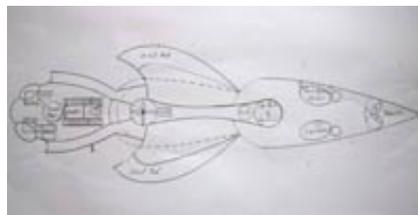
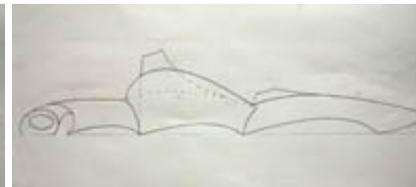
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### V5.0 Current Designs

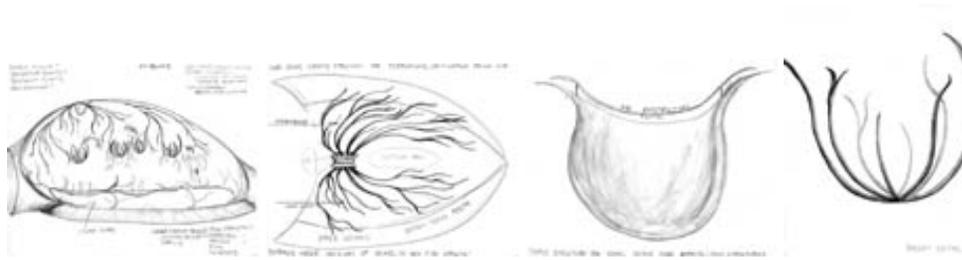
#### Mobile slithering version (drawings by Dann Davis)

Body made from hoop and stretched cloth. Side exposed lung terrariums made from inflatables with sculptural steel superstructure. Articulating steel sectioned floor with integral caterpillar tractor for pulling.



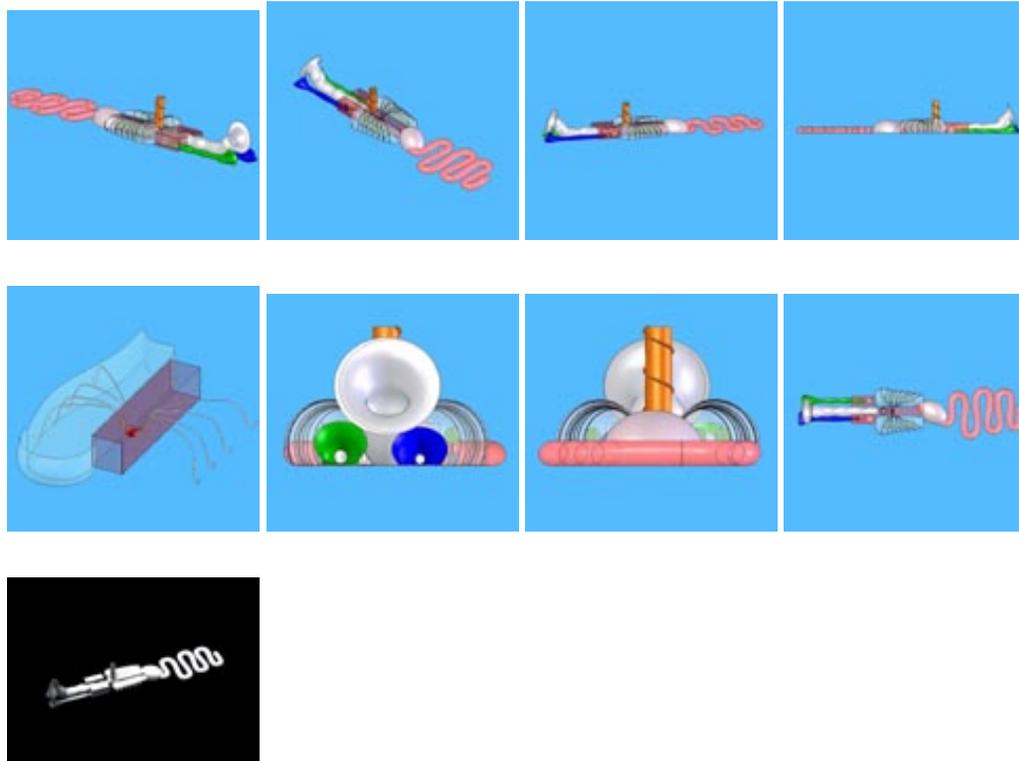
#### Internals of V-8 Lung Terrarium (drawings by Jess Hobbs)

Drawings of the clear lung terrarium plants, fire flower sculpture and walkway. The superstructure is formed by a steel sculpture in the form of branching veins. Both plants and flower fire sculptures hang from above.



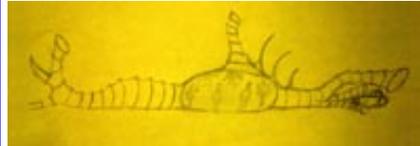
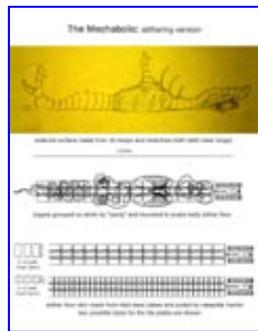
**V4.0 Stationary installation version, now deprecated** (renderings by John Devenezia)

Organ body made from hoop/stretched cloth and inflatables . Side exposed lung terrariums made from inflatables with sculptural steel superstructure. Shipping containers used for base structural and logistical units



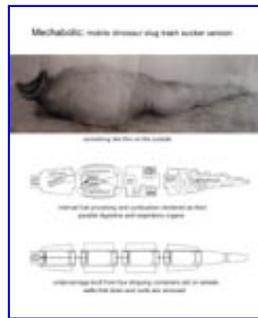
**V3.0 First slithering design.** (depracated)

Tiled steel snake scale belly. Hoop and stretched cloth stucture. Exposed lung terrariums.



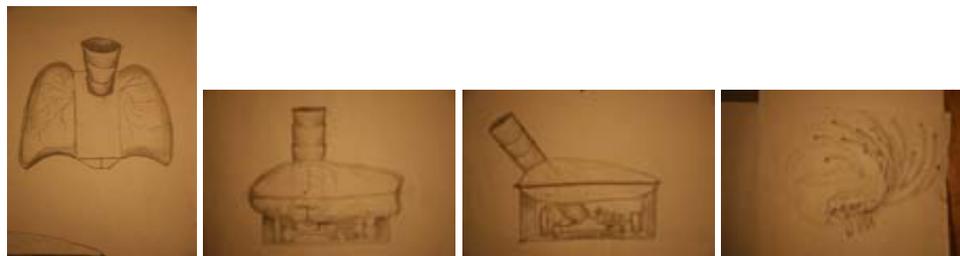
### V2.0 First mobile design. (depracated)

Dinosaur slug on on multiple wheeled trailers made from shipping containers.

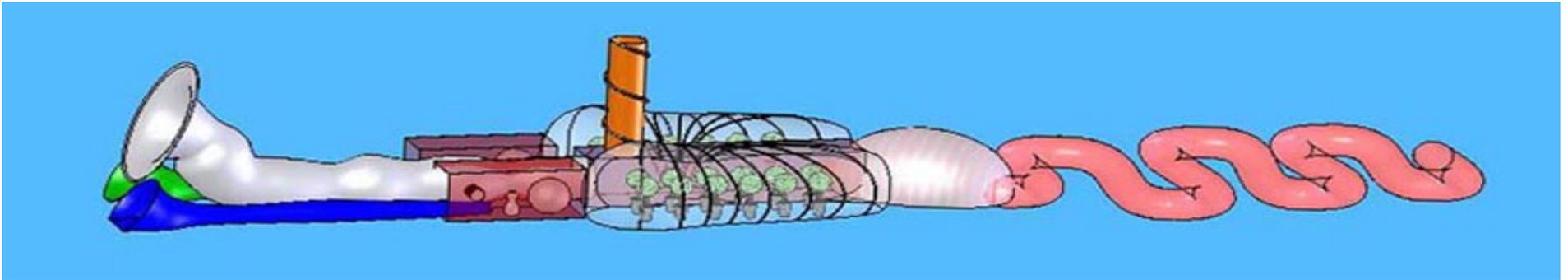


### V1.0 First renderings of bio elaborated engine and flamethrower. (depracated)

Early studies for re-rendering the old ICP V40 plan as biological organs. These drawings were still working with the 5 separate propeller wind pods to make a large overhead vortex. This has been abandoned in the current proposal







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The Mechabolic is obviously a very large and ambitious project. It is Belgium waffle, Serpent Mother, or La Contessa in scale and difficulty. It is much too big for any single individual to shoulder, or really any single core group of people.

We therefore have are conceiving of the project as having three separate fronts, each lead by a different individual over a different group of collaborators. A full time project manager will coordinate between the three sub-groups and orchestrate all project logistics. The three areas and leaders are as follows:

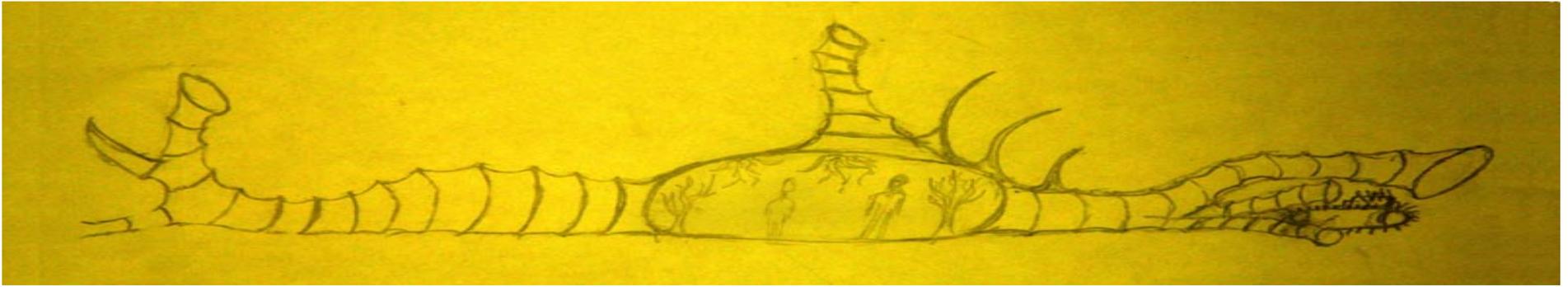
1. Biomass alt fuel processing and combustion technology: Jim Mason
2. Creature sculpture and mobility mechanics: Dann Davis and Michael Christian
3. Gasifier work shops, educational outreach, and fuel collecting on playa: Chicken John

Project Manager: Babalou

Other main collaborators to date are:

Dov Jelen and Kiko Almund: Liquifaction Tech  
Jess Hobbs and Brandi Hugo: Orchid Lung Terrariums  
Peef Sadow: Embedded Control and Automation of Gasifiers  
Jae Rhim Lee: Digestion  
Darrel Licks: Fabrication  
Peter Durand: Regional Outreach

Lots of volunteer minions are already interested, and many more will be genetically engineered and grown in large number very soon.



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details coming soon. see current info in "overview" and "physical specifics" sections.

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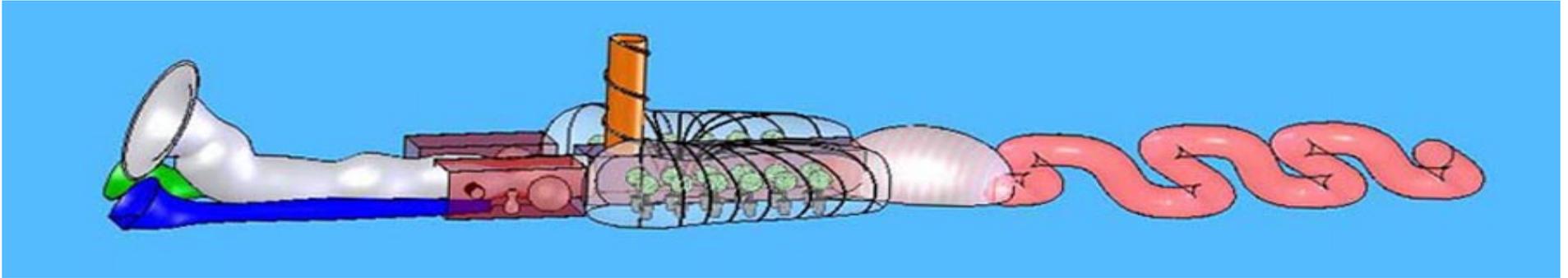
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The Mechabolic is a broad collaborative project, bringing together a variety of local provocateurs, who share the goal of artistically recasting the technology and cultural associations of alternative energy scenarios.

Where energy has usually been assumed to be a zero sum game of background "need fulfillment", we intend to recast it as an idiom rich in opportunities for creative self-expression, social discourse, and general sensual pleasure. Where currently we hear of only a massive and unyielding technological problem, a problem that seems to require near impossible "salvatory" gestures from centers of governmental and corporate power, we intend to show there are very compelling human rewards and good leverage over the larger energy problem using the social strategies of participatory creativity, diy improvisation, and general open source doing.

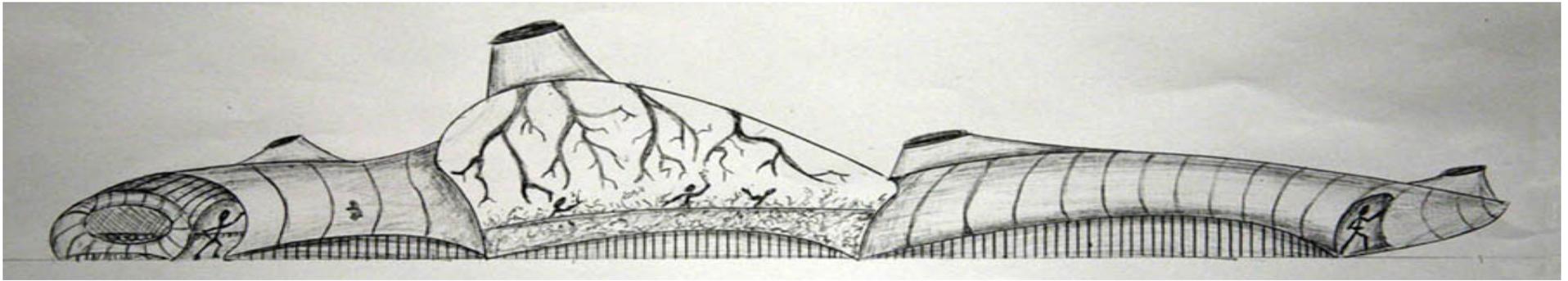
Through the thoughtful application of "participatory creative work" to the larger energy conversation, we hope to clarify the liabilities of the current "central broadcast and distributed consumption" model of energy, as well as demonstrate the multi-modal rewards that will flow in a world where power is reckoned over a "network" model of distributed production and consumption, with bi-directional exchange, learning and play.

Many simple technologies are currently available to make each of us both producers and consumers of power. Those who set out on the path of creative power hacking, usually quickly find themselves more broadly engaged with the larger planetary metabolism as both authors and deep readers. And in doing so, such individuals nearly always find themselves in direct experience with and meaningful relationship to the systems and sensualities of both the natural and synthetic world.

The Mechabolic project will be exploring and exposing the problem and potentials of energy as exactly this sort of sensual and imaginative journey.

(see also, "The [Mechabolic Thesis](#)")





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available on request

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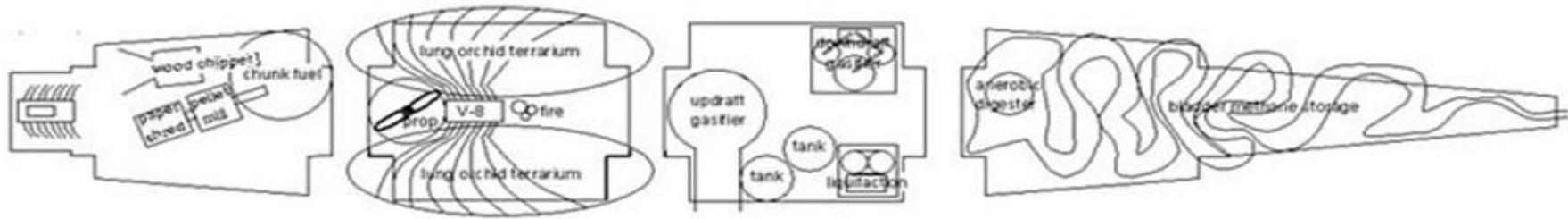
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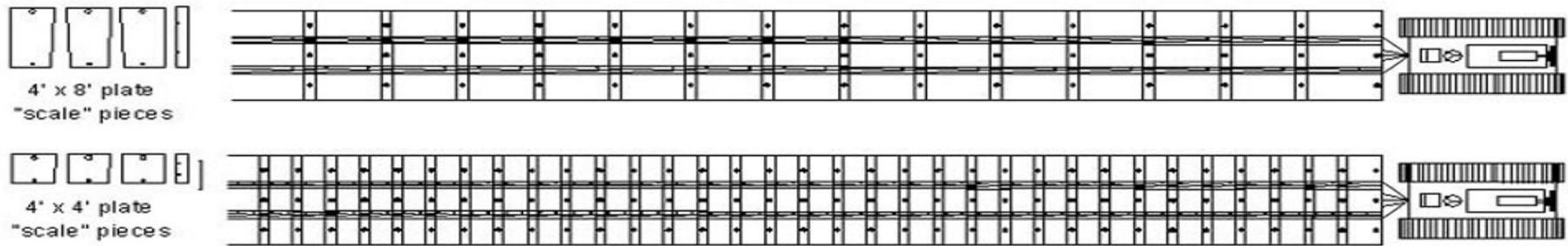
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### October - January: Exploration

- review gasification literature in full (done)
- establish relationships in DIY gasification circles (done)
- start prototyping DIY gasification systems at shipyard (done)
- identify potential collaborators (done)

### February: Project Conceptualization

- finalize core collaborators for project (done)
- finalize project scope and plan (done)
- continue prototyping gasification systems (done)
- build 1:30 (4 foot) model of the creature and experiment (second half of February)
- set up project bank account and quick books accounting system

### March: Prototyping, Research and Purchasing

- build 1:6 (20 foot) model of creature and experiment
- finalize design for creature
- purchase and test various materials for creature and organ skins
- finalize design for DIY gasification system ofr art cars
- prototype Fischer Tropsch liquifaction and digestion systems
- research major machine purchases (wood chipper, paper shredder, pellet mill, dragster engine, tanks, bladders)
- explore different locomotion scenarios and test prototypes
- make final decision on whether creature will be mobile or stationary
- start weekly project meetings

- start assembling wider circle of project volunteers
- explore donations for all major components

#### **April: Prototyping Purchasing, Construction and Workshops**

- finalize design for all gasification, liquifaction and digestion systems
- attempt donations for all major components
- purchase all major machines for creature (wood chipper, paper shredder, pellet mill, dragster engine, tanks, bladders, pyro parts)
- purchase all major materials to construct creature (steel, fabrics, plumbing, hardware)
- start "Power Exchange" monthly workshops to build gasifiers for art cars
- start construction on creature
- start construction of all gasification, digestion, and liquifaction systems

#### **May: Construction, Workshops and Fundraising**

- continue construction of creature
- continue construction of all gasification, digestion, and liquifaction systems
- continue "Power Exchange" monthly workshops to build gasifiers for art cars
- start construction of pyro effects
- start assembly of terrarium and plants
- start fundraising

#### **June: Continue Construction, Workshops and Fundraising**

- continue construction of creature
- continue construction of all gasification, digestion, and liquifaction systems
- continue "Power Exchange" monthly workshops to build gasifiers for art cars
- continue construction of pyro effects
- continue assembly of terrarium and plants
- continue fundraising

#### **July: Finish Construction and start desert Logistics**

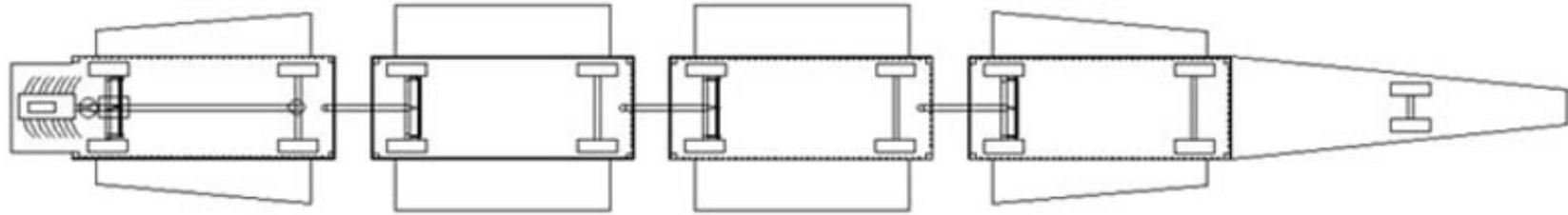
- finish construction of creature
- finish construction of all digestive and respiratory systems
- finish construction of pyro effects
- finish assembly of terrarium and plants
- organize transport to and from desert
- finalize containerization of all components
- continue "Power Exchange" monthly workshops to build gasifiers for art cars

### **August: Deal with Problems, Sleep, Go to Desert**

- continue "Power Exchange" monthly workshops to build gasifiers for art cars
- fix what isn't working
- break things that are working, then fix them too
- make every attempt and plan so there is no binge over-the-top work marathons in august
- arrive in the desert relaxed and refreshed on Sunday, August 10. go to hot springs

### **Set up on desert**

- Monday, Aug 20: unload containers
  
- Tuesday, Aug 21: set up skid floors
  
- Wednesday, Aug 22: : install main machinery components and planter beds on skid floor
  
- Thursday, Aug 23: erect hoop and wire mesh skin. erect terrarium sculpture and skin. this is a precut and configured post and cloth stretch type structure. somewhat like putting up a shade structure.
  
- Friday, Aug 24: plumbing and wiring bundle hookup. all prepared and plug type. no onsite hard plumbing or wiring.
  
- Saturday, Aug 25: finish details.
  
- Sunday, Aug 26: finish details.
  
- Monday, Aug 27: open for interaction.



## The Mechabolic: Clean Up *(and its relation to set up)*

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The Mechabolic will be a containerized installation to the greatest extent possible. We are planning this project in a manner so that it will survive in usable forms for future contexts, Burning Man related and otherwise. We are therefore avoiding "loose part" on-site builds wherever possible.

All creature organs and processes will be self-contained, modular units, either skidded on container floors, or skidded on custom platforms, sized for easy fit inside a standard shipping container. Similarly, all superstructure and locomotion items will be designed and fabricated for easy containerization. We intend to make all Mechabolic components to fit into two 40' containers, Russian Doll style. And do so with each module still assembled, allowing for easy individual module demonstration in future contexts, without having to rebuild the entire installation from scratch.

This containerization strategy was the original motivation for the container based Shipyard art/build facility. Following the very painful "stuff everywhere and always in pieces" nature of the stock puppets, I decided that i would never build another large art project except in a manner that it could be easily stored and transported in shipping containers. No rented box trucks filled to the rafters with a million loose parts, all ending up as a dusty rusty pile in your shop the following winter. Containers allow for transport and storage in the same structure, with forklift transfer between the two modes, no loading and unloading required.

Over the ensuing years, this formula elaborated into an intention to also use the container itself as the foundation for the artwork. The shipping container as the sculpture, as the transport, as the storage. However, given our need for organic "non-square" shapes in the Mechabolic, I doubt we will be able to use containers in raw form for the organs. But skidding each organ and having it easily fork into and out of a container, assembled and ready to go, is nearly as good.

A containerized building and transport strategy will create a desert set up involving next to zero on site immaculate building. All components will arrive "pre-assembled" and only need to be set in place for a forklift and snap plumbed together. The superstructure will require more "by piece" assembly of the hoops and cloth, but all these pieces just slide into fixture "poles holes" and the cloth is stretched like a shade awning.

Likewise, this modular building strategy will make take down and clean up more of an effort of "truck loading" than object disassembly and loose part chasing.

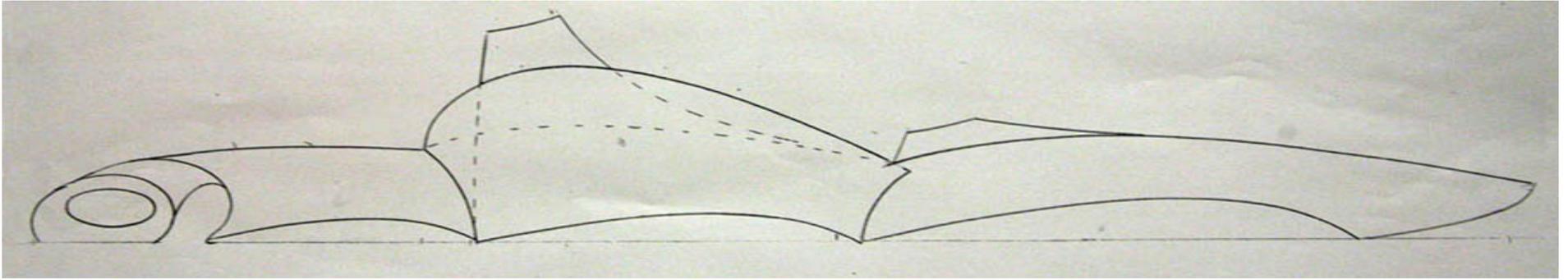
To expediate set up, maintenance and take down, we propose trucking the Shipyard forklift to the desert for the combined use of the Mechabolic, Neverwas Haul and Serpent Mother projects. The current DPW formal scheduling and "DPW only operators" make quick adjustments and fixes of unexpected problems very difficult to handle in an efficient manner. It is difficult to schedule problems and fixes, and when clear long engagements are needed, DPW equipment is often stretched between several different projects and needs to break in the middle of long projects to go tend to other needs. We therefore think it would be a good investment to have our own forklift for discretionary use, 24/7. I will offer my 15,000lb capacity forklift free of charge for use by these three projects, but request money to haul it there and back.

As for direct clean up, I believe the most important strategy is to have clear up front agreements on responsibilities, as well as publically stated "can't leave before x date" mutual understandings. Each sub project leader in the Mechabolic will have to agree to remain in the desert until the entire project is back in the containers, the site picked clean and magnet broomed, with a final walk line survey. No individual decisions that clean up is "done", and it is ok to leave now because the person is tired. All the project leaders have to stay until we can all sign off on the clean up effort together.

Trash at the end should be a non-issue, as the Mechabolic eats trash for its food/fuel. The only real expected "discard" is the charash byproduct of gasification, which we will use for terra preta fertilizer in the lung terrariums. After the event, we want to leave this fertilizer for a local agricultural use, where the charash carbon will be sequestered by the plow and transformed into fuel for the next crop, not released as methane, nitrous oxide and CO2 during rotting, as would have otherwise happened had the original trash just gone to the dump.

Completing the biomass cycle in this manner, the Mechabolic project will operate with a quantifiable green house gas NEGATIVE footprint. The total Mechabolic effort will remove more CO2 and other greenhouse gases from the atmosphere than it will emit through powering itself and its fire efforts. Such is the real and interesting "clean up" that the Mechabolic project will bring to the desert this year.

The thoughtful burning of things through gasification, is very different than the regular burning of things through open combustion.



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## **Contact Info:**

jimmason@whatiamupto.com

The Shipyard

1010 Murray Street

Berkeley, CA 94710

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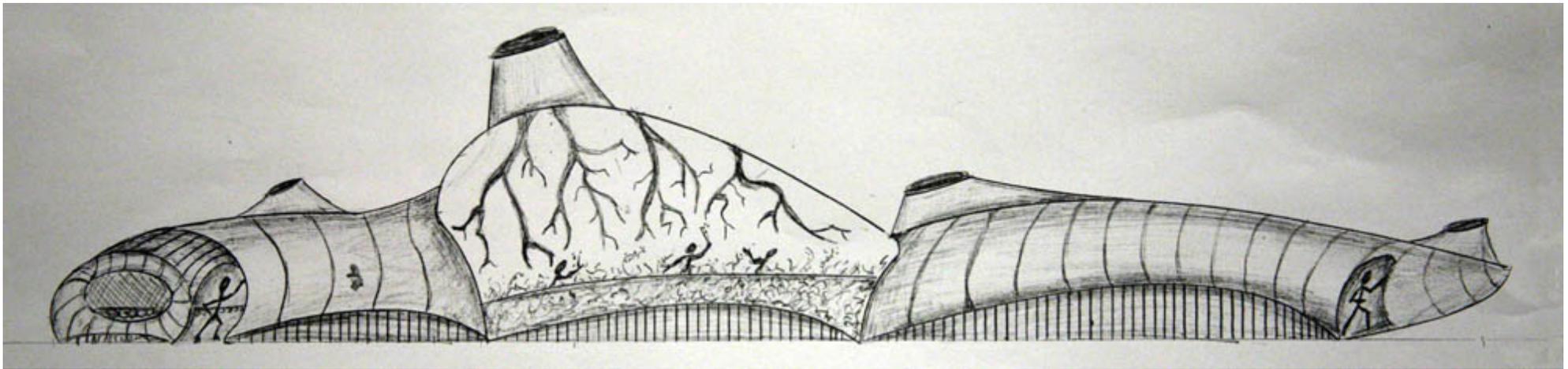
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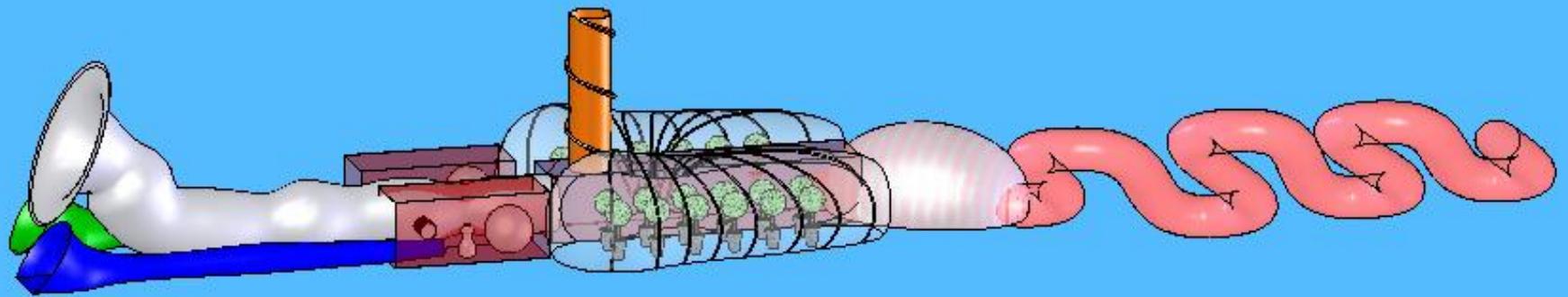
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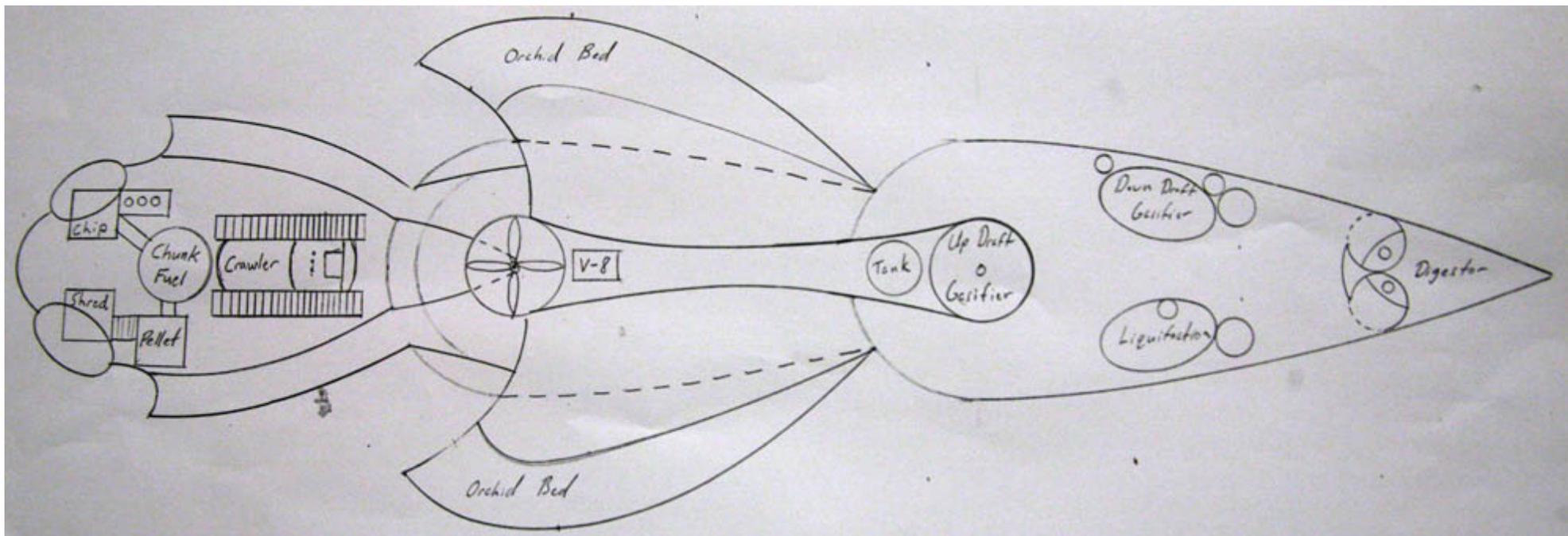
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**Welcome to the Biomass Energy Foundation (BEF) website**, here since 1997. We are interested and knowledgeable about all aspects of biomass energy, but particularly in high temperature conversion and gasification that can produce heat, power and fuels, as oil prices escalate. This site ([www.woodgas.com](http://www.woodgas.com)) was developed by Dr. Tom Reed, a well-known scientist. Dr. Reed has served as a professor at MIT (Massachusetts Institute of Technology) and at the Colorado School of Mines. His career also includes research work with the National Renewable Energy Lab (NREL) in Golden, Colorado.

Dr. Reed now works out of several private labs, also located in Golden, which operate in part under the name of "**The Biomass Energy Foundation.**" We have a separate **website** for the Foundation, which describes our current research projects and accepts financial support through memberships. We hope you will visit that **site** as well, and consider becoming a member!

## **GREAT NEWS!**

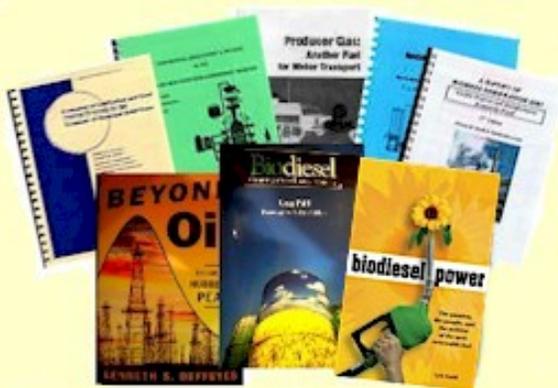
**Our manufacturer has now added a new "Big Brother" WoodGasXL stove that burns twice as long and provides 20% more heat where small size is not so**

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**It always has been, and remains, our intention to keep the prices of our merchandise as reasonable as possible. In fact, we have not changed the prices of our books (with the exception of number 16) in several years. However, in part because we are a small foundation and because "nonprofit" does not mean "go broke," we are forced by increased printing costs and higher U.S. Postal Service charges finally to increase our prices. So, starting May 1, 2008, most of the prices for our merchandise are slightly higher. At least one price, however, is lower!**



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## **Now, on to Tom Reed's wildly popular and informative Woodgas site...!**

The World has been developing "Alternative Energy" - Solar, Wind, Geothermal etc. for 35 years since the first oil embargo. While these have niche applications, they are not fuels. They are intermittent, costly and unlikely to replace more than 10% of our current fossil fuel needs.

Alternative Energy Sources are a RED HERRING tolerated to divert our attention from our real needs. Oil is a fuel and its products can be used anywhere, anytime. The era of "cheap oil" is over and now we need to find ALTERNATIVE FUELS (not alternative energy).

Oil prices are rising and availability falling. I expect prices to at least double every 5 years. This will make a profound difference to our Civilization. Our Earth would be far beyond its carrying capacity for Humans if it weren't for cheap oil. We hear a lot about substituting "alternate energy". We aren't running out of energy - we are running out of "cheap oil", and need to find an "alternate fuel source"...

Our green earth is already covered with plants and trees busily converting sunlight to biomass products and fuel. All we need to do is learn how to use the fuel fraction, mostly wasted today. See our page on [Biomass Energy](#) for details.

While we have deplored the "hydrogen economy" as a red herring for practical energy, the WoodGas made by well known technology has a high concentration of hydrogen and is VERY clean burning. So, we have been using and promoting "hydrogen rich gas" as an alternate name for the "producer gas" made from wood and coal. We are now also involved in reforming liquid fuels to a hydrogen rich gas.

**"Woodgas"** is my nickname for the gases that can be made from wood, other biomass and waste for heat, power and synthesis of ammonia and fuel. (It is also called "producer gas", "synthesis gas" etc.). I have worked in this field since the first

OPEC oil embargo in 1973 when I began experimenting with methanol as a gasoline additive and oil supplement.

Hydrogen is both the best of fuels (because it burns fast and clean) and the worst of fuels (because it is difficult to ship and store, because it must be made from other fuels, preferably at the point of use). However, it constitutes about half the fuel value of most practical fuels, so making it from wood and biomass is a proven technology. Probably your grandmother cooked on a hydrogen rich gas stove and didn't even know it.

Here is a greatly oversimplified animation of a wood gasification system made by my grandson, Drew Reed (Senior at UC Santa Barbara). (If a picture is worth a thousand words, for processes an animation is worth a thousand pictures.)

*The animation above is our first attempt to show what happens inside a gasifier running an engine. The air and fuel are fed in at the top, they meet a rising "flaming pyrolysis" flame front and are converted to gas and charcoal, which is consumed making more gas. The gas is sucked out at the right along with spent char-ash particles. We are working on a more detailed animation, but this gives a good general idea.*

## **Site News**

*We are including an "Energy Rosetta Stone" that converts our obsolete energy units*

*to a common well understood unit, the kWhr (either thermal or electrical). Now we can compare apples and oranges on the same basis.*

## The Energy Rosetta Stone



The Rosetta Stone enabled scholars to decipher the Hieroglyphics of Ancient Egypt into modern Greek and English.

Our **Rosetta Stone Energy table** enables anyone to translate the obscure energy units we now use into the commonly understood kilowatts.

## LIQUID FUELS

The first energy OPEC crisis of 1973 was all about oil, a source of liquid fuels. We responded by looking for alternate energy forms such as wind and solar, all well and good, but not fuels. We formed a Department of Energy, DOE, but it should have been a Department of fuels.

In 1974 I was embroiled in a controversy at MIT with the oil and motor companies over the use of methanol as an alternative fuel. They won! As a result we have paid higher prices for foreign oil and funded the terrorism that has taken a million lives, culminating in 9/11 in the U.S. Check it out at **METHANOL**.

Now methanol has become even more important because one gallon of methanol can make ten gallons of biodiesel, a superior replacement for petroleum diesel. Here at the Biomass Energy Foundation we were the first to make and demonstrate biodiesel from waste vegetable oil (yellow grease). If you would like to make a little biodiesel in the kitchen, see our new recipe at **Biodiesel in the Kitchen**.

Three billion people in the world cook slowly on smoky, inefficient **woodfires**. We have developed two novel "**WoodGas CampStoves**" that we believe far exceed the

performance of any other biomass cooking device because it first turns the wood to gas, and then burns the gas with the correct amount of air. They put out up to 3 and 6 kW of heat (3kW is comparable to the big element on an electric stove). They burn only 10 and 20 g of fuel/min (40% efficient). While they can be used indoors with minimal emissions, we recommend that all cooking be done outdoors or under a hood.. We hope similar designs will be used in developing countries where the need is greater, but we are developing our product first in the U.S., so we have developed a company to manufacture, market and distribute the stove.

We believe that these stoves will have a much wider application in the developing countries of the world. See our WoodGas Stove page for other information about WoodGas stoves. We hope to see a billion of these stoves in use in the next the next few decades.

We have re-issued our 3 volume "**Survey of Biomass Gasification**" from 1980 as a one volume "Encyclopedia of Biomass Thermal Conversion". The National Renewable Energy Lab, (SERI then, NREL now) commissioned it as a prerequisite for me to build gasifiers. It contains chapters by various experts on many aspects of thermal conversion and other aspects of biomass for energy. I wish there were something more current that covers all aspects of biomass, but this is the best to date. See this and our other books on gasification and biomass in the **BEF BOOKSTORE**.

---

## **SITE OVERVIEW**

**Biomass Energy** is the oldest, most widespread and practical form of renewable energy. The residues from agriculture and forestry could provide 20% of U.S. energy. Biomass has been a major concern of mine since 1974, the first "energy crisis". This page has lots of information on the properties and availability of biomass in its many forms, particularly **moisture content**, **fuel densities**, and the **biomass analyses** and

energy content.

BIOMASS **Gasification** turns biomass into a more useful form, WoodGas.

"WoodGas" is my nickname for gas produced from biomass for heat, power and synthetic fuel applications. During World War II, over a million vehicles, boats etc. ran on Woodgas. (See **History** of Woodgas). While I have written a number of articles and books on all aspects of gasification, my specialty has been **small gasifiers** for power, transportation and cooking.

**Liquid Fuels** and chemicals can also be produced from biomass and as petroleum runs out we will increasingly turn to biomass as a renewable resource. I am chemical engineer and have worked toward oil replacement fuels for 28 years (for the future fuel security of my grandchildren and the rest of us.) Lots going on in this field today.

**Cookstoves** consume most of the biomass in developing countries, often wastefully with terrible health effects. We cook now much better with propane or natural gas, but this requires infrastructure not available for half the world. A great deal of research is in progress to improve world stoves, see **Cookstoves**.

Reliable **BOOKS** on biomass energy are difficult to find. We have written some of them, edited others and are choosy about what we publish. The Biomass Energy Foundation Press publishes 20+ books on biomass energy and related subjects and you can order them online, by mail, fax or phone. You can buy our books at our online **BEF store**.

The Biomass Energy Foundation, the BEF is a 501-C-3 non-profit organization. Founded by the flamboyant and fascinating Dr. Harry LaFontaine, now deceased. It is currently operated by Dr. Tom Reed and his wife Vivian. Find out about the **History** and **Current Research** of the BEF. Finally, we have links to other sites that will give you more information on biomass energy.

This Website combines two previous websites and has more content and advanced

features. We would appreciate your comments either on the site itself or its contents.

Contacts: **tombreed@comcast.net**

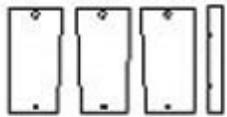
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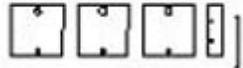
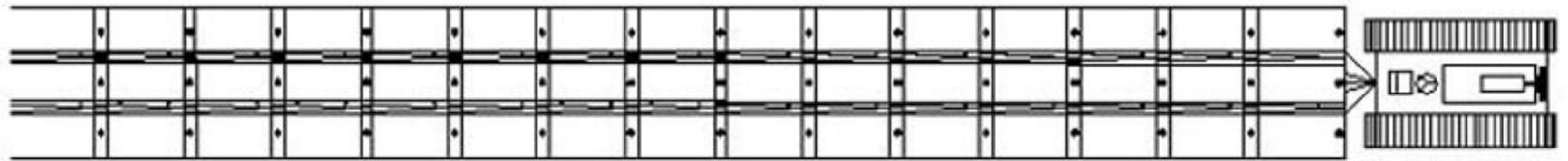
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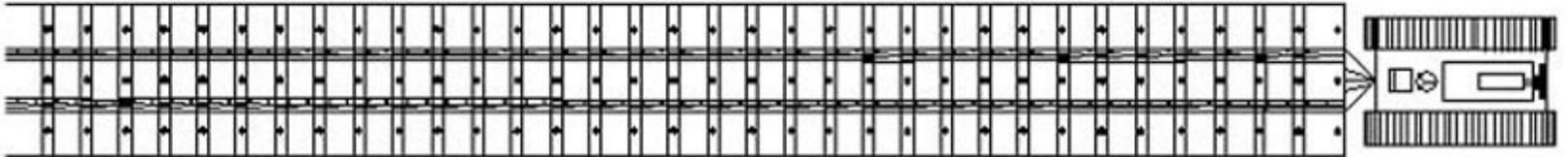
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4' x 8' plate  
"scale" pieces



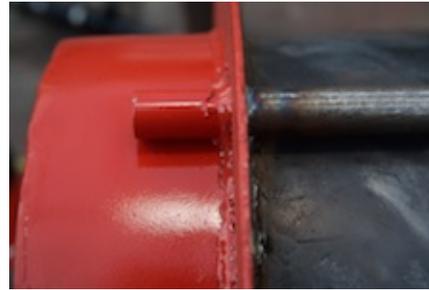
4' x 4' plate  
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A Lego Set for Experimentation





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Vessel  
Tubes,  
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- Caption:  
All  
Vessel  
Tubes,  
Flanges  
and End  
Plates



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- Caption:  
Hopper  
Tube  
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Flanges





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- [Caption:  
Gas  
Cowling  
Tube,  
Flange,  
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Plate](#)





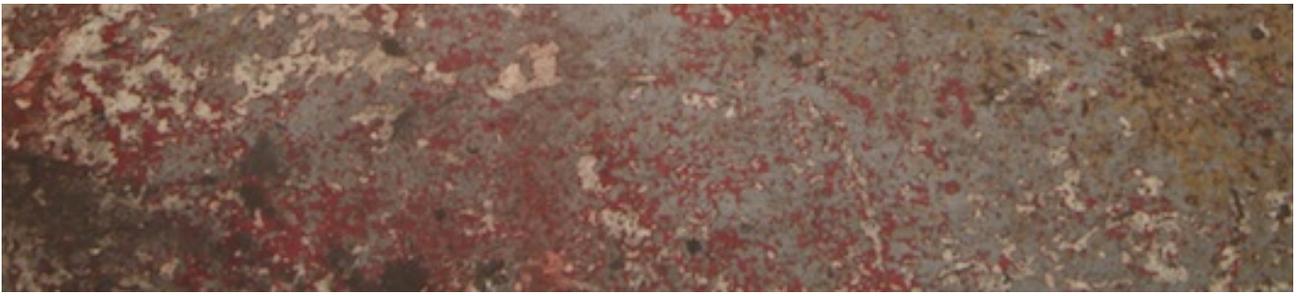
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- Caption:  
Downdraft  
Reactor  
Tubes,  
Flanges,  
End  
Plates, and  
Reduction  
Bell Weld  
Rings





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- [Caption:  
Cyclone  
Tube  
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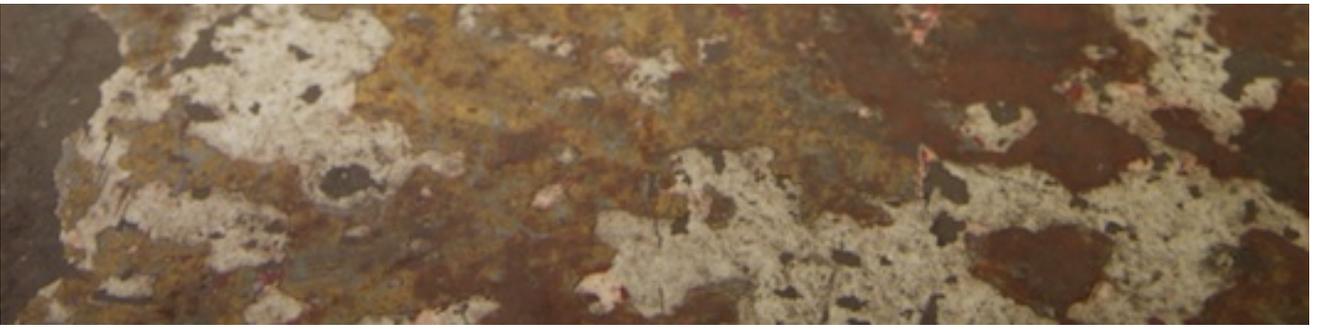
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- Caption:  
Swirl  
Burner  
Tube  
and End  
Plate





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- Caption:  
All  
Vessel  
Tubes



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- Caption:  
All  
Flanges  
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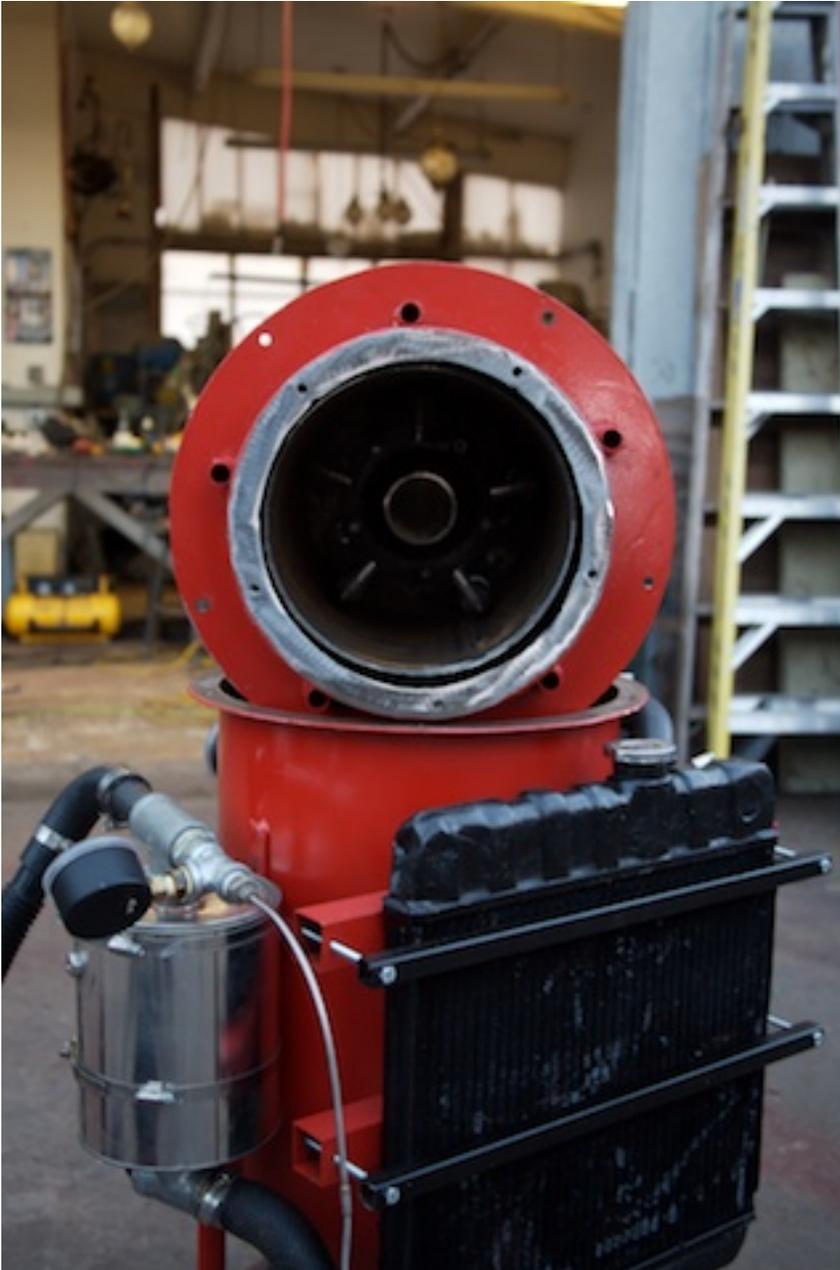


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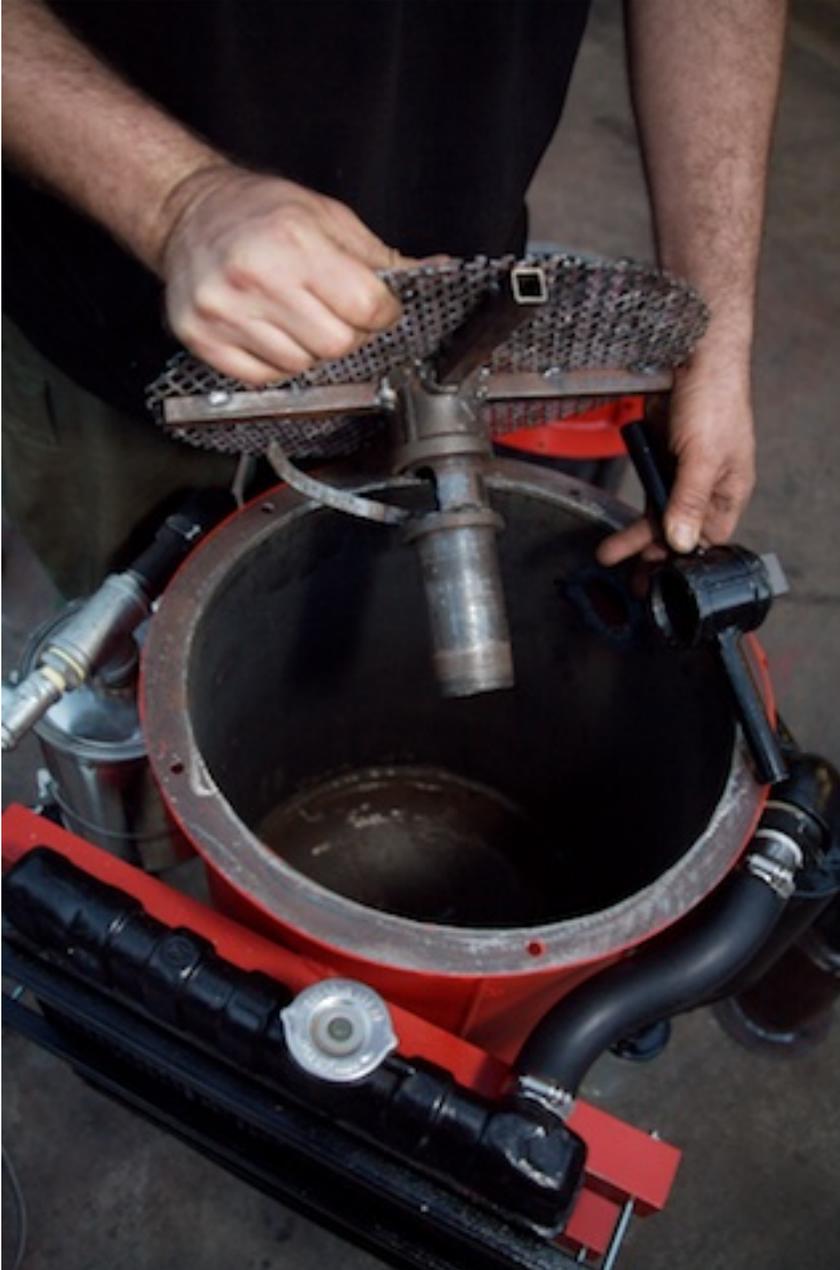
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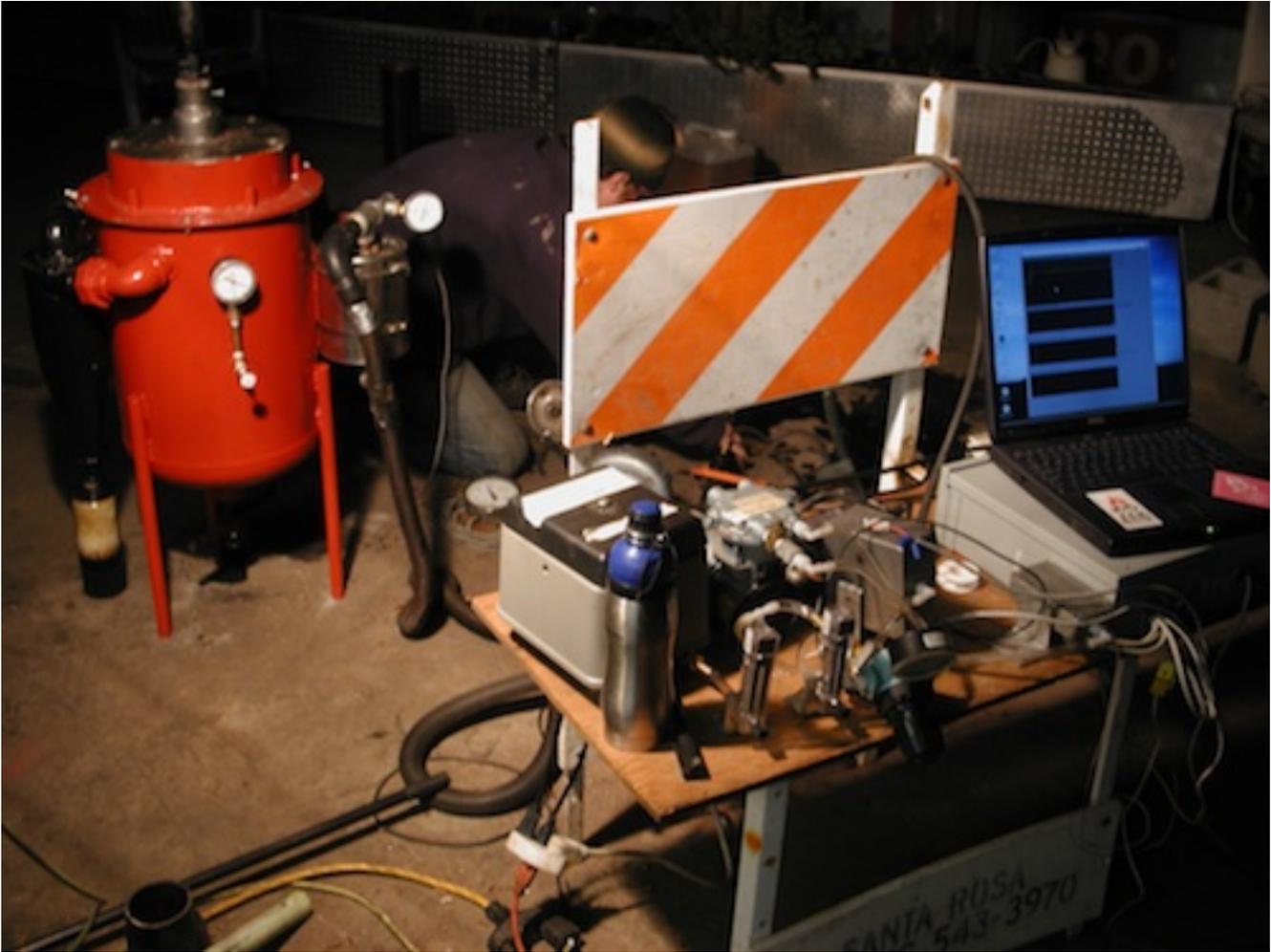
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# WOODGAS

## BIOMASS ENERGY

### BIOMASS - THE ONLY RENEWABLE FUEL

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- Gasification & Reforming
- Liquid Fuels
- Wood Cooking
- Energy Rosetta Stone
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The name "Biomass" was invented about 1975 to describe natural materials used as energy sources. The Office of Technology Assessment ([OTA](#)) estimated in 1980 that biomass could potentially supply more than 20% of US energy requirements - if we were serious about energy independence (we're not, since oil and oil profits are international). Biomass now supplies 3% of US energy (see [EIA](#) and their [table](#) of biomass consumption).

While biomass is one of the best forms of renewable energy, it is not a great fuel. It occurs in a wide variety of forms



Truck unloading wood chips

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(wood, paper, trash, ...).

This can be reduced by **densification**

(pelletization) to a uniform fungible fuel that can be easily shipped, stored and used.

Biomass varies widely in both mass and volume fuel density. It varies in chemical composition and the **proximate/ultimate analysis** gives records this data. It often has high **water content**, and the different methods of recording and measuring MC can be confusing.

While biomass can be used directly (mostly in wood fires), it can be converted to higher forms of fuels. Biomass is converted to various fuel forms in thermal (combustion, pyrolysis and gasification) processes and biological (fermentation and digestion) processes. **Click here** for a road map to all the various biomass conversion processes.

Probably most of you were exposed to chemistry in high school and promptly forgot it. The chemistry of biomass and other conversion processes is very simple, involving primarily carbon, C, hydrogen, H and oxygen, O. A brief explanation is given here in terms of a "**Ternary diagram**" of fuels which will help to keep the chemistry of fuels straight in your minds.

Air Fuel Ratios for biomass pyrolysis, gasification and combustion:

Air is the primary requirement for these thermal reactions

of biomass, and adjusting to the correct air fuel ratio has given us incredibly clean cars in the last 20 years. **This diagram shows the air-fuel ratios for pyrolysis, gasification and combustion of biomass.**

This website is devoted primarily to biomass gasification, the primary business and pleasure of Tom Reed over the last 3 decades. However, all combustion and gasification processes must pass through pyrolysis at low temperature, so there is a lot of information here about pyrolysis and combustion as well.

Biomass fuels are characterized by what is called the "Proximate and Ultimate analyses". They can be burned directly for heat or to make steam for power. The "proximate" analysis gives moisture content, volatile content (when heated to 950 C), the free carbon remaining at that point, the ash (mineral) in the sample and the high heating value (HHV) based on the complete combustion of the sample to carbon dioxide and liquid water. (The low



One inch birch dowell  
pyrolysing at 600C

heating value, LHV, gives the heat released when the hydrogen is burned to gaseous water, corresponding to most heating applications.)

The "ultimate" analysis" gives the composition of the biomass in wt% of carbon, hydrogen and oxygen (the major components) as well as sulfur and nitrogen (if any).

The attached table of **Proximate and Ultimate analyses** is from Appendix A of our book<sup>1</sup>, and gives analyses of over 140 fuels, including biomass components, natural biomass (woods, agricultural products), processed biomass, other solid and liquid fuels.

(1) "Thermal Data for Natural and Synthetic Fuels", S. Gaur and T. Reed, Marcel Dekker, 1998.





## BIOMASS GASIFICATION

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Biomass Gasification is a very old art ... and there isn't enough science in it, but we're working on that here at BEF and other places. Visit our Biomass Books to learn most of what is currently known about about wood and other biomass gasification, and what you can do with the gas. Lots of practice, lots of science, some gasifier plans and other related subjects there. Visit our [History](#) page for a quick overview of

*The animation above is our first attempt to show what happens inside a gasifier running an engine. The air and fuel are fed in at the top, they meet a rising "flaming pyrolysis" flame front and are converted to gas and charcoal, which is consumed making more gas. The gas is sucked out at the right along with spent char-ash particles. We are working on a more detailed animation, but this gives a good general idea.*

gasification.

Tom Reed has been working in this field since the first energy crisis in 1974 and knows all the names that have been used for the gases produced by various processes. However, in his casual conversation, he calls it "WOODGAS", a term easily understood and acknowledging the first renewable source, wood since >100,000 years ago. So he has chosen this for the name of this renewable energy web site. In practice it includes gas from agricultural and forest residues and

even  
Municipal  
Solid Waste  
as well,  
though these  
materials are  
harder to  
gasify.

Briefly  
biomass can  
be gasified  
pyrolytically by  
heating to  
>400 C,  
yielding also  
25% charcoal  
and LOTS of  
condensibles -  
tars). Or it can  
be gasified  
with air to  
make  
"producer gas"  
(typically CO  
22%; H<sub>2</sub> 18%;  
CH<sub>4</sub> 3%, CO<sub>2</sub>  
6% and N<sub>2</sub>  
51%). During  
World War II  
there were  
over a million  
small gasifiers  
running cars,  
trucks, boats  
and buses  
(see  
**HISTORY**).  
OR it can be  
gasified with  
oxygen to  
make  
synthesis gas

(typically 40% CO, 40% H<sub>2</sub>, 3% CH<sub>4</sub> and 17% CO<sub>2</sub>, dry basis) which can be used to make methanol, ammonia and diesel fuel with known commercial catalytic processes. I expect that gasification will be even more useful in the future as we deplete our low cost fossil fuels. For more on this, visit **SYNTHETIC FUELS**.

I have been particularly interested in **small gasifiers** for distributed power, cookstoves or transportation. Visit that site if you are interested in kW rather than MW.

**Database**

The book, "A SURVEY OF BIOMASS GASIFICATION-2001", was written for the National Renewable Energy Laboratory, NREL by T. B. Reed and S. Gaus. It has now been published by the BEF PRESS. It contains (Chapter 2) a database of gasifiers. Please visit the [DATABASE](#) page to see large gasifier systems, small gasifiers and gasifier equipment manufacturers in the table. The database was created in MS Access and can be downloaded and viewed there or in MS Excel or other spreadsheets.

The database is included in our recent book "[A Survey of Biomass Gasification - 2000](#)" (available from the Biomass Energy Press, see order blank) which also discusses the various technologies and issues in gasification.

If you wish, you can search the database for a particular item (using Control F for find). Or, you can download it and use it in your own computer if you will have continual need to refer to it. (Select the table with Control-A and copy with Control-C, then insert in a spreadsheet or database with Control-V).

If you are listed in the database, please examine your listing. If there is any factual mistake, please let Dr. Reed know at [tombreed@comcast.net](mailto:tombreed@comcast.net) and he will fix it. If you would like to be listed, send the data to Dr. Reed by Email so he can transfer it to the database. We hope you find this information useful.

### [Database](#)



# WOODGAS

## LIQUID FUELS

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Currently (2002) we obtain over 80% of world energy from petroleum, our "birthright" gift from Mother Nature.

Predictions differ as to when world petroleum production will peak and then start to decline. Some say as early as 2008; others pooh pooh this and act as if tar oil shale, sands, bitumen and other ucky stuff will prolong the oil age (but at ever increasing prices) through their lifetimes and that seems to be all they care about. If you think we have plenty of time to develop alternate fuels, check out the time of peak oil production and other links at "[Oil](#)".

I have 4 children and 7 grandchildren (not to mention the rest of you) who will also need liquid fuels, so I have been motivated for 25 years to find alternate, renewable fuels. Unfortunately, the oil companies are not motivated to encourage any competition from alternative fuels. Read how they killed [methanol](#) in 1974.

Some liquid fuels (ethanol) are made by biological processes, slow with lots of water. They are currently not competitive with oil except with subsidies. Others (synthetic methanol, Fischer Tropsch diesel) are made by [gasification](#) of organic energy sources (biomass, coal and natural and landfill gas) and conversion to liquid fuel.

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In 1973 (the year of the first OPEC Fuel Crisis) I began testing methanol as an alternative fuel with great success in 10% blends with gasoline in 10 cars. I wrote an article for the journal Science "Methanol: A Versatile Fuel for Immediate Use" (Vol. 182, pp 1299, 1973) showing that methanol was the easiest alternative fuel to make by gasification and one of the best for engines and fuel cells. That article changed my life from being a material scientist at MIT to a fuel scientist at NREL, the Colorado School of Mines and now the Biomass Energy Foundation. In addition to methanol there are groups that promote "ecalene", a mixture of many alcohols that have more energy than pure methanol and are more compatible with gasoline.

I have operated my own personal cars on mixtures of 10% methanol and pure methanol. Methanol is a component today in making biodiesel which we also developed at the Colorado School of Mines in 1990.

## **OTHER ALCOHOLS**

Ethanol is currently the favored alcohol fuel in the US (from corn) and Brazil (sugar cane). But there are other alcohol choices on this page.

## **BIODIESEL**

Biodiesel is another alternate fuel, though it is not made by gasification.

## **HYDROGEN**

Hydrogen as a fuel has been much in the news lately.

This is a red herring. Hydrogen does not occur naturally and must be made from other fuels and energy sources, always with some and usually considerable loss of energy. In my view, hydrogen is being touted either by those who don't understand the source to application chain that must be in place for any new fuel to be successful, or by those who are cynically diverting the view from our current wasteful energy policies by promising pie in the sky in the future. But, if you think hydrogen may be the answer, read an **extended review** by some responsible scientists working in the field.



# WOODGAS

## WOOD COOKING

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One of the worst problem for 2-3 billion people in the world is cooking on wood fires. They cook slowly, the smoke causes glaucoma and lung diseases for the women and children, the children get burned in the fire, and they burn much too much fuel that must be gathered from greater and greater distances. Our heart bleeds for our less fortunate cousins and we believe **gasification of biomass** holds a significant part of the answer.



We became aware of this world cooking problem in 1985 on a trip to South Africa, and invented a new type of gasifier, *useful for cooking and heating stoves*. One solution to the world cooking problem is to convert wood and other biomass to gas which can then be burned cleanly in a

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**"WoodGas Stove."** After 23 years of research, testing, and finding a manufacturer, we have a WoodGas Stove that you can **buy in our store.** We hope to see a billion of these stoves in use in the next few decades.



These stoves are NOT wood stoves. They are based on gasifying the wood in the lower section with a small amount of air and then burning the gas with about 6 times as much air for clean combustion. They generate respectively 3 and 6 kW of clean heat,

The new WoodGas XL stove was tested by the Aprovecho Research Center and found to perform very well. They reported "The WoodGas XL stove met or exceeded all performance benchmarks and is hereby certified as seen below."

While most wood stoves burn stick wood, the wood gas stove can work on any reasonably dense biomass, such as sticks, twigs, woodchips, wood pellets, seeds, shells, and even coal. None of these are currently used for "wood cooking".

**See what people using Woodgas Stoves have to say about them.**

**Wood Stoves:**

Alas, most wood cooking is not done with gas, so will be

smoky and less efficient. However, there has also been a lot of progress in more conventional wood cookstoves, so be sure to check on [wood cookstoves](#). We at the BEF are peripherally involved with many groups developing these stoves and are also interested in improving them as well. We know a lot about simple stove fabrication and insulation techniques. In particular, visit the [Aprovecho](#) website, and if you are serious, consider visiting their workshops for a week in Summer, or attend their annual stove event.

We are currently working on developing a biomass cookstove for field kitchens for the army. We presume that what works there will also work for many others. Stay tuned.

Questions? Contact Dr. Tom Reed at [tombreed@comcast.net](mailto:tombreed@comcast.net)





## Energy Rosetta Stone

| FUEL                   | OLD UNITS   | NEW UNITS     | OLD UNIT COST    |                   | ENERGY COST \$/kWhr |                |             |
|------------------------|-------------|---------------|------------------|-------------------|---------------------|----------------|-------------|
|                        |             |               | Fuel (dry basis) | Conventional Unit | kWhr                | Cost/Unit      | Heat-¢/kWhr |
| <b>Electricity</b>     | kWhr        | 1             | 8¢               | 8¢                | 100%                | 8¢             |             |
| <i>(1 AA Dry Cell)</i> | <i>mAhr</i> | <i>0.0025</i> | <i>50¢</i>       | <i>20,000¢</i>    | <i>100%</i>         | <i>20,000¢</i> |             |
| <b>Natural Gas</b>     | Therm       | 29            | 80¢              | 3¢                | 30%                 | 9¢             |             |
| <b>Propane</b>         | gal         | 26            | 4\$              | 15¢               | 30%                 | 51¢            |             |
| <b>Gasoline</b>        | gal         | 35            | 3\$              | 9¢                | 20%                 | 43¢            |             |
| <b>Diesel</b>          | gal         | 41            | 3\$              | 7¢                | 30%                 | 24¢            |             |
| <b>Coal</b>            | ton         | 7033          | 20\$             | 0.3¢              | 40%                 | 0.7¢           |             |
| <b>Biomass</b>         | ton         | 4396          | 50\$             | 1.1¢              | 25%                 | 4.5¢           |             |
| <i>Sawdust</i>         |             |               |                  |                   |                     |                |             |
| <i>Pellets</i>         | <i>ton</i>  | <i>4396</i>   | <i>250\$</i>     | <i>5.7¢</i>       | <i>20%</i>          | <i>28.4¢</i>   |             |
| <i>Cordwood</i>        | <i>ton</i>  | <i>4396</i>   | <i>200\$</i>     | <i>4.5¢</i>       | <i>15%</i>          | <i>30.3¢</i>   |             |
| <i>Slash</i>           | <i>ton</i>  | <i>4396</i>   | <i>20\$</i>      | <i>0.5¢</i>       | <i>20%</i>          | <i>2.3¢</i>    |             |
| <i>Tipping</i>         | <i>ton</i>  | <i>4396</i>   | <i>-20\$</i>     | <i>-0.5¢</i>      | <i>20%</i>          | <i>-2.3¢</i>   |             |

We invite you to make your own Energy Conversion table by downloading our [Energy Rosetta Conversion](#) spreadsheet and substituting the values applicable to your needs.

If you download the table you can click on the cells with red corners to see the assumptions used in making the table. You can then substitute values appropriate to your location and needs.

The spreadsheet table contains more columns than shown here. It shows typical values for the energy content of each fuel. It also shows the environmental cost of each fuel based for instance on a carbon dioxide credit of \$30/ton. (Change to suit your needs below) and the total local plus environmental costs.

Electricity is a particularly difficult energy form to evaluate since some of it is almost free (from hydroelectric dams long since paid for) while newer sources reflect fuel or nuclear costs. To illustrate the range an value of electric costs I have included the humble AA battery which has a cost of \$200 per kWh, 2400 times what we pay on the grid. Many people do not have access to grid based power and are paying \$1-\$10 for battery stored power or diesel generated power.

We have added a number of different prices for biomass to show the wide spread between highly processed biomass (pellets) and “junk” biomass (negative tipping fee).

The Rosetta Stone enabled scholars to decipher the Hieroglyphics of Ancient Egypt into modern Greek and English.



Our Rosetta Stone Energy table below enables anyone to translate the obscure energy units we now use into the commonly understood kilowatts.

Starting with James Watt in the 18<sup>th</sup> Century, our use and understanding of energy has grown up in a very useful but confusing manner. The US and England used British Thermal Units, BTUs, while the rest of the world used Calories for heat. Fortunately, nowadays we can all use the kilowatt both for heat and electric energy. We have made the conversions here and show costs based on the Denver market.





## The BEF Press Books



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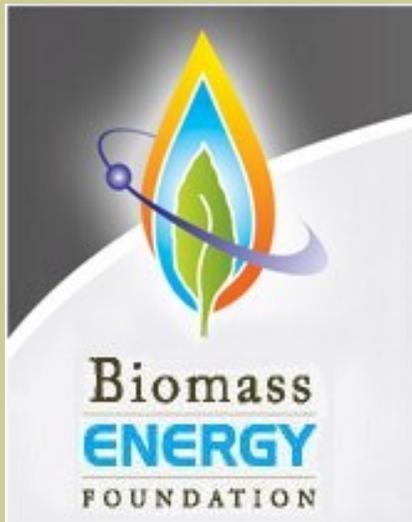


### **PURPOSES OF THE BIOMASS ENERGY FOUNDATION PRESS:**

Biomass energy and particularly biomass gasification is a field where publications are often difficult to find. Millions of dollars of writing and research are published in runs of a few hundred, and lost in government offices. (We wrote some of them so we know). We republish the best of these on biomass energy, (sometimes updating them) and offer other books as a service to the biomass community. We make available information on biomass - sometimes old, sometimes new - at reasonable prices in attractive "lie flat" bindings at 1/2 the cost from original sources.

**It always has been, and remains, our intention to keep the prices of our merchandise as reasonable as possible. In fact, we have not changed the prices of our books (with the exception of number 16) in several years. However, in part because we are a small foundation and because "nonprofit" does not mean "go broke," we are forced by increased printing costs and higher U.S. Postal Service charges finally to increase our prices. So, effective May 1, 2008, most of the prices for our merchandise have risen slightly. At least one price, however, is lower!**

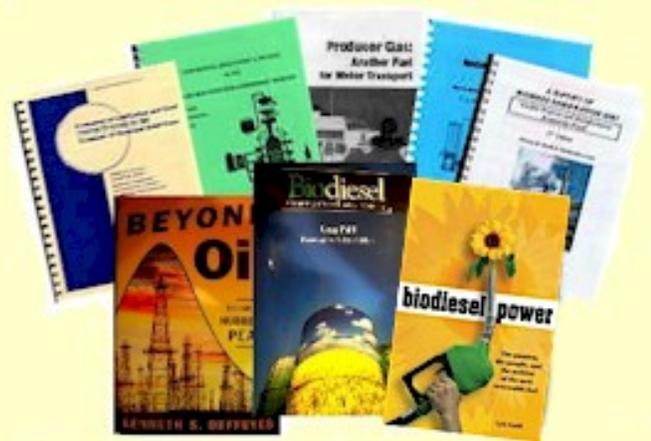
*Welcome, Biomass  
Energy Foundation  
supporters!*



## BEF BOOK CATALOGUE

### Book Categories

- Biomass Properties
- Gasification
- Synthetic Fuels
- Gasifier Tars
- General Energy
- (Not Just) for Kids!



Click here to return to the Biomass Energy Foundation site.

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The Original Woodgas Camp Stove provides the cleanest heat in the remotest area, burning almost any fuel nature provides. Stay longer on any trip, using the stove that doesn't require commercial fuel.

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Camp Stove](#)

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## Biomass properties

### ***ENCYCLOPEDIA OF BIOMASS THERMAL CONVERSION: PYROLYSIS, GASIFICATION AND COMBUSTION PRINCIPLES AND TECHNOLOGY:***

First Published in 1970, then republished in 1972, this monumental work has long been out of print. Nevertheless, it is the most complete survey of this field, written by a stable of scientists and engineers for the new (then) Solar Energy Research Institute to guide their choices of

programs. The facts of biomass life don't change, and most of them can be found here.

ISBN:1-890607-20-7

420 pp      \$60

**[Add item #20 to my shopping cart.](#)**

***DENSIFIED BIOMASS: A NEW FORM OF SOLID FUEL:***

Tom Reed and Becky Bryant, A "State of the Art evaluation of densified biomass fuels" with documentation of processes, energy balance, economics and applications. First published in 1978, & still the best (only?) text on theory and practice. Second edition with Paper on Energy of Biomass Densification appended.

ISBN 1-890607-16-9

35pp      \$22.50

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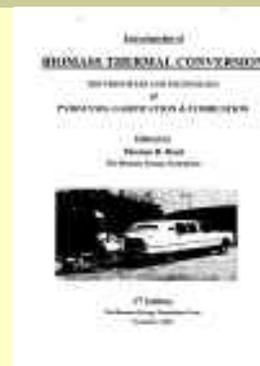
***TREE CROPS FOR ENERGY CO-PRODUCTION ON FARMS:***

Tom Milne (SERI 1980) Evaluation of the energy potential to grow trees for energy.

ISBN 1-890607-05-3

260pp      \$35

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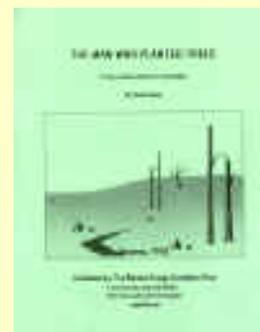
**TREES:** by Jean Giono, 1953. While we strongly support using biomass for energy, we are also very concerned about forest destruction. This delightful story says more than any sermon on the benefits and methods of reforestation.

ISBN 1-89060712-6

8pp

\$2

**unchanged!**



**Add item #16 to my shopping cart.**

---

## Gasification

Solar power and wind are niche replacements for oil, but biomass gasification powered the cities of Europe during WW II and will make a major contribution to post cheap oil energy...

### **A SURVEY OF BIOMASS**

**GASIFICATION 2001:** T. Reed and S.

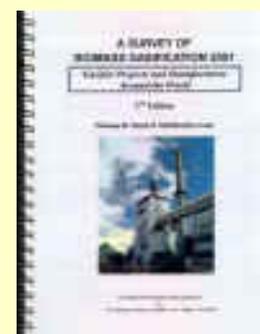
Gaur have surveyed the biomass gasification scene for the National Renewable Energy Laboratory and the Biomass Energy Foundation. 180 pages of large gasifiers systems, small gasifiers and gasifier research institutions with descriptions of the major types of gasifiers and a list of most world gasifiers. 2nd edition.

ISBN 1-890607-13-

4180

180pp

\$35



**Add item #1 to my shopping cart.**

**BIOMASS DOWNDRAFT GASIFIER ENGINE SYSTEMS HANDBOOK:** T. Reed and A. Das, (SERI-1988) Over a million wood gasifiers were used to power cars and trucks during World War II. Yet, there are now only a few companies manufacturing gasifier systems. The authors, who have spent more than 20 years working with various gasifier systems, discuss the factors that must be correct to have a successful "gasifier power system." Our most popular book, the "new Testament" of gasification.

ISBN 1-890607-00-

2

140pp

\$35



**Add item #2 to my shopping cart.**

**GENGAS: THE SWEDISH CLASSIC ON WOOD FUELED VEHICLES:** (SERI-1979) T. Reed, D. Jantzen and A. Das, with index. This is the "Old Testament" of gasification, written English translation, of "Gen-Gas", written by the Swedish Royal Academy at the end of WW II after successfully converting 90% of transportation of WW II Sweden to wood gasifiers.

ISBN 1-890607-01-

0

340pp

\$40



**Add item #5 to my shopping cart.**

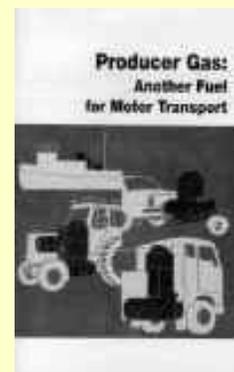
***PRODUCER-GAS: ANOTHER FUEL FOR MOTOR TRANSPORT:*** Ed. Noel Vietmeyer (The U.S. National Academy of Sciences-1985) A seeing-is-believing primer with historical and modern pictures of gasifiers. An outstanding text for any introductory program.

ISBN 1-890607-02-

6

80pp

\$10



**Add item #7 to my shopping cart.**

***SMALL SCALE GAS PRODUCER-ENGINE SYSTEMS:*** A. Kaupp and J. Goss. (Veiweg,1984) Updates GENGAS and contains critical engineering data and good common sense, indispensable for the serious gasifier project. Ali Kaupp is thorough and knowledgeable.

ISBN 1-890607-06-

1

278pp

\$35



**Add item #6 to my shopping cart.**

**FUNDAMENTALS, DEVELOPMENT,  
AND SCALE UP OF THE AIR-  
OXYGEN STRATIFIED DOWNDRAFT  
GASIFIER:** T. Reed, M. Graboski and B.  
Levie (SERI 1988). In 1980 the Solar  
Energy Research Institute initiated a  
program to develop an oxygen gasifier  
to make methanol from biomass. A  
novel air/oxygen low tar gasifier was  
designed and studied for five years at  
SERI at 1 ton/d and for 4 years at Syn-  
Gas Inc. in a 25 ton/day gasifier. This  
book describes the theory and operation  
of the two gasifiers in detail and also  
discusses the principles and application  
of gasification as learned over eight  
years by the author-gasifier team.

ISBN 1-890607-03-  
7

290pp

\$40

**Add item #8 to my shopping cart.**

**EVALUATION OF GASIFICATION  
AND NOVEL THERMAL PROCESSES**

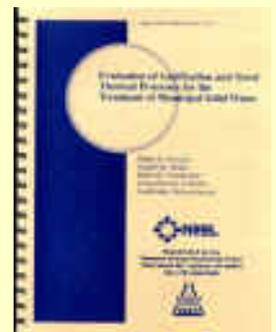
**FO** W. Niessen et al. A 1996 NREL  
report by on energy conversion  
processes for MSW.

ISBN 1-890607-15-0

198pp

\$27.50

**Add item #9 to my shopping cart.**



***CONSTRUCTION OF A SIMPLIFIED  
WOOD GAS GENERATOR:*** H.

LaFontaine (1989) - Over 25 drawings and photographs on building a gasifier for fueling IC engines in a Petroleum Emergency (FEMA RR28).

ISBN 1-890607-11-8

68pp

\$17.50



**Add item #12 to my shopping cart.**

***DRIVING ON WOOD: THE LOST ART  
OF DRIVING WITHOUT GASOLINE:***

***3rd Edition*** N. Skov and M. Papworth, (1974). Description and beautiful detailed drawings of various gasifiers and systems from World War II. In this new edition we have reduced Skov's 20 X 30 in plans to 11 X 17 " and bound them in the book, still very readable.

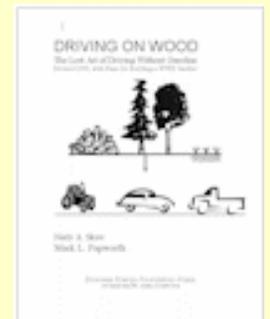
The gasifier was used to drive a Checker car around campus. Nils Skov was in the Danish Underground and write of his experiences in a new book, see [www.kalama.com/~NASKOV/](http://www.kalama.com/~NASKOV/)

ISBN 1-890607-09-

6

80pp

\$27.50



**Add item #14 to my shopping cart.**

### ***NEW/OLD: MODERN GAS***

***PRODUCERS:*** N. E. Rambush, the most complete collection of information on the golden age of coal gasification, when every city had a "gasworks" . Lots of food for thought on biomass gasification and why it's different.

ISBN 1-890607-18-5

550 pp

\$40



**[Add item #18 to my shopping cart.](#)**

### ***WOOD GAS GENERATORS FOR VEHICLES:*** Nils Nygard's (1973).

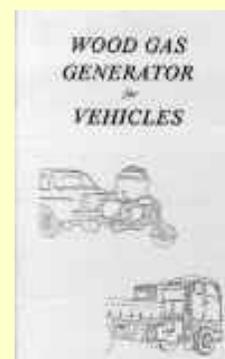
Translation of recent results of Swedish Agricultural Testing Institute a sequel to Gen-Gas.

ISBN 1-890607-08-8

50pp

\$5

**unchanged!**



**[Add item #11 to my shopping cart.](#)**

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## **Synthetic Fuels**

Oil is nice but getting pricey and less available. Here are a few alternatives that I have worked on. See also "Fundamental Study and Scaleup..." above.

## **BIOMASS TO METHANOL**

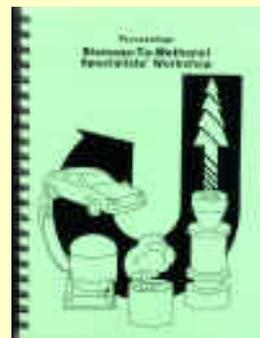
**SPECIALISTS' WORKSHOP:** Ed. T. Reed and M. Graboski, 1982 Expert articles on the conversion of biomass to methanol from a conference in 1982 when we were still worried about oil...

ISBN 1-890607-10-

X

331pp

\$40



**Add item #13 to my shopping cart.**

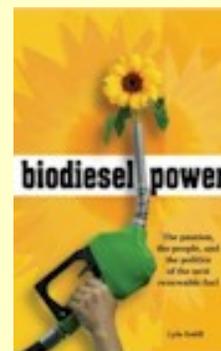
***BIODIESEL POWER: The Passion, the People, and the Politics of the Next Renewable Fuel*** by Lyle Estill, New Society Publishers, 2005. "Biodiesel has buzz." So says Lyle Estill, V.P of Stuff at Piedmont Biofuels LLC in North Carolina and author of the newest addition to our list of important and helpful books, *Biodiesel Power*. The actress Daryl Hannah, a prominent biodiesel activist, says that Estill "has chronicled (like no other) the complex and often entertaining dynamics of the burgeoning world of biodiesel." The book has occasional flashes of humor and insight. It provides some instructions for making and using biodiesel, and it's a "good read."

ISBN:

0865715416

288pp

\$16.95 **unchanged!**



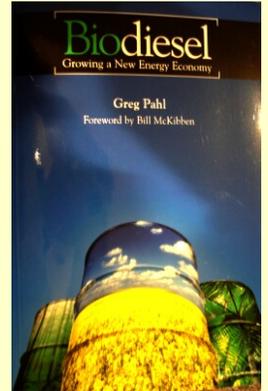
**Add item #25 to my shopping cart.**

***BIODIESEL: GROWING A NEW ENERGY ECONOMY*** by Greg Pahl, Chelsea Green Press, 2005. Greg Pahl has brought the history and technology of biodiesel together in this comprehensive, well written book. On pp 152-3 he records the history of the invention of waste oil biodiesel by T. Reed at the BEF, as well as all the other contributions by our friends. ISBN: 1-931498-65-

2

281pp

\$18 **unchanged!**



**Add item #23 to my shopping cart.**

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## Gasifier Tars

Coal gasification is a done deal - see our "Modern Gas Producers". But biomass pyrolysis produces mainly volatiles (tars) that can be a great nuisance unless properly measured and removed. Here are two books directly addressing that problem....

***REVISED: CONTAMINANT TESTING FOR GASIFIER ENGINE SYSTEMS:*** A.

Das (TIPI 1989, 1999). Test that gas for tar! Long engine life and reliable operation requires a gas with less than 30 mg of tar and particulates per cubic meter (30 ppm). The simplified test methods described here are adapted from standard ASTM and EPA test procedures for sampling and analyzing

char, tar and ash in the gas. Suitable for raw and cleaned gas. New edition & figures.

ISBN 1-890607-04-5

32pp

\$12.50



**[Add item #3 to my shopping cart.](#)**

***BIOMASS GASIFIER "TARS": THEIR NATURE, FORMATION, AND***

***CONVERSION:*** T. Milne, N. Abatzoglou, & R. J. Evans. Tars are the Achilles Heel of gasification. This thorough work explores the chemical nature of tars, their generation, and methods for testing and destroying them. (100 page bibliography also available for additional \$10)

ISBN 1-890607-14-2

80pp

\$30



**[Add item #4 to my shopping cart.](#)**

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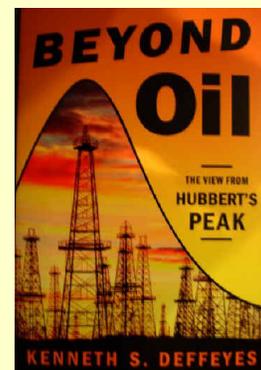
## Other Books

As you can see, I have been involved in energy research all my life. My book on thermodynamics below prepared me for sophisticated calculations. King Hubbert was my office mate when I worked at Shell Oil...

***BEYOND OIL: THE VIEW FROM HUBBERT'S PEAK*** by Kenneth

Deffeyes, Hill and Wang  
(March 15, 2005) Hardcover. Ken Deffeyes is a famous petroleum geologist at Princeton. In this book he uses the methods that Hubbard developed to predict the 1974 peak in US oil production, to predict a 2005 peak in world oil production. He then considers what our fuel options will be as the oil prices double every 5 years. Be prepared for an exciting century!

ISBN: 0809029561 224 pp \$20 **price LOWER!!**



**Add item #21 to my shopping cart.**

***FREE ENERGY OF BINARY COMPOUNDS: AN ATLAS OF CHARTS FOR HIGH-TEMPERATURE CALCULATIONS, 2<sup>nd</sup> edition***, Thomas

B. Reed. We published this book with MIT Press in 1971 when I was working in high temperature materials research. The data and charts apply to all of chemistry, so you can calculate the thermodynamics of almost any reaction. MIT Press, 1971. My magnum opus! ISBN 1-890607-19-

3 90pp \$22.50



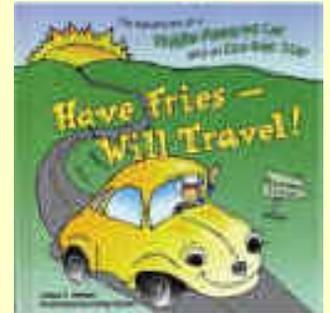
**Add item #19 to my shopping cart.**

## (not just) for kids!

We're offering our first children's book! We would like to offer more, so if you know of titles we should be offering, please let us know!

**Have Fries - Will Travel!** Written by  
Linda K. Hempel, illustrated by Kathy  
Dotson

This is an adventure story for kids of all ages, featuring "Rock," an eco-rap singer, who goes to a used car lot and buys "Tiny," a smelly diesel car. Pretty soon, Rock has Tiny running on biodiesel fuel made from used veggie oil from Rock's favorite restaurant.



The book's introduction was written by film star Daryl Hannah and Grassolean Solutions founder Charris Ford, both of whom use and promote biodiesel. In the introduction, they say "Running our cars on clean-burning fuel grown by farmers is just one of the many ways people can have fun and help take care of the Earth at the same time."

One of the book's key lessons is that keeping the Earth clean and beautiful is everyone's job, and if each of us does "just a little" we'll be able to continue to enjoy its beauties for a "long, long, long time!"

ISBN: 0865715491

72

pp

\$12.95 **unchanged!**

**[Add item #24 to my shopping cart.](#)**

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Our fax: 303-279-3734  
Our e-mail: [mike@befp.org](mailto:mike@befp.org)

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\$4/lb

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### SHIPPING WEIGHTS - Biomass Energy Books

| Price   | Item # | BEF ORDER BLANK  | WEIGHT (Pounds) |
|---------|--------|--|-----------------|
| \$35    | 1      | A SURVEY OF BIOMASS GASIFICATION 2000:                               | 1.50            |
| \$35    | 2      | BIOMASS DOWNDRAFT GASIFIER ENGINE SYSTEMS<br>HANDBOOK:               | 1.50            |
| \$12.50 | 3      | CONTAMINANT TESTING FOR GASIFIER ENGINE SYSTEMS:                     | 0.25            |
| \$30    | 4      | BIOMASS GASIFIER "TARS": THEIR NATURE, FORMATION,<br>AND CONVERSION: | 1.00            |
| \$40    | 5      | GENGAS: THE SWEDISH CLASSIC ON WOOD FUELED<br>VEHICLES:              | 2.50            |
| \$35    | 6      | SMALL SCALE GAS PRODUCER ENGINE SYSTEMS:                             | 2.00            |
| \$10    | 7      | PRODUCER-GAS: ANOTHER FUEL FOR MOTOR TRANSPORT:                      | 0.25            |
| \$40    | 8      | FUNDAMENTAL STUDY .. OF THE AIR-OXYGEN .. DOWNDRAFT<br>GASIFIER      | 2.50            |

|         |    |  |      |
|---------|----|--|------|
| \$27.50 | 9  | EVALUATION OF GASIFICATION..FOR..MSW                     | 1.00 |
| \$22.50 | 10 | DENSIFIED BIOMASS: A NEW FORM OF SOLID FUEL:             | 0.50 |
| \$5     | 11 | WOOD GAS GENERATORS FOR VEHICLES:                        | 0.10 |
| \$17.50 | 12 | CONSTRUCTION OF A SIMPLIFIED WOOD GAS GENERATOR:         | 1.00 |
| \$40    | 13 | BIOMASS TO METHANOL SPECIALISTS' WORKSHOP:               | 2.50 |
| \$27.50 | 14 | DRIVING ON WOOD  | 1.00 |
| \$30    | 15 | GASIFICATION OF RICE HULLS: THEORY AND PRAXIS:           | 2.00 |
| \$ 2    | 16 | TREES:   | 0.10 |
| \$35    | 17 | TREE CROPS FOR ENERGY CO-PRODUCTION ON FARMS:            | 2.00 |
| \$40    | 18 | MODERN GAS PRODUCERS (1923)                              | 2.50 |
| \$22.50 | 19 | FREE ENERGY OF BINARY COMPOUNDS                          | 1.00 |
| \$60    | 20 | ENCYCLOPEDIA OF BIOMASS THERMAL CONVERSION               | 4.00 |
| \$20    | 21 | BEYOND OIL: THE VIEW FROM HUBBERT'S PEAK                 | 1.00 |
| \$25    | 22 | BIOMASS TO ENERGY: THE SCIENCE AND TECHNOLOGY OF<br>IIsC | 1.00 |
| \$18    | 23 | BIODIESEL: GROWING A NEW ENERGY ECONOMY                  | 1.00 |
| \$12.95 | 24 | HAVE FRIES - WILL TRAVEL!                                | 1.00 |
| \$16.95 | 25 | BIODIESEL POWER  | 1.00 |
| \$55    | 26 | WOODGAS CAMP STOVE                                       | 4.00 |
| \$75    | 27 | XL WOODGAS CAMP STOVE                                    | 4.00 |



# WOODGAS

About the biomass energy foundation



**Home**

**Biomass  
Energy**

**Gasification &  
Reforming**

**Liquid Fuels**

**Wood  
Cooking**

The Biomass Energy Foundation (BEF) is a 501-3-C non profit foundation devoted to biomass energy and specializing in gasification.

**Energy  
Rosetta Stone**

The BEF was founded in 1984

**Bookstore**

by my good friend and mentor, Dr.

**About the  
BEF**

Harry  
LaFontaine.

**Links**

Harry built gasifiers during World War II as a cover for his nighttime activities in the Danish Underground.

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Member  
of the  
Biomass  
Energy  
Foundation**

When the "energy crisis" struck in 1974, Harry gave lectures and demonstrations on gasification in many universities around the East. He converted a Lincoln Continental stretch limo to WoodGas and demonstrated it and lectured on gasification in many Eastern colleges.



Tom Reed met Harry in 1985. In 1982 Harry set up a 501-3-C (not for profit) foundation for his activities in biomass. Reed was invited to be a member of the board of directors of BEF. At that time Tom Reed began to publish books at the Biomass Energy Foundation.

In 1994 Harry died (at age 80) and left the BEF to Dr. Reed to pursue its original purposes. It is used for research, consulting, publishing and travel activities in the field of biomass and gasification. The BEF is able and willing to sponsor projects related to these purposes.



Tom in Amsterdam, 2001

Currently **Tom Reed** is president and his wife Vivian is secretary of the BEF. Mr. Tom Smith is the treasurer. We have been publishing books and developing new gasifiers and stoves, and now we are expanding into stove

manufacture and alternate fuel research.

### CURRENT RESEARCH IN ALTERNATE ENERGY AT BEF

I am a Physical Chemist (PhD, U. Minn.) and I love research, (as well as engineering, teaching, inventing, and now manufacturing stoves). Following my extended careers at Linde (Praxair) on high temperature research (8 years) and at MIT (18 years in Material Science), I became interested in Alternate Energy and Fuels. I published a major article in *Science* on *Methanol as the Fuel of the Future* in 1973 that totally changed my career.



I have a laboratory in my garage and workshop in my basement where I perform experiments on biomass pyrolysis and gasification, make stoves and am measuring flame velocities.

In 1990 I developed with Bill Mobeck an oil absorbent called "SeaSweep".

I have been working on **small gasifiers** since 1980. Starting in 1998 I have been working on the design of small gasifiers for distributed power with the **Community Power Corporation**, CPC. In 1999 we built a small 5 kW gasifier in my garage workshop.

In 2000 we installed a 15 kW combined heat and power gasifier in a village in the Philippines and in 2001 another at the Hoopa Indian reservation.

In 1985 I began work on gasifiers for cooking and we are

currently manufacturing and selling a WoodGas stove for campers.

In 2002 I began working with the National Alternative Fuels Foundation, [NAFF](#). We believe that there are important improvements that can be made to fuels such as gasohol and biodiesel and we are building a research laboratory to investigate these fuels.

In 2002 I built 15 of our woodgas campstoves in my shop and gave them to various people to test. With positive results from those tests in 2003 Shivayam Ellis produced 100 stoves to market at our new corporation, WoodGasLLC. We now [sell these stoves](#) through this website.

In 2004 we were selected as a subcontractor to design a stove for army field kitchens.

Our most recent research is described in the [Biomass Energy Foundation's new website!](#)

Contacts: [tombreed@comcast.net](mailto:tombreed@comcast.net)



# WOODGAS

## MAJOR BEF links



**Home**

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**Gasification &  
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**Liquid Fuels**

**Wood  
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**Energy  
Rosetta Stone**

**Bookstore**

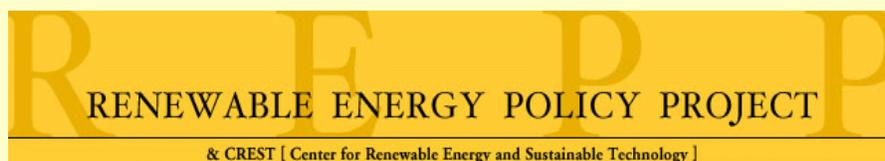
**About the  
BEF**

**Links**

### WOODGAS SITES WORTH VISITING (added in August 2006):

- **WoodGas in Wikipedia**
- **Greentrust**
- **WoodGas Producers**
- **A WoodGas Stove**
- **Australian Van conversion**
- **Wood and WoodGas Stoves**

### Major BEF links...



### REPP - THE RENEWABLE ENERGY POLICY PROJECT

REPP, (formerly CREST) is a site dedicated to renewable energy. I am the moderator at their site "GASIFICATION" and we have 5 years of archives of hundreds of letters to and from members of the field. When last I checked there were >300 members of GASIFICATION and a similar number from STOVES, but we mostly hear from a few dozen. (I presume the rest are "lurking" and will respond when someone touches their hot button.)

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Foundation**

**REPP** maintains **files on** GASIFICATION, STOVES, BIOCONVERSION, BIOENERGY, ETHANOL, BIOGAS, and other areas relevant to biomass energy. Check the other sites out too if you are interested. Read over their archives to get a flavor. Anyone interested in joining the gasification (or other) discussion groups should visit the site and follow their **instructions** for joining or check out the **old** and **new** archives. We are particularly interested in the **STOVES** group since we are developing and working with manufacturers of **WoodGas Stoves**.

**CPC**: I have been working with the Community Power Corporation here in Denver to develop Small Modular Biomass Power systems and woodgas cookstoves since 1998. We have had operating gasifier power systems in the Philippines and US and contracts for many gasifier projects. Visit our site to see our major advances in this field.



**BIODIESEL - McDIESEL - EEA** In Fall 1989, Dr. Tom Reed developed a process for the conversion of animal fats and vegetable oils to their methyl esters for fuel purposes. The product is now called "Biodiesel" and the process is quite simple. It works for new vegetable oils (~\$2/gal) or waste oil (<\$0.50/gal). Guess which the US Department of Agriculture is pushing. Tom Reed is the grandfather of biodiesel from waste cooking oil. He is now running his 2002 VW Jetta on 20% biodiesel and plans to run 100% this summer.

**OTHER LINKS**: Here are links that I have found useful and thoughtful about Alternate Fuels stoves, biomass, thermodynamics etc. I'll be adding more soon.

**pelletbase** - a free fuel pellet & biomass forum

**Stovesonline** supplies stoves mainly to the UK domestic market but they have also been supplying stoves for

refugees/crisis situations and recently supplied 500 stoves to Pakistan.

**[Welcome to the NIST WebBook](#)** - Thermochemical data for over 7000 organic and small inorganic compounds:

**[CGPL Home Page](#)** - The "Combustion, Gasification, Pyrolysis Laboratory in Bangalore, India with 10 times the research we do in alternate fuels

**[Alex English's Stove Page](#)** - Alex displays recent work on cookstoves

**[Gridwise \(sm\) Power Guide](#)** - GridWise seeks to modernize the nation's electric system - from central generation to customer appliances and equipment

**[Vegivan](#)** - Josh Tickel's page on Biodiesel and making your own..

**[APPROVECHO RESEARCH CENTER](#)** - Research on stoves and alternate energy

**[ETHOS](#)** - Research on wood stoves at Approvecho Summer Camp, 2005

**[BIOBIB](#)** - A Database on biofuels

**[Soygold - Solvents, Diesel Additive, and Methylated Seed Oil](#)** - Other chemicals you can make from biodiesel

**[NREL Homepage](#)** - The National Renewable Energy Laboratory here in Golden has been doing "renewable energy research" since 1990. Too bad they didn't focus on "renewable fuels".

**[This is Winrock](#)** - The Winthrop Rockefeller Foundation funds proven technology around the world

**[Fluidyne Gasifiers](#)** - Doug Williams at The Fluidyne Company of New Zealand has been making gasifiers for 25 years and makes some of the best comments at "Gasification"

**[Pellet Stoves](#)** - Wood pellet stoves for post "cheap oil" era

**[Peterson Corp](#)** - Heavy machinery converts low-grade organic materials into high value products. Industrial chippers produce high quality, low bark pulp chips for the biomass/wood energy market. Asphalt shingle grinders

recycle roofing materials for re-use in road surfacing and other applications.

**ZZ Manufacturing Stoves** - Steve Scofield's new production of the pretty good Hottenroth Sierra camp stove...

**The Shell Foundation** - Shell has decided to support renewable energy big time...

**Welcome to M. K. Hubbert Center** - The latest on when the oil runs out...

Last updated ~ September 2005. Send me other links you think may be important for biomass at [tombreed@comcast.net](mailto:tombreed@comcast.net)





Clean hydrogen flame, invisible during daylight.



**Biomass**  
**ENERGY**  
FOUNDATION

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- Who We Are
- Our Vision
- Team
- Science Advisors
- History

**PROGRAMS**

- Ongoing H2 Projects
- Açai Brazil
- BEF 2006 Goals

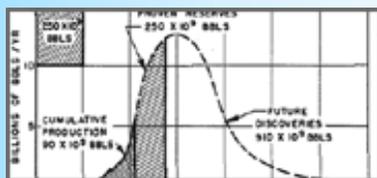
**LEARN**

- Hydrogen
- Fuel Issues
- Peak Oil
- Biodiesel
- Biomass
- Scientific Papers
- Bookstore

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## Our Mission is to Develop and Deploy Renewable Alternative Fuels



>The era of Cheap Oil is over. Alternatives are imperative.



>Buy hard- to-find and interesting books about biomass, gasification, peak oil and more.



You will also want to visit Dr. Reed's long-running (and very popular) **Woodgas website!**

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# WOODGAS

## THE WOODGAS CAMP STOVE!

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Gasification &  
Reforming

Liquid Fuels

Wood Cooking

Bookstore

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**GREAT NEWS! We're now selling Tom's WoodGas camp stoves!**

WoodGas Camp Stoves provide the cleanest heat in the remotest area, burning almost any fuel nature provides. Stay longer on any trip, using the stove that doesn't require commercial fuel.

- Cooks cleanly with very little smoke.
- Burns wood, pine cones, leaves - any plant based fuel.
- Light and compact. Equivalent to weight of a 1-Quart bottle of propane.
- Easy refueling while burning for long cooking sessions
- Two speed setting provides heat control. Great for camping, backpacking, or smores anywhere.
- Calibrated to reproduce the heat of a normal kitchen stove.

The current dimensions for the WoodGas LE are:

**Weight:** 23 oz

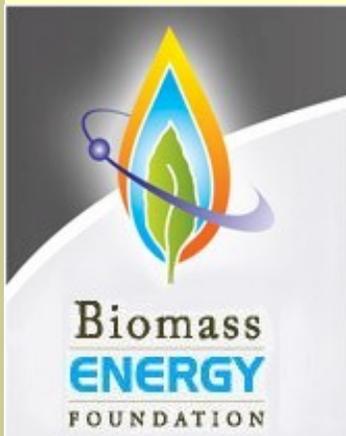
**Height:** 6.25"

**Diameter:** 5.1 "

Note: the unit requires two AA batteries to run the small fan.



Welcome, Biomass  
Energy Foundation  
supporters!



**Click here to visit  
the Biomass  
Energy Foundation  
site.**

**Add a WoodGas Camp Stove to my  
shopping cart!**

- **Original WoodGas Camp Stove \$55**
- **WoodGas XL Camp Stove \$75**



**See what people using WoodGas Camp Stoves have to say.**

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## Old & Modern Gasifiers

On March 9, 2001 I visited a Mr. Mel Strand at his home in Boulder, CO. Mel was born in Minneapolis, but during WWII he was stranded in Norway during the occupation and drove a gasifier truck - delivering groceries in the day and weapons to the underground at night.

Mel returned to the U.S. after the war and his career has been in machining and fabrication. As a hobby a few years ago he decided to construct the gasifier he remembered it from a 1948 Chevy pickup. What a beauty he made!



Mel turned on the auxiliary starting fan, and started the gasifier on large aspen chunks with a newspaper. After a few minutes he lit the gas at the front of the truck and started the engine. We drove around Colorado Springs for several hours. I realized what an art it was to drive a gasifier car, since he could control the spark advance, air fuel ratio and throttle, all from the steering column, while talking about the old and new days.

## Modern Small Gasifiers

A great deal of development of gasifiers is going on around the world.

In 1999 I collaborated with the company Community Power, **CPC**, Corporation, CPC, to build a 5 kW "Turnkey, Tarfree" gasifier using new principles I had discovered and learned. The picture at the right shows Kurt Kirscher, Shivayam Ellis, myself, Agua Das and Robb Walt (President of CPC) outside my laboratory.



CPC developed this gasifier with the aid of grants from the US DOE, Shell International, the California Energy commission and others into field gasifiers tested in Alaminos in the Philippines and the Hoopa Valley Indian Reservation in California.

CPC is now quite active in many aspects of gasifier research and has a dozen 15 kW "Turnkey, Tarfree" gasifiers in the field and used by the US Forest Service and Others to turn forest litter and biomass trash into heat and power. CPC is now also developing a 5 kW heat/power and a 50 kW gasifier.



### THE DASIFIER FOUNDRY GASIFIER

Here's a nifty gasifier developed by my colleague and co-author, Agua Das, for melting bronze and other metals with biomass. Built from tincans and a refrigerator compressor, it burns all kinds of biomass trash. I also call it an "up-down draft gasifier. See the description at "[Dasifier](#)".



### BIG GASIFIERS

I have lots of descriptions of large gasifier projects in my book "Survey of Biomass Gasification - 2000" (see [Books](#)). Here is the famous Burlington Vt. 5 MW fluidized bed that makes a very rich gas of 15 MJ/m<sup>3</sup>. It is based on the double fluidized bed developed at Battelle and has been scaled up by FERCO and the US Dept. of Energy. It operates on wood chips from the Vermont forests. I believe it is no longer in operation (July, 2004).

The BEF is involved with research, design and construction of all gasifier sizes.



### GASIFIERS FOR FUELS AND CHEMICALS

When biomass is gasified with *air* the resulting gas has ~50% nitrogen, and so is good only for use at the point of origin. For pipelines, for some storage or for chemical synthesis, oxygen gasification produces a gas with twice the energy (~12 MJ/m<sup>3</sup>) while pyrolytic gasification can produce a gas with 20 MJ/m<sup>2</sup>.

In 1973 at MIT, I wrote the lead article for the journal Science, "[Methanol: A versatile Fuel for Immediate Use](#)", (Vol. 182, pp 1299, 1973). Unfortunately, the US chose not to develop fuels alternative to gasoline and so has been exporting money for oil to finance terrorists. Read the sad story at our [Methanol](#) page.

In 1980 we built an oxygen gasifier at SERI/NREL which eventually was tested on pure oxygen at the 25 ton/d level. This is discussed in our book FUNDAMENTAL STUDY AND SCALE UP OF THE AIR-OXYGEN STRATIFIED DOWNDRAFT GASIFIER on the [Books](#) Page.





# WOODGAS

## METHANOL: A VERSATILE FUEL FOR IMMEDIATE USE

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I began experimenting with alcohol and alcohol blend fuels in 1973 when I worked at MIT. I published my results in an article<sup>1</sup>, "[Methanol: A Versatile Fuel for Immediate Use](#)" with a colleague, Bob Lerner in the premier science journal, SCIENCE (Vol 182, p.1299) in December 1973. This coincided with the peak of the first OPEC gasoline shortage and the article was summarized in the New York Times. I couldn't believe the attention we got. The public and Congress didn't realize that cars can run on other fuels than oil. I testified in the U.S. Senate and several state legislatures and had many phone calls inquiring about what I knew and telling me many things I didn't know.

One reader, a Mr. Hawley from Minneapolis had made a great deal of money in oil and gas and sent a check for \$100,000 to me and MIT to do research on methanol production and use. I took a year leave of absence from my material science interests to work at the newly created MIT Energy Laboratory (and teach Thermodynamics). We set up a gas station test for MIT students and faculty who would be willing to use our blends in order to find out what problems might arise.

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Unfortunately the oil and motor industry was less than enthusiastic. A few months later a grant of \$1,000,000 was given to the MIT Energy Laboratory. We were informed that the oil companies were the real experts in this field and so the permission to run the tests was revoked after we had spent 6 months and \$50,000 developing our test methods.

In 1975, SCIENCE sent a reporter, Allen L. Hammond, to MIT to investigate the project cancellation. Science published a news article<sup>1</sup>, "**Methanol at MIT: Industry Influence Charged in Project Cancellation**", (vol 190, p. 761, November 1975).

It is interesting - and fruitless - to speculate on how history might have been different if the US had developed an aggressive synthetic fuel program in the 1970s. The threat of alternate production from gas, coal or biomass would have tempered future rises in oil prices and reduced our funding of the Near East oil sheikhs. It would have prevented the Iran-Iraq war and the US Iraq wars and the terrorist attacks and 9-11 and saved thousands of life; it would have also saved millions of dollars. And we would have a much better estimate of the cost and means of producing the alternate fuels that we will need as the oil runs out.

*"Of all sad words of tongue or pen, The saddest are these  
"It might have been" (Whittier)*

Now, 30 years later and facing another presidential election, we can hope that we can develop a sensible energy policy

~~~

Permit me a little personal history of how I came to be interested in alternate fuels. In 1972 I was working at the Massachusetts Institute of Technology (MIT) in crystal growth. I ate lunch occasionally with a Peter Robeck who grew up in Germany and knew a great deal about the Nazis synthetic fuel program during WWII. He flew a spotter plane at the battle of Stalingrad fueled with what we now call "gasohol", a high octane mixture of gasoline and ethanol (the drinking alcohol made by fermentation of corn etc) .

Oil, diesel and gasoline have become such a major base of our society that I first heard concerns about "when the oil runs out", in 1959, and we still do. I became interested in the question of alternate fuels in 1973 when my boss asked me to look into "hydrogen from sunlight" as a possible new energy source. However, hydrogen does not occur in nature and Mother Nature has had 3 billion years of development on renewable fuels through photosynthesis. So I began inquiring about alcohols as fuels. Ethanol is easily made from any starchy plant and Henry Ford predicted that some day our case would be running on fuels growing beside the road.

However, methanol is by far the simplest and cheapest (\$0.15/gal at that time) synthetic fuel to make synthetically. It is used in preference to gasoline at the race track, and I learned in 1973 that student teams had converted cars to methanol and won clean air car races. It is made in enormous quantities, mostly from natural gas. It is also be made in well known processes from coal, wood, agricultural and forest wastes and municipal

wastes, according to...

Gas, Coal, Biomass ==> (gasification, catalytic conversion, separation) ==> METHANOL or other alcohols or FT diesel

A close friend of mine, Dr. John Anderson, had just patented a process for converting municipal waste to synthesis gas which could be used to make methanol. I wrote a draft of the article for SCIENCE magazine proposing that methanol would be the most likely replacement for gasoline as the oil ran out. I gave the article to another friend, Dr. R. M. Lerner to read and comment. He liked the article, but suggested that the transition to a methanol fueled future would be easier if it could be blended in increasing amounts into gasoline, say starting with 5 to 10% and gradually developing more capacity as oil became increasingly difficult to find.

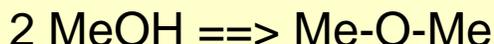
I liked this suggestion, so tested a little methanol in gasoline and found it dissolved at all ratios (at room temperature). Being adventurous and having an aging 1969 Toyota, I got a gallon of methanol from the stockroom and added it to my tank to get a 10% mixture. It started fine and I spent the afternoon doing several errands - didn't notice any difference in the driving. After a few more tanksfull of 10% methanol in my gasoline, I noticed that the "tank to tank" fuel economy was equal to or better than gasoline. As a chemist, I knew that a gallon of gasoline had twice as much energy as a gallon of methanol, so I didn't believe it so decided to make some more scientific tests. I obtained a fuel burette (graduated cylinder) and mounted it in the window of my car and drove over a test course involving a 1 mile hill climb using 0%, 5%, 10%, 15% and 20% methanol in the burette. My

mileage went up from 26.8 MPG on gasoline to 28.8 MPG on 15% methanol (a 7% increase), then declined but was still drivable.

~~~

Propane is one of my favorite fuels, because we can ship and store it as a liquid under very modest pressure, but it burns very cleanly because it is a gas at room temperature, so that it is easy to mix in proper proportion with air. Unfortunately, there isn't nearly enough for our needs in the oil barrel.

An even better fuel closely related to methanol is dimethyl ether, DME, made by combining two methanol molecules (or directly with a suitable catalyst, according to



Dimethyl ether boils at -23.6 C, propane at -42.1, so DME can be shipped, stored and burned in similar equipment. It is even easier to make synthetically than methanol.

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Many people are converting “yellow grease” to biodiesel or using it directly. (See [http://en.wikipedia.org/wiki/Yellow\\_grease](http://en.wikipedia.org/wiki/Yellow_grease)) and <http://www.easternct.edu/depts/sustainenergy/calendar/biodiesel/Geise%20-%20Biodiesel%20from%20Recycled%20Vegetable%20Oil.pdf>)

It requires additional lye to neutralize the free fatty acids and the process so more chemistry than the kitchen provides.

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<sup>1</sup> Corn based ethanol has been a “renewable fuel” since about 1980, available as a 10% blend with gasoline. It competes directly with corn for food and can cause economic upsets if we make too much. Biodiesel is made from soy oil and many other vegetable oils and animal fats. Soy beans are raised primarily for their protein content and the oil is a by product, since many other plants also contain vegetable oils. Used cooking oil (yellow grease) is a waste product, but is fed to cattle or burned for heat.

I have been running my diesel vehicles on biodiesel since I first discovered it in 1990 and it is now the most successful of our “renewable fuels”.

<sup>2</sup> Don’t worry about long complicated chemical names. They are usually descriptive of the molecule and more like a map. You probably heard them in high school chemistry and promptly forgot them. Your doctor measures the “triglyceride” content of your blood on any blood test. Healthy humans are typically about 20% triglyceride (fat) or else all your joints would squeak. Making biodiesel on a large scale is a task for chemical engineers. It is a relatively simple process, but requires purification and washing to make a commercial fuel

<sup>3</sup> Don’t worry about these long and complicated chemical names. They are usually descriptive of the molecule and more like a map. Your doctor measures the “triglyceride” content of your blood on any blood test. Healthy humans are typically about 20% triglyceride (fat) or else all your joints would squeak. Making biodiesel on a large scale is a task for chemical engineers. It is a relatively simple process, but requires purification and washing to make a commercial fuel.

<sup>4</sup> The easiest source of methanol is Dri- Gas, obtainable from any automotive store. Be sure to get the cheap yellow variety - contains methanol - not the red one containing iso-propyl alcohol. Methanol is also used as the preferred fuel at most race tracks and you can buy a 5 gallon can.) The methanol must be new and DRY.

<sup>5</sup> Red Devil lye or the equivalent is carried by most grocery and hardware stores. Read the safety instructions. Stir well into the methanol with a wooden spoon, crushing as needed until all the flakes disappear. The mixture will be slightly cloudy and is called "sodium methoxide".



# WOODGAS

## COOKSTOVES

### Home

### Biomass Energy

### Gasification & Reforming

### Liquid Fuels

### Wood Cooking

Half the world (~3 billion people) cooks substandard meals, consuming too much wood, breathing too much smoke and burning the kids. My grandmother had a wood/coal range that worked pretty well, but wood is difficult to burn on a smaller scale. On first lighting the volatiles are driven off faster than combustion air can be supplied. Then, when the wood is reduced to charcoal, it is difficult to supply enough air to make flames. We think that our WoodGas stoves are the best fix for these problems. However, we don't think they are the only fix and there is a lot of good work going on around the world. The best way to keep in touch is to join the **STOVE** discussion group at the Renewable Energy Policy Project, REPP.

### Energy Rosetta Stone

### Bookstore

### About the BEF

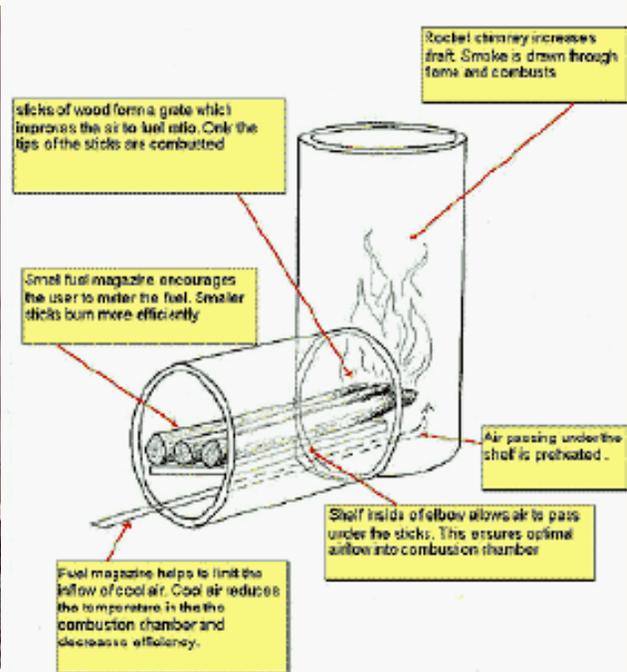
### Links

### Become a Member of the Biomass Energy Foundation

**REPP** maintains a discussion group on STOVES and GASIFICATION with archives of thousands of letters on file asking and answering questions about all aspects of biomass stoves and gasification. Anyone seriously wanting to help with world stove problems should join this group.

The **Aprovecho** research institute is actively developing new improved stoves and deploying them around the world. They also maintain a school for cookstoves, alternative building methods etc. Worth a trip anytime. They will be having a Spring Cookoff in June 2003. Maybe I'll see you there.

I have long admired the wood stoves developed by Fred Hottenroth. Unfortunately, Fred died several years ago, but the stoves are still being manufactured by the ZZ Manufacturing Co.



Source:

<http://www.zzstove.com/>

Source:

<http://www.aprovecho.net/at/atindex.htm>

However, these are not gasifier stoves, so have lots of unburned gas. Gas which burns more than an inch above any stove will be quenched by the cooking pot when it is put on the fire, resulting in blackened pots and high emissions.

You can purchase a **WoodGas Camp Stove** through our online bookstore.



# WOODGAS

## WOODGAS COOKSTOVES



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Gas from wood? That's my specialty and the name of this site.

It is now possible to turn wood into Wood-Gas which is then easy to burn efficiently with low emissions, as shown above. I have been working on wood-gas stoves since I became aware of the world cooking problem on a trip to South Africa in 1985. We have developed both natural

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convection (with Ron Larson) and forced convection stoves (Patent applied for). Check out these papers for the principles of WoodGas stoves and performance details. We expect to continue this work indefinitely and hope to deploy a billion stoves to ease the world cooking problem - an ambitious target. (You can also use larger variations of these stoves for clean, indoor cooking and other major heat applications.)

Our first target for this fundamental new development is the U.S. campstove market. There are lots of campers that don't want to lug propane or gasoline on their backs and do want to use the biomass they find along the way. There are lots of others worried about possible cutoff of gas or power. They are critical users and we will welcome their comments (at [tombreed@comcast.net](mailto:tombreed@comcast.net)).

We believe our WoodGas Cook Stove far exceeds the performance of any other biomass cooking device. It will burn twigs, chips or the wood-pellets widely sold in hardware stores (typically \$3 for a 40 lb bag). It generates 1.5 - 3 KW of heat, comparable to the big element on an electric stove; it burns only 10 g of fuel/min (40% efficient); and it can be used indoors with minimal emissions. It uses a single AA cell that lasts 3 hours on HIGH and 6 hours on LOW. We hope a lithium hydride battery and solar charger will be available as an accessory soon.

The current dimensions for the WoodGas LE are:

Weight: 23 oz

Height: 6.25"

Diameter: 5.1 "

We plan to sell these stoves in the US campstove market first to establish our manufacturing and sales abilities before designing stoves for the international community. The stove sells for \$55 plus shipping and comes with a full instructional manual. You can **[purchase a Woodgas Stove](#)** through this site.

Our second target for wood-gas stoves will be the refugee camps around the world that have 40 million mouths to cook for, and are currently using propane, gasoline or kerosene. They have the skills to manufacture the stove and labor to do it. They could also manufacture for the country as a whole. The BEF is prepared to apply our skills to the needs of developing countries and recommend a stove program that fits local conditions. If interested in working with the Biomass Energy Foundation to develop a stove program for other countries, please check with us at **[tombreed@comcast.net](mailto:tombreed@comcast.net)**.

You can purchase a **[WoodGas Camp Stove](#)** through our online bookstore.

**[See what people using them have to say.](#)**



# WOODGAS

## BIOMASS

### WATER CONTENT OF BIOMASS

#### Home

#### Biomass Energy

The water content of biomass can be a major problem if it isn't recognized, and a wet log looks exactly like a dry one , so one can't judge "by eye".

Biomass is a complex fuel, composed of the volatile components (typically 70-90%), charcoal that results on heating (10-30%), some mineral/ash content (1-20%) and varying amounts of moisture. For this reason most analyses are given on a "dry ash free" (DAF) basis.

#### Gasification & Reforming

#### Liquid Fuels

#### Wood Cooking

However, wood and other biomass are almost NEVER bone dry, and go up and down with the seasons. Worse yet, sometimes moisture content is reported on a wet basis (MCWB) and sometimes on a dry basis. When a tree is cut down in summer it can contain 50% moisture (wet basis) or 100% moisture (!) dry basis. These two standards can cause a lot of confusion unless understood.

#### Energy

#### Rosetta Stone

#### Bookstore

#### About the BEF

#### Links

However it is easy to measure water content. Weigh a sample, then heat to 105 C for 1-4 hours, depending on sample size to find bone dry weight. (I use my wife's oven.) The moisture content wet basis (MCWB) is given by

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$$\text{MCWB} = 100 \times (\text{Initial Wt} - \text{Dry weight}) / (\text{Initial Weight})$$

However, since we are interested in the dry use of biomass and don't want to pay for the water, biomass moisture content is sometimes reported on a "dry" basis (MCDB) where

$$\text{MCDB} = 100 \times (\text{Initial Wt} - \text{Dry weight}) / (\text{Dry Weight})$$

MCWB would be the basis usually assumed, but if one is interested in the fuel or lumber properties, one is most interested in the MCDB.



## FUEL DENSITIES



We usually find the mass energy content of fuels tabulated on an energy/mass basis. Yet the energy/volume is often equally important for shipment, storage and use. This table includes the densities of various fuels and calculates the volumetric energy density.

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| ref nr | FUEL TYPE              | Mass    |          | Moisture | Ash*            | Energy Density | Volumetric |                | Volumetric     |                | Relative     |              |              | Unit**       | Cost         | Co2 Emissions |       |           |           |
|--------|------------------------|---------|----------|----------|-----------------|----------------|------------|----------------|----------------|----------------|--------------|--------------|--------------|--------------|--------------|---------------|-------|-----------|-----------|
|        |                        | Density | Moisture |          |                 |                | Mass       | Energy Density | Energy Density | Energy Density | Mass         | Bulk Vol.    | Bulk Vol.    |              |              |               | Mass  | Bulk Vol. | Bulk Vol. |
|        |                        | kg/m3   | % MC     | %        | MJ/kg or GJ/ton | GJ/m3          | GJ/m3      | GJ/m3          | GJ/m3          | Ener. Dsy      | Ener.Dsy     | Multiplier   | Ener. Dsy    | Ener.Dsy     | Multiplier   | Cost \$       | \$/Gj | kg/Gj1    | kg/Gj2    |
|        |                        | solid   | bulk     |          |                 | Solid          | bulk       | Solid          | bulk           | (to coal AW)   | (to coal AW) | (to coal AW) | (to coal TR) | (to coal TR) | (to coal TR) |               |       |           |           |
| 1      | Brown Coal - VIC       | 1120    | 860      | 62.5     | 2               | 8.0            | 9.0        | 6.9            |                | 0.33           | 0.34         | 2.97         |              |              |              | 5/t           | 0.63  | 93.3      | 87.7      |
| 2      | Black Coal - NSW       | 1450    | 940      | 8        | 22              | 24.0           | 34.8       | 22.6           |                | 1.00           | 1.11         | 0.90         |              |              |              | 30/t          | 1.25  | 90.7      | 89.4      |
| 3      | Petrol                 |         | n/a      | <1       | <1              | 34.2/l         |            |                |                |                |              |              |              |              |              | 0.73/l        | 21.35 |           | 71.3      |
| 4      | Auto Diesel            | 842     | n/a      | <1       | <1              | 45.7           | 38.5       |                |                | 1.90           |              |              |              |              |              | 0.74/l        | 19.25 | 69.7      | 74.9      |
| 5      | LPG                    |         | n/a      | <1       | <1              | 26.2/l         |            |                |                |                |              |              |              |              |              |               |       | 59.4      | 64.7      |
| 6      | Natural Gas            | n/a     | n/a      | <1       | <1              | 37.2/l         |            |                |                |                |              |              |              |              |              | n/a           | 13.81 | 50.9      | 59.4      |
| 7      | Sawdust (wet)          | 1100    | 367      | 50%      | <1 variable     | 11.85          | 13.0       | 4.3            |                | 0.49           | 0.21         | 4.69         |              |              |              | 20/t          | 1.69  | 90.0      |           |
| 8      | Sawdust (air dry)      | 800     | 267      | 10%      | <1 variable     | 17.06          | 13.6       | 4.6            |                | 0.71           | 0.22         | 4.48         |              |              |              | 20/t          |       | 90.0      |           |
| 9      | Woodchips (wet)        | 1100    | 550      | 50%      | <1 variable     | 11.85          | 13.0       | 6.5            |                | 0.49           | 0.32         | 3.13         |              |              |              | 35/t          | 2.95  | 90.0      |           |
| 10     | Woodchips (forest dry) | 800     | 400      | 10%      | <1 variable     | 17.06          | 13.6       | 6.8            |                | 0.71           | 0.33         | 2.99         |              |              |              | 35/t          |       | 90.0      |           |
| 11     | Wood Pellets           | n/a     | 705      | 6+ 2%    | 0.33 to 1       | 19.75          |            | 13.9           |                | 0.82           | 0.68         | 1.47         |              |              |              | 165/t         | 8.35  | 90.0      |           |
| 12     | US Forest Residues     | n/a     | 340      | 50%      | <1 variable     | 11.6           |            | 3.9            |                | 0.48           | 0.19         | 5.17         |              |              |              | 38/t          | 1.64  | 90.0      |           |
| 13     | Bagasse (wet)          |         |          | 50%      |                 | 8.2            |            |                |                | 0.34           |              |              |              |              |              |               |       |           |           |
| 14     | Bagasse (air dry)      |         |          | 13%      |                 | 16.2           |            |                |                | 0.68           |              |              |              |              |              |               |       |           |           |
| 15     | Charcoal               |         |          | 5%       |                 | 30             |            |                |                | 1.25           |              |              |              |              |              |               |       |           |           |
| 16     | Torrefied Wood         | 600     | 300      | 10%      | <1 variable     | 21.5           | 12.9       | 6.5            |                | 0.90           | 0.32         | 3.16         |              |              |              | n/a           |       |           |           |

Biomass Energy Foundation: Fuel Densities

|    |                           |      |      |    |  |      |  |  |      |      |      |      |      |      |
|----|---------------------------|------|------|----|--|------|--|--|------|------|------|------|------|------|
| 17 | Internatl steam coal      |      | 850  |    |  | 24   |  |  | 20.4 |      |      | 1.00 | 1.00 | 1.00 |
| 18 | Loose saw dust (dry)      |      | 200  |    |  | 18   |  |  | 3.6  |      |      | 0.75 | 0.18 | 5.67 |
| 19 | Wood pellets (dry)        | 1300 | 650  |    |  | 18   |  |  | 23.4 | 11.7 |      | 0.75 | 0.57 | 1.74 |
| 20 | Torrefied pellets         | 1300 | 650  | 3% |  | 22   |  |  | 28.6 | 14.3 |      | 0.92 | 0.70 | 1.43 |
| 21 | softwood chips (dry)      |      | 190  | 7% |  | 20   |  |  |      |      |      | 3.8  |      |      |
| 22 | HD 1/4"sawdust pellets    |      | 680  |    |  | 20   |  |  |      |      |      | 13.6 |      |      |
| 23 | 3/8" peanut shell pellets |      | 650  |    |  | 19.8 |  |  |      |      |      | 12.9 |      |      |
| 24 | Corn                      |      | 760  |    |  | 19   |  |  |      |      |      | 14.4 |      |      |
| 25 | Soybeans                  |      | 770  |    |  | 21   |  |  |      |      |      | 16.2 |      |      |
| 26 | Coconut shells 1/4"       |      | 540  |    |  | 20.5 |  |  |      |      |      | 11.1 |      |      |
| 27 | Coal bitumous             |      | 1100 |    |  | 32.5 |  |  |      |      |      | 35.8 |      |      |
| 28 | Biodiesel                 | 920  |      |    |  | 41.2 |  |  |      |      | 37.9 |      |      |      |
| 29 | Diesel                    | 880  |      |    |  | 45.7 |  |  |      |      | 40.2 |      |      |      |

|      |      |      |
|------|------|------|
| 0.62 | 0.11 | 9.42 |
| 0.62 | 0.38 | 2.63 |
| 0.61 | 0.36 | 2.78 |
| 0.58 | 0.40 | 2.48 |
| 0.65 | 0.45 | 2.21 |
| 0.63 | 0.31 | 3.23 |
| 1.00 | 1.00 | 1.00 |
| 1.27 |      |      |
| 1.41 |      |      |

\* Percentages by weight.

Mass energy density (in MJ/kg or GJ/ton) and Solid and Bulk Volumetric density (in GJ/m3) on Low Heat Value or High Heat Value

Costs - Unit cost for Black and Brown coal from Brockway (1997).

Energy density - effects volume of throughput required, storage, cost of transport per btu etc

Figures for Wood Pellets based on 8500 btu/lb. Wood pellets range in energy from just under 8000 to almost 9000 btu/lb.

Figures for sawdust and woodchips are based on an energy value for oven dry eucalypt hardwood of about 19Kj/g. Figures

for energy value by weight for softwoods such as pine, would be about 10% higher.

Figures were converted to energy values at various moisture contents

$$\text{using the formula } EV (\text{energy value @ mc\%}) = EV(od) \cdot (100 - (MC/8)) / (100 + MC)$$

Density of wood reflect approximate averages for common East coast Australian hardwoods. Green density varies considerably

less than air dry density (700- to 900+), reflecting variation in moisture contents of 'green' timber.

Bulk Density of woodchips and sawdust are taken to be 50% and 33% of the original woods density respectively.

1 - Co2 emission factors from [www.gas.asn.au/australia/gas1.htm](http://www.gas.asn.au/australia/gas1.htm)

2 - Co2 emission factors from Oz inst energy site

35.315 cu foot per cu metre

1055.056 joules per btu British thermal units(International table)x 1055.056

Btu (th) x 1054.350

Btu (mean) x 1055.87

|    |  |
|----|--|
|    | ** - Unit cost is the cost of the fuel to the end user in units common for that fuel.  |
|    | Hence coal is cost to power station, petrol to consumers etc. Pellet costs are USD.  |
|    | ^ - Bulk densities for coal as sized for transporting on conveyors.  |
|    | In terms of value on the world market, 1 green tonne of woodchips is worth \$75/tonne,   |
|    | compared with \$60 for coal and \$30 for iron ore  |
|    | FUEL SOURCE references   |
| 1  | Pers Comm Mr. Michael Laird Mine Strategy Manager Loy Yang Power - email 31 Oct 2000   |
| 2  | Pers Comm Ross Shirtly - Sevices Manager Eraring Power Station, email 2/11/00.   |
|    | Pers Comm Ministry of Energy & Utilities - Pers Comm 31 Oct 2000   |
| 3  | Australian Institute of Energy web site - <a href="http://www.aie.org.Australia/melb/material/resource/fuels.htm">www.aie.org.Australia/melb/material/resource/fuels.htm</a> |
| 4  | Australian Institute of Energy web site - <a href="http://www.aie.org.Australia/melb/material/resource/fuels.htm">www.aie.org.Australia/melb/material/resource/fuels.htm</a> |
| 5  | Energy value from OzInst energy av of two figures given.   |
| 6  | Gross calorific value after extraction of NGL's WEC 2000. Price (1998) from Energy at a Glance 1999 NSW  |
| 7  |  |
| 8  |  |
| 9  |  |
| 10 |  |
| 11 | from Pellet Flame web site - <a href="http://www.pelletflame.com/pelletanalysis.htm">www.pelletflame.com/pelletanalysis.htm</a> , price averige retail from                  |
|    | Pellet Fuels Inst Arlington, VA USA in \$US  |
|    | energy varies by +- 6% depending on fuel quality   |
| 12 | Pers Comm Steve Jolley Dec1 00 @ 38\$ per bdt  |
| 13 | Energy and mc from Greenhouse Gas Assessment handbook  |
| 14 | Energy and mc from Greenhouse Gas Assessment handbook  |
| 15 | 5mc and 29 according to GGAH   |
| 16 | Assumed a 20% weight loss TW from "forest dry" chips.  |
| 17 | approximate plant data from A. Weststeijn  |
| 18 | approximate plant data from A. Weststeijn  |
| 19 | approximate plant data from A. Weststeijn  |
| 20 | data from Tom Reed via A.Weststeijn  |
| 21 | data from Tom Reeds posting of May 28th, 2001  |
| 22 | data from Tom Reeds posting of May 28th, 2001  |

|    |   |
|----|---|
| 23 | data from Tom Reeds posting of May 28th, 2001 |
| 24 | data from Tom Reeds posting of May 28th, 2001 |
| 25 | data from Tom Reeds posting of May 28th, 2001 |
| 26 | data from Tom Reeds posting of May 28th, 2001 |
| 27 | data from Tom Reeds posting of May 28th, 2001 |
| 28 | data from Tom Reeds posting of May 28th, 2001 |
| 29 | data from Tom Reeds posting of May 28th, 2001 |





## DENSIFICATION



## PROXIMATE AND ULTIMATE ANALYSES

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Biomass fuels are characterized by what is called the "Proximate and Ultimate analyses". The "proximate" analysis gives moisture content, volatile content (when heated to 950 C), the free carbon remaining at that point, the ash (mineral) in the sample and the high heating value (HHV) based on the complete combustion of the sample to carbon dioxide and liquid water. (The low heating value, LHV, gives the heat released when the hydrogen is burned to gaseous water, corresponding to most heating applications and can be calculated from the HHV and H<sub>2</sub> fraction.)

The "ultimate" analysis" gives the composition of the biomass in wt% of carbon, hydrogen and oxygen (the major components) as well as sulfur and nitrogen (if any).

The table below, showing Proximate and Ultimate analyses, is from Appendix A of our book<sup>1</sup>, and gives analyses of over 140 fuels, including biomass components, natural biomass (woods, agricultural products), processed biomass, other solid and liquid fuels. For ease of reading download to a spreadsheet file.

The Proximate Analysis (D-3175), gives the fixed carbon, volatile and ash content of biomass. The Ultimate Analysis gives the elemental (C, H, O, S, N) analysis. The Gross heating value The data is often published with various articles in widely scattered journals. The data have been brought together for convenience in this one place. These standard ASTM tests and are performed by many laboratories in the country, routinely on coal, but competently on biomass. They typically cost \$100-\$200 so it is good to be able to find collected results for various biomass materials.

Our book "Thermal Data for Natural and Synthetic Fuels", Marcel Dekker, 1998, gives an extended list of the Prox and Ult analyses of about 300 forms of biomass, most of which were collected in the thesis of S. A. Channiwala from the Indian Institute of Technology, 1992.

I have long been fascinated with the close relationship between the heat of combustion (high heating value, HHV) and the elemental composition as given in the ultimate analysis. This was first noticed by DuLong in the 19th century and brought up to date by other scientists. Most recently a Mr. S. A. Channiwala 1992 thesis, The

Indian Institute of Technology, Bombay) collected data on over 200 species of biomass and fitted the following equation to the data:

$$\text{HHV (in kJ/g)} = 0.3491\text{C} + 1.1783\text{H} - 0.1034\text{O} - 0.0211\text{A} + 0.1005\text{S} - 0.0151\text{N}$$

(where C is the weight fraction of carbon; H of hydrogen; O of oxygen; A of ash; S of sulfur and N of nitrogen appearing in the ultimate analysis. )

He found that this equation fitted the experimental data with an average error of 1.45%, typical of the error of most measurements. This equation permits using heat values in calculations and models of biomass processes.

Other analyses can be found at the following websites:

### [The Energy Center of the Netherlands](#),

[IEA](#), The International Energy Agency,

[Biobib](#) (Austria)

| Name           | Fixed  | Volatiles | Ash  | C     | H    | O     | N    | S    | HHV   | HHV   |
|----------------|--------|-----------|------|-------|------|-------|------|------|-------|-------|
|                | Carbon |           |      |       |      |       |      |      | MEAS  | CALC  |
|                | %      | %         | %    | %     | %    | %     | %    | %    | kJ/g  | kJ/g  |
| WOOD           |        |           |      |       |      |       |      |      |       |       |
| Beech          | -      | -         | 0.65 | 51.64 | 6.26 | 41.45 | 0.00 | 0.00 | 20.38 | 21.10 |
| Black Locust   | 18.26  | 80.94     | 0.80 | 50.73 | 5.71 | 41.93 | 0.57 | 0.01 | 19.71 | 20.12 |
| Douglas Fir    | 17.70  | 81.50     | 0.80 | 52.30 | 6.30 | 40.50 | 0.10 | 0.00 | 21.05 | 21.48 |
| Hickory        | -      | -         | 0.73 | 47.67 | 6.49 | 43.11 | 0.00 | 0.00 | 20.17 | 19.82 |
| Maple          | -      | -         | 1.35 | 50.64 | 6.02 | 41.74 | 0.25 | 0.00 | 19.96 | 20.42 |
| Ponderosa Pine | 17.17  | 82.54     | 0.29 | 49.25 | 5.99 | 44.36 | 0.06 | 0.03 | 20.02 | 19.66 |

|                          |       |       |      |       |      |       |      |      |       |       |
|--------------------------|-------|-------|------|-------|------|-------|------|------|-------|-------|
| Poplar                   | -     | -     | 0.65 | 51.64 | 6.26 | 41.45 | 0.00 | 0.00 | 20.75 | 21.10 |
| Red Alder                | 12.50 | 87.10 | 0.40 | 49.55 | 6.06 | 43.78 | 0.13 | 0.07 | 19.30 | 19.91 |
| Redwood                  | 16.10 | 83.50 | 0.40 | 53.50 | 5.90 | 40.30 | 0.10 | 0.00 | 21.03 | 21.45 |
| Western Hemlock          | 15.20 | 84.80 | 2.20 | 50.40 | 5.80 | 41.10 | 0.10 | 0.10 | 20.05 | 20.14 |
| Yellow Pine              | -     | -     | 1.31 | 52.60 | 7.00 | 40.10 | 0.00 | 0.00 | 22.30 | 22.44 |
| White Fir                | 16.58 | 83.17 | 0.25 | 49.00 | 5.98 | 44.75 | 0.05 | 0.01 | 19.95 | 19.52 |
| White Oak                | 17.20 | 81.28 | 1.52 | 49.48 | 5.38 | 43.13 | 0.35 | 0.01 | 19.42 | 19.12 |
| Madrone                  | 12.00 | 87.80 | 0.20 | 48.94 | 6.03 | 44.75 | 0.05 | 0.02 | 19.51 | 19.56 |
| Mango Wood               | 11.36 | 85.64 | 2.98 | 46.24 | 6.08 | 44.42 | 0.28 |      | 19.17 | 18.65 |
| BARK                     |       |       |      |       |      |       |      |      |       |       |
| Douglas Fir bark         | 25.80 | 73.00 | 1.20 | 56.20 | 5.90 | 36.70 | 0.00 | 0.00 | 22.10 | 22.75 |
| Loblolly Pine bark       | 33.90 | 54.70 | 0.40 | 56.30 | 5.60 | 37.70 | 0.00 | 0.00 | 21.78 | 22.35 |
| ENERGY CROPS             |       |       |      |       |      |       |      |      |       |       |
| Eucalyptus Camaldulensis | 17.82 | 81.42 | 0.76 | 49.00 | 5.87 | 43.97 | 0.30 | 0.01 | 19.42 | 19.46 |
| Casuarina                | 19.58 | 78.58 | 1.83 | 48.50 | 6.04 | 43.32 | 0.31 | 0.00 | 18.77 | 19.53 |
| Poplar                   | 16.35 | 82.32 | 1.33 | 48.45 | 5.85 | 43.69 | 0.47 | 0.01 | 19.38 | 19.26 |
| Sudan Grass              | 18.60 | 72.75 | 8.65 | 44.58 | 5.35 | 39.18 | 1.21 | 0.01 | 17.39 | 17.62 |
| PROCESSED BIOMASS        |       |       |      |       |      |       |      |      |       |       |

|                                 |       |       |       |       |      |       |      |      |       |       |
|---------------------------------|-------|-------|-------|-------|------|-------|------|------|-------|-------|
| Plywood                         | 15.77 | 82.14 | 2.09  | 48.13 | 5.87 | 42.46 | 1.45 | 0.00 | 18.96 | 19.26 |
| AGRICULTURAL                    |       |       |       |       |      |       |      |      |       |       |
| Peach Pits                      | 19.85 | 79.12 | 1.03  | 53.00 | 5.90 | 39.14 | 0.32 | 0.05 | 20.82 | 21.39 |
| Walnut Shells                   | 21.16 | 78.28 | 0.56  | 49.98 | 5.71 | 43.35 | 0.21 | 0.01 | 20.18 | 19.68 |
| Almond Prunings                 | 21.54 | 76.83 | 1.63  | 51.30 | 5.29 | 40.90 | 0.66 | 0.01 | 20.01 | 19.87 |
| Black Walnut Prunings           | 18.56 | 80.69 | 0.78  | 49.80 | 5.82 | 43.25 | 0.22 | 0.01 | 19.83 | 19.75 |
| Corncoobs                       | 18.54 | 80.10 | 1.36  | 46.58 | 5.87 | 45.46 | 0.47 | 0.01 | 18.77 | 18.44 |
| Wheat Straw                     | 19.80 | 71.30 | 8.90  | 43.20 | 5.00 | 39.40 | 0.61 | 0.11 | 17.51 | 16.71 |
| Cotton Stalk                    | 22.43 | 70.89 | 6.68  | 43.64 | 5.81 | 43.87 | 0.00 | 0.00 | 18.26 | 17.40 |
| Corn Stover                     | 19.25 | 75.17 | 5.58  | 43.65 | 5.56 | 43.31 | 0.61 | 0.01 | 17.65 | 17.19 |
| Sugarcane Bagasse               | 14.95 | 73.78 | 11.27 | 44.80 | 5.35 | 39.55 | 0.38 | 0.01 | 17.33 | 17.61 |
| Rice Hulls                      | 15.80 | 63.60 | 20.60 | 38.30 | 4.36 | 35.45 | 0.83 | 0.06 | 14.89 | 14.40 |
| Pine needles                    | 26.12 | 72.38 | 1.50  | 48.21 | 6.57 | 43.72 |      |      | 20.12 | 20.02 |
| Cotton gin trash                | 15.10 | 67.30 | 17.60 | 39.59 | 5.26 | 36.38 | 2.09 | 0.00 | 16.42 | 15.85 |
| AQUATIC BIOMASS                 |       |       |       |       |      |       |      |      |       |       |
| Water Hyacinth (Florida)        | -     | 80.40 | 19.60 | 40.30 | 4.60 | 33.99 | 1.51 | 0.00 | 14.86 | 15.54 |
| Brown Kelp, Giant, Soquel Point | -     | 57.90 | 42.10 | 27.80 | 3.77 | 23.69 | 4.63 | 1.05 | 10.75 | 10.85 |
| AVERAGE                         |       |       |       | 47.91 | 5.74 | 40.98 | 0.52 | 0.05 | 19.11 | 19.15 |

|  |       |       |       |       |       |       |      |      |       |       |
|--|-------|-------|-------|-------|-------|-------|------|------|-------|-------|
| LIQUID FUELS                                 |       |       |       |       |       |       |      |      |       |       |
| n-octane                                     | 0.00  | -     | 0.00  | 84.10 | 15.90 | 0.00  | 0.00 | 0.00 | 47.80 | 48.09 |
| Benzene, C <sub>6</sub> H <sub>6</sub>       | 0.00  |       |       | 92.25 | 7.75  | 0.00  | 0.00 | 0.00 | 41.79 | 41.34 |
| Motor Gasoline                               | 0.00  |       |       | 85.50 | 14.40 | 0.00  | 0.00 | 0.10 | 46.88 | 46.83 |
| Kerosene                                     | 0.00  |       | 0.01  | 85.80 | 14.10 | 0.00  | 0.00 | 0.10 | 46.50 | 46.58 |
| Methanol,<br>CH <sub>3</sub> OH              | 0.00  |       | 0.00  | 37.50 | 12.50 | 50.00 | 0.00 | 0.00 | 22.69 | 22.65 |
| Ethanol,<br>C <sub>2</sub> H <sub>5</sub> OH | 0.00  |       | 0.00  | 52.20 | 13.00 | 34.80 | 0.00 | 0.00 | 30.15 | 29.94 |
| PYROLYSIS<br>OILS                            |       |       |       |       |       |       |      |      |       |       |
| LBL Wood Oil                                 |       |       | 0.78  | 72.30 | 8.60  | 17.60 | 0.20 | 0.01 | 33.70 | 33.53 |
| BOM wood oil                                 |       |       | 0.66  | 82.00 | 8.80  | 9.20  | 0.60 | 0.00 | 36.80 | 38.02 |
| Coke-oven tar                                |       |       | 0.25  | 91.75 | 5.50  | 0.80  | 0.90 | 0.80 | 38.20 | 38.49 |
| Low Temp Tar                                 |       |       |       | 83.00 | 8.20  | 7.40  | 0.60 | 0.80 | 38.75 | 37.94 |
| SOLID FUELS                                  |       |       |       |       |       |       |      |      |       |       |
| Coal - Pittsburgh<br>Seam                    | 55.80 | 33.90 | 10.30 | 75.50 | 5.00  | 4.90  | 1.20 | 3.10 | 31.75 | 31.82 |
| Peat, S-H3                                   | 26.87 | 70.13 | 3.00  | 54.81 | 5.38  | 35.81 | 0.89 | 0.11 | 22.00 | 21.70 |
| Charcoal                                     | 89.31 | 93.88 | 1.02  | 92.04 | 2.45  | 2.96  | 0.53 | 1.00 | 34.39 | 34.78 |
| Oak char (565C)                              | 55.60 | 27.10 | 17.30 | 64.60 | 2.10  | 15.50 | 0.40 | 0.10 | 23.05 | 23.06 |
| Casuarina Char<br>(950C)                     | 71.53 | 15.23 | 13.24 | 77.54 | 0.93  | 5.62  | 2.67 | 0.00 | 27.12 | 27.26 |

|  |       |         |       |        |        |       |               |              |             |        |
|--|-------|---------|-------|--------|--------|-------|---------------|--------------|-------------|--------|
| Coconut Shell Char (750C)                                | 87.17 | 9393.00 | 2.90  | 88.95  | 0.73   | 6.04  | 1.38          | 0.00         | 31.12       | 31.21  |
| Eucalyptus char (950C)                                   | 70.32 | 19.22   | 10.45 | 76.10  | 1.33   | 11.10 | 1.02          | 0.00         | 27.60       | 26.75  |
| ORGANIC CHEMICALS  |       |         | M     |        |        |       | <i>cal/mo</i> | <i>cal/g</i> | <i>kJ/g</i> |        |
| Acetone; (CH <sub>3</sub> ) <sub>2</sub> CO              |       |         | 58    | 62.07  | 10.34  | 27.59 | 428           | 7.38         | 30.9        | 31.01  |
| Acetic Acid; CH <sub>3</sub> CO <sub>2</sub> H           |       |         | 60    | 40.00  | 6.67   | 53.33 | 209           | 3.48         | 14.6        | 16.30  |
| D-Glucose; C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> |       |         | 180   | 40.00  | 6.67   | 53.33 | 670           | 3.72         | 15.6        | 16.30  |
| Phenol; C <sub>6</sub> H <sub>5</sub> OH                 |       |         | 94    | 76.60  | 6.38   | 17.02 | 730           | 7.76         | 32.5        | 32.50  |
| Cellulose; C <sub>6</sub> H <sub>10</sub> O <sub>5</sub> |       |         | 162   | 44.44  | 6.17   | 49.38 |               |              |             | 17.68  |
| Lignin (Softwood)  |       |         |       | 63.8   | 6.30   | 29.90 |               |              |             | 26.60  |
| Lignin (Hardwood)  |       |         |       | 59.8   | 6.40   | 33.70 |               |              |             | 24.93  |
| EXCEPTIONS   |       |         |       |        |        |       |               |              |             |        |
| Hydrogen, H <sub>2</sub>                                 |       |         |       | 0.00   | 100.00 | 0.00  | 0.00          | 0.00         | 141.26      | 117.83 |
| Carbon Monoxide, CO                                      |       |         |       | 42.86  | 0.00   | 57.14 | 0.00          | 0.00         | 10.16       | 9.05   |
| Acetylene  |       |         |       | 92.25  | 7.75   | 0.00  | 0.00          | 0.00         | 49.60       | 41.34  |
| Carbon   |       |         |       | 100.00 | 0.00   | 0.00  |               |              | 32.81       | 34.91  |

|                                    |  |  |  |       |       |       |  |  |      |      |
|------------------------------------|--|--|--|-------|-------|-------|--|--|------|------|
| Carbon dioxide,<br>CO <sub>2</sub> |  |  |  | 27.27 | 0.00  | 72.7% |  |  | 0.00 | 9.45 |
| Water                              |  |  |  | 0.00  | 11.11 | 88.89 |  |  | 0.00 | 3.90 |

(1) "Thermal Data for Natural and Synthetic Fuels", S. Gaur and T. Reed, Marcel Dekker, 1998.



# WOODGAS

## SMALL GASIFIERS

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Gasifiers are usually rated in kW (or Horsepower) of output, either kW<sub>th</sub> or kW<sub>el</sub> and vary from . If you have a large quantity of biomass (ie MSW) you might like a 100 ton/day unit which would yield about 20 MW<sub>thermal</sub> or about 4 MW<sub>el</sub> at 20% efficiency. Could cost you \$10 Million (at \$2000/kW capacity). These large gasifiers can be fixed bed (updraft or downdraft), fluidized bed, or even entrained feed gasifiers.

I have written a number of articles and books on all aspects of gasification and you can get an overview of current activity from our book "Survey of Biomass Gasification - 2001" including the different gasifier types, who is making them, costs, addresses etc. ([see books](#)). The "old testament" of small gasifiers is "Gengas: The Swedish Classic on Wood Fueled Vehicles". The "new testament" of small gasifiers is the "Biomass downdraft Gasifier Handbook", by T. Reed and A. Das.

I am very much dedicated to seeing gasifiers serve the needs of humanity, but most of the world can't afford to use large scale gasifiers and doesn't have a large supply, so there needs to be information on small gasifiers as well.

So, my personal specialty has been small gasifiers for

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power and transportation that I can make in my own small laboratory here in Golden Colorado. These small gasifiers are particularly useful and educational because they are easy to build, alter and study. From 1980-1986 we built and operated a 1 ton/day gasifier at the Solar Energy Research Institute, spending possibly \$6 million for designers, fabricators, instrumentation engineers and rented space at Hazen Research here in Golden. Each institutional step could take days or weeks to complete.

While waiting for the institutional wheels to grind, we took matters into our own hands and built a 5 gallon pail gasifier in the alley behind our laboratory. It had a blower and a flair, and we learned more about the basic science of gasification in that zero cost project than we learned from the \$6 million project. All of this is described in our book "FUNDAMENTAL STUDY AND SCALE UP OF THE AIR-OXYGEN STRATIFIED DOWNDRAFT GASIFIER" ([see Books](#)).



One of our smallest gasifiers was used to investigate the relationship between the superficial velocity and the amount of charcoal and tar produced in the pyrolysis stage of gasification. It resulted in a paper, "[Superficial Velocity - The Key to Biomass Gasification](#)", which is one of the most fundamental studies of my long career and which informs my judgment on all gasifier design. The gasifier was only 30 cm tall and 5 cm inside diameter. The research was completed in less than a week (but took months to appreciate the importance).

Currently our smallest gasifier is incorporated in our

**WoodGas Cookstoves** which we hope will eventually cook better meals for the 3 billion people now cooking substandard meals with too much fuel and smoke. The stove is only 15 cm tall and 12 cm in diameter and is ideal for camping or emergency cooking. We hope to build an even smaller gasifier for lighting.



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## Web Hosting Companies and Service Providers

Having the right hosting solution can make all the difference in the world. But with thousands of web hosting companies in the market place it can be difficult if not impossible to know which web site hosting companies truly provide an excellent hosting solution at an excellent price. Our Web Hosting directory includes those web hosting companies that we've hand picked based on the overall hosting value they provide. And yes, there are many web hosting companies that provide high quality, reliable web hosting at very inexpensive price - we've just selected the best. To get started simply make your selection for the links below.



### Top Web Hosting Companies

Last Update: **Thursday, October 09, 2008**

| # | WEB HOSTING COMPANY            | PRICE / MONTH | SETUP | DISK SPACE / BAND WIDTH | Email | FEATURES   | EDITOR'S RATING   |
|---|--------------------------------|---------------|-------|-------------------------|-------|--|---|
| 1 | <a href="#">IX Web Hosting</a> | \$3.95        | Free  | 100,000 MB / 1,000 GB   | 2,500 | <ul style="list-style-type: none"> <li>✦ Hosts 2 Domains</li> <li>✦ 100 GB Web Space</li> <li>✦ 1 Free Domain Reg</li> <li>✦ 100 Sub Domains</li> <li>✦ 1,000 GB Data Transfer</li> <li>✦ Perl, CGI-BIN, MYSQL, etc.</li> <li>✦ Web Stats and more!</li> </ul>   | <b>Overall Rating</b><br>★★★★★<br>Uptime 5/5<br>Support 5/5<br>Service 5/5<br>Pricing 5/5<br>Features 5/5 |
| 2 | <a href="#">IPower</a>         | \$7.95        | Free  | 50,000 MB / 750 GB      | 2,500 | <ul style="list-style-type: none"> <li>✦ 1 FREE Domain Name</li> <li>✦ SSL / CGI / PHP / MySQL</li> <li>✦ E-Commerce Enabled</li> <li>✦ \$30 Google Credit</li> <li>✦ \$50 Yahoo Credit</li> <li>✦ Marketing / Content Package</li> <li>✦ Website Templates</li> <li>✦ Website Builder</li> <li>✦ Host 6 Domains in 1</li> </ul> | <b>Overall Rating</b><br>★★★★★<br>Uptime 5/5<br>Support 5/5<br>Service 5/5<br>Pricing 5/5<br>Features 4/5 |

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|   |                            |        |      |                       |           |   |   |
|---|----------------------------|--------|------|-----------------------|-----------|---|---|
| 3 | <a href="#">LunarPages</a> | \$6.95 | Free | 35,000 MB / 800 GB GB | Unlimited | <ul style="list-style-type: none"> <li>✦ FREE Domain Name For Life</li> <li>✦ Unlimited MySQL Databases</li> <li>✦ Ruby on Rails</li> <li>✦ E-Commerce</li> <li>✦ Frontpage® Compatible</li> <li>✦ Blog, Forum &amp; Photo Gallery</li> <li>✦ Spam Protection</li> <li>✦ Includes 1 Addon Domain</li> <li>✦ And Much More!</li> </ul> | <b>Overall Rating</b><br>★★★★★<br>Uptime 5/5<br>Support 5/5<br>Service 5/5<br>Pricing 5/5<br>Features 4.5/5 |
|---|----------------------------|--------|------|-----------------------|-----------|---|---|

**Lunarpages** also offers [Web Hosting](#), [Windows Hosting](#), [Virtual Private Servers](#), and [Dedicated Servers](#).

|   |                            |        |      |                       |           |  |   |
|---|----------------------------|--------|------|-----------------------|-----------|--|---|
| 4 | <a href="#">StartLogic</a> | \$5.95 | Free | 50,000 MB /<br>750 GB | Unlimited | <ul style="list-style-type: none"> <li>✦ Host 10 Domains in 1</li> <li>✦ 30 Day Money Back</li> <li>✦ FREE Domain</li> <li>✦ CGI-bin, PHP, MySQL</li> <li>✦ Frontpage® Compatible</li> <li>✦ VDECK 2.0 Control Panel</li> <li>✦ Website Templates</li> <li>✦ And Much More!</li> </ul> | <b>Overall Rating</b><br><br>Uptime 5/5<br>Support 5/5<br>Service 4/5<br>Pricing 5/5<br>Features 4/5 |
|---|----------------------------|--------|------|-----------------------|-----------|--|---|

**StartLogic** also offers [Web Hosting](#), [Windows Hosting](#), [Virtual Private Servers](#), and [Dedicated Servers](#).

|   |                             |        |      |                               |      |  |   |
|---|-----------------------------|--------|------|-------------------------------|------|--|---|
| 5 | <a href="#">Dot5Hosting</a> | \$4.95 | Free | 100 GB /<br>1000 GB<br>(NEW!) | 5000 | <ul style="list-style-type: none"> <li>✦ Free Domain Forever</li> <li>✦ Host 6 Domains on 1</li> <li>✦ SSL, FTP, Stats</li> <li>✦ CGI, Ruby, Perl, PHP, MySQL</li> <li>✦ Front Page Extensions</li> <li>✦ Free Site Builder</li> <li>✦ 24/7 Phone Support</li> </ul> | <b>Overall Rating</b><br><br>Uptime 5/5<br>Support 5/5<br>Service 5/5<br>Pricing 5/5<br>Features 4/5 |
|---|-----------------------------|--------|------|-------------------------------|------|--|---|

|   |                          |        |      |                                   |           |  |   |
|---|--------------------------|--------|------|-----------------------------------|-----------|--|---|
| 6 | <a href="#">MidPhase</a> | \$7.95 | Free | 25,000 MB /<br>1,500 GB<br>(NEW!) | Unlimited | <ul style="list-style-type: none"> <li>✦ E-Commerce Enabled</li> <li>✦ 24/7 Phone Support</li> <li>✦ FREE Web Design Software</li> <li>✦ MySQL, Python, PERL/CGI, CRON Access</li> <li>✦ CMS Software</li> <li>✦ Easy Control Panel</li> <li>✦ Frontpage Compatible</li> <li>✦ And Much More!</li> </ul> | <b>Overall Rating</b><br><br>Uptime 4/5<br>Support 4/5<br>Service 5/5<br>Pricing 5/5<br>Features 5/5 |
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**MIDPHASE** also offers [Web Hosting](#), [Windows Hosting](#), [Virtual Private Servers](#), and [Dedicated Servers](#).

|   |                        |        |      |                       |           |  |   |
|---|------------------------|--------|------|-----------------------|-----------|--|---|
| 7 | <a href="#">POWWEB</a> | \$5.77 | Free | 20,000 MB /<br>400 GB | Unlimited | <ul style="list-style-type: none"> <li>✦ Load Based Technology</li> <li>✦ 30-Day Money-Back</li> <li>✦ Host Unlimited Domains</li> <li>✦ MySQL, PHP, CGI-BIN, SSI .htaccess and more!</li> <li>✦ Web Stats</li> <li>✦ E-Commerce Ready</li> <li>✦ 24/7 Tech Support</li> <li>✦ And Much More!</li> </ul> | <b>Overall Rating</b><br><br>Uptime 5/5<br>Support 4/5<br>Service 5/5<br>Pricing 5/5<br>Features 4/5 |
|---|------------------------|--------|------|-----------------------|-----------|--|---|

|   |                             |        |      |                |           |   |   |
|---|-----------------------------|--------|------|----------------|-----------|---|---|
| 8 | <a href="#">HostMonster</a> | \$4.95 | Free | 50 GB / 999 GB | Unlimited | <ul style="list-style-type: none"> <li>✦ CGI, Ruby (RoR), Perl, PHP, MYSQL, etc.</li> <li>✦ SSH Access (Secure Shell)</li> <li>✦ Front Page Extensions</li> <li>✦ Unlimited Domains</li> <li>✦ Free Domain Forever</li> <li>✦ Free Site Builder</li> <li>✦ Great Control Panel</li> </ul> | <b>Overall Rating</b><br><br>Uptime 5/5<br>Support 5/5<br>Service 5/5<br>Pricing 4/5<br>Features 4/5 |
|---|-----------------------------|--------|------|----------------|-----------|---|---|

|    |                           |        |      |                       |           |  |   |
|----|---------------------------|--------|------|-----------------------|-----------|--|---|
| 9  | <a href="#">ANHosting</a> | \$6.95 | Free | 49,000 MB /<br>999 GB | Unlimited | <ul style="list-style-type: none"> <li>✦ Host 10 Domains on 1</li> <li>✦ Free Domain for Life</li> <li>✦ FTP Accounts</li> <li>✦ Free Shopping Cart, Blogs</li> <li>✦ CGI, Ruby (RoR), Perl, PHP, MYSQL, etc.</li> <li>✦ SCSI, RAID-5 Technology</li> <li>✦ Dual Core Dual Opteron Servers</li> <li>✦ Diesel Generator Backup</li> </ul> | <b>Overall Rating</b><br><br>Uptime 4/5<br>Support 4/5<br>Service 4/5<br>Pricing 5/5<br>Features 4/5 |
| 10 | <a href="#">HostGator</a> | \$6.95 | Free | 3,500 MB /<br>50 GB   | Unlimited | <ul style="list-style-type: none"> <li>✦ 24/7 Phone Support</li> <li>✦ 99.5% Uptime</li> <li>✦ Dual Xeon Servers</li> <li>✦ CGI, Ruby (RoR), Perl, PHP, MYSQL, etc.</li> <li>✦ E-Commerce Enabled</li> <li>✦ And More!</li> </ul>  | <b>Overall Rating</b><br><br>Uptime 4/5<br>Support 4/5<br>Service 5/5<br>Pricing 4/5<br>Features 4/5 |

**HostGator** also offers [Shared Hosting](#) and [Dedicated Server](#) hosting packages.

### Web Hosting Companies by State

- |  |                                 |                                  |                                  |
|--|---------------------------------|----------------------------------|----------------------------------|
| ✦ <a href="#">Alabama</a>              | ✦ <a href="#">Indiana</a>       | ✦ <a href="#">Nevada</a>         | ✦ <a href="#">Tennessee</a>      |
| ✦ <a href="#">Alaska</a>               | ✦ <a href="#">Iowa</a>          | ✦ <a href="#">New Hampshire</a>  | ✦ <a href="#">Texas</a>          |
| ✦ <a href="#">Arizona</a>              | ✦ <a href="#">Kansas</a>        | ✦ <a href="#">New Jersey</a>     | ✦ <a href="#">Utah</a>           |
| ✦ <a href="#">Arkansas</a>             | ✦ <a href="#">Kentucky</a>      | ✦ <a href="#">New Mexico</a>     | ✦ <a href="#">Vermont</a>        |
| ✦ <a href="#">California</a>           | ✦ <a href="#">Louisiana</a>     | ✦ <a href="#">New York</a>       | ✦ <a href="#">Virginia</a>       |
| ✦ <a href="#">Colorado</a>             | ✦ <a href="#">Maine</a>         | ✦ <a href="#">North Carolina</a> | ✦ <a href="#">Washington</a>     |
| ✦ <a href="#">Connecticut</a>          | ✦ <a href="#">Maryland</a>      | ✦ <a href="#">North Dakota</a>   | ✦ <a href="#">West Virginia</a>  |
| ✦ <a href="#">Delaware</a>             | ✦ <a href="#">Massachusetts</a> | ✦ <a href="#">Ohio</a>           | ✦ <a href="#">Wisconsin</a>      |
| ✦ <a href="#">District of Columbia</a> | ✦ <a href="#">Michigan</a>      | ✦ <a href="#">Oklahoma</a>       | ✦ <a href="#">Wyoming</a>        |
| ✦ <a href="#">Florida</a>              | ✦ <a href="#">Minnesota</a>     | ✦ <a href="#">Oregon</a>         | ✦ <a href="#">Guam</a>           |
| ✦ <a href="#">Georgia</a>              | ✦ <a href="#">Mississippi</a>   | ✦ <a href="#">Pennsylvania</a>   | ✦ <a href="#">Puerto Rico</a>    |
| ✦ <a href="#">Hawaii</a>               | ✦ <a href="#">Missouri</a>      | ✦ <a href="#">Rhode Island</a>   | ✦ <a href="#">Virgin Islands</a> |
| ✦ <a href="#">Idaho</a>                | ✦ <a href="#">Montana</a>       | ✦ <a href="#">South Carolina</a> |                                  |
| ✦ <a href="#">Illinois</a>             | ✦ <a href="#">Nebraska</a>      | ✦ <a href="#">South Dakota</a>   |                                  |

### Web Hosting Companies by Category

- |  |  |
|--|--|
| ✦ <a href="#">Free Web Hosting</a>           | ✦ <a href="#">Virtual Web Hosting</a>                  |
| ✦ <a href="#">Free Domain Web Hosting</a>    | ✦ <a href="#">UNIX Web Hosting</a>                     |
| ✦ <a href="#">Cheap Web Hosting</a>          | ✦ <a href="#">Linux Website Hosting</a>                |
| ✦ <a href="#">Discount Web Hosting</a>       | ✦ <a href="#">MYSQL Web Hosting</a>                    |
| ✦ <a href="#">Windows Web Hosting</a>        | ✦ <a href="#">Fast Web Hosting</a>                     |
| ✦ <a href="#">e-Commerce Web Hosting</a>     | ✦ <a href="#">Inexpensive, Low Cost Web Hosting</a>    |
| ✦ <a href="#">PHP Web Hosting</a>            | ✦ <a href="#">Shared Web Hosting</a>                   |
| ✦ <a href="#">Best Web Hosting</a>           | ✦ <a href="#">Web Server Hosting</a>                   |
| ✦ <a href="#">Web Design and Hosting</a>     | ✦ <a href="#">UK Web Hosting</a>                       |
| ✦ <a href="#">Dedicated Web Hosting</a>      | ✦ <a href="#">Sympatico Web Hosting</a>                |
| ✦ <a href="#">Frontpage Web Hosting</a>      | ✦ <a href="#">Web Hosting Domain Name Registration</a> |
| ✦ <a href="#">Small Business Web Hosting</a> | ✦ <a href="#">Reliable Web Hosting</a>                 |
| ✦ <a href="#">Linux Web Hosting</a>          | ✦ <a href="#">Professional Website Hosting</a>         |
| ✦ <a href="#">ASP Web Hosting</a>            | ✦ <a href="#">Website Development Hosting</a>          |

- ✦ [Business Website Hosting](#)
- ✦ [Christian Web Hosting](#)
- ✦ [Domain Name Web Hosting](#)

- ✦ [Private Website Hosting](#)
- ✦ [Managed Web Hosting](#)
- ✦ [Unlimited Web Hosting](#)

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- [Cool Hit Counters](#)
- [Digital Hit Counters](#)
- [Fancy Hit Counters](#)

## Web Resources

- [Web Hosting](#)
- [Website Design](#)

## Account Login

## Download A Free HTML Hit Counter!

At Hit-Counter-Download.com we provide you the html code you can download in order to create an attractive and reliable hit counter for your website. Our web hit counters are free, easy and quick to install, but best of all they are very reliable. So get started by selecting the hit counter design for your website from our selection of hit counters below or from our menu to the left. Once you've selected the hit counter you like we'll supply you with the html code for that counters. Its really just that easy.

(**Note:** Our hit counters may not be used on password protected pages.)

### Step 1: Select a Hit Counter Below:

|                          |                          |
|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> |

# WOODGAS

## SYNTHETIC FUELS BY GASIFICATION

**Home**

**Biomass  
Energy**

**Gasification &  
Reforming**

**Liquid Fuels**

**Wood  
Cooking**

**Energy  
Rosetta Stone**

**Bookstore**

**About the  
BEF**

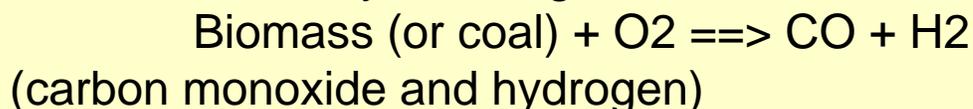
**Links**

Gasification is used to make synthetic fuels and chemicals such as methanol, ammonia, diesel fuel and even (with more difficulty) gasoline. It is difficult to imagine our current civilization continuing without them.

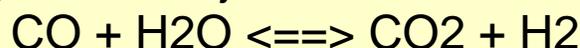
In 1980 we built a high pressure biomass oxygen gasifier at SERI/NREL (now the National Renewable Energy Lab). Eventually that became the "Syngas, Inc." gasifier, operated on oxygen at 25 tons/d and on air at 75 t/d. (See FUNDAMENTAL STUDY AND SCALE UP OF THE AIR-OXYGEN STRATIFIED DOWNDRAFT GASIFIER: T. Reed, M. Graboski and B. Levie (SERI 1988) in **Books**.)

When fossil fuels are gone or too expensive we can make these necessities from coal and biomass with the following three stages of reactions:

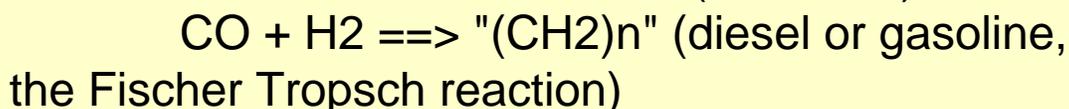
1. Manufacture of synthesis gas:



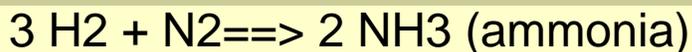
2. Water gas shift adjusts CO/H<sub>2</sub> ratio:



3. Synthesis with Catalyst



**Become a  
Member  
of the  
Biomass  
Energy  
Foundation**



Sounds simple, but is usually done commercially in chemical plants making 50 -2000 tons/day.

My specialty since 1974 has been the synthesis of methanol, a superior automotive fuel, from biomass. (Methanol is used at the racetrack in preference to gasoline and would replace gasoline with a minimum of changes. Methanol is no better than ethanol as a fuel, but would cost 1/4 as much to make and can be made from biomass, waste, coal, natural gas, and oil (not from corn!).

See the article from Science on [methanol](#) that changed my career from material scientist at MIT in 1973 to Fuel scientist today.



DATABASE

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[Liquid Fuels](#)

[Wood Cooking](#)

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| DATE    | CATEGORY               | ORGANIZATION  | PURPOSE/ DESCRIPTION  | COUNTRY | CONTACT               | PHONE/ FAX                   | E-MAIL                       | WWW PAGE                | ADDRESS  | STATUS  | FUELS  | SIZES            | YEARS       | UNITS BUILT | COST | COMMENTS  |
|---------|------------------------|---|---|---------|-----------------------|------------------------------|------------------------------|-------------------------|--|---|--|------------------|-------------|-------------|------|---|
| 9/20/99 | EQUIPMENT & CONSULTING | BG TECHNOLOGIES, LLC  | Exclusive marketing and installation of Ankur (ASCENT) gasifiers          | USA     | Wm. E. Partanen       | 202 452 1911<br>202 452 8323 | delaquai@ibm.net             | www.bgtechnologies.com  | 1155 15 <sup>th</sup> St., NW, Suite 810, Washington, D.C. 20005       | 546 gasifiers installed by Ankur since 1987                             | 3 - 700 kWe installations; also thermal applications | 1 - 700 kWe      | 10: 18000hr | 2           |      | BG Systems aimed at gasificatin of ag wastes for power  |
| 9/1/97  | EQUIPMENT & CONSULTING | CALIFORNIA PELLET MILL CO.  | Manufacturer of pellet mills for biomass densification                    | USA     | Bob Massengill        | 612 332 1400<br>612 755 3713 |                              |                         | 2524 118 <sup>th</sup> Lane NW, Coon Rapids, MN 55433                  | Active  |  |                  |             |             |      |   |
| 9/20/99 | EQUIPMENT & CONSULTING | CAPSTONE MICROTURBINES  | Build and market small turbines (30 kW)                                   | USA     | Ake Almgren           | 818 716 2929<br>818 716 9910 |                              | www.capstoneturbine.com |  |   |  |                  |             |             |      |   |
| 9/20/99 | EQUIPMENT & CONSULTING | DTI (Danish Technological Institute, DTI Environment, Waste Management) | Updraft pilot plant for hazardous waste. Consulting on updraft and waste. | DENMARK | Bjorn Malmgren-Hansen | 45 8943 8943<br>45 8943 8673 | bjorn.malmgren-hansen@dti.dk | www.dti.dk              | DTI Environment, DTI, Teknologiparken #22, DK-8000, Aarhus C, Denmark. | Pilot plant operational, planning full scale plants for hazardous waste | Leather waste, impregnated wood,                     | Planning 2-15 MW |             |             |      | Pilot plant operational, larger plants in planning stage  |
| 9/20/99 | EQUIPMENT & CONSULTING | FERN ENGINEERING, INC.  | Adaptation of gas turbines to run on producer gas, design gasif. Eqpt.    | USA     | Jeff Phillips         | 508 563 7181<br>507 564 4851 | fermeng@capecon.net          | www.capecod.net/fermeng | Bix 3380 55 Portside Dr., Pocasset, MA 02559                           | Active  | NA   | NA               | 30          | NA          | NA   | Prodoeed designs for gas turbines to operate on producer gas modifying nozzles etc., unaffiliated withturbine mfrs. |
| 9/1/97  | EQUIPMENT & CONSULTING | FLEXENERGY (Formerly Reflective Energies)                               | Small turbine development for biomass                                     | USA     | Edan Prabhu           | 949 380 4899<br>949 380 8407 | edanprabhu@msn.com           |                         | 22922 Tiagua, Mission Viejo, CA 92692-1433                             | Active  | Producer gas   |                  |             |             |      | Gas turbines typically need high pressure gas, but Prabhu developing atmospheric producer pressure turbines         |
| 1/20/98 | EQUIPMENT & CONSULTING | KAMENGO TECHNOLOGY, INC.  | Non-consolidating feeder system   | CANADA  | Nazmir Bundalli       | 604 270 9995<br>604 270 9921 |                              |                         | Suite 210-10451 Shellbridge Way, Richmond, BC, V6X2W8, CANADA          | ACTIVE  | Most biomass fuels                                   |                  | 10          |             |      | Novel feeder design, a "spin-off" from British Columbia Research Corporation  |
| 3/1/98  | EQUIPMENT & CONSULTING | STIRLING THERMAL MOTORS   | Manufacturers of Stirling Engines   | USA     | William McKeough      | 314 458 0169<br>314 458 4937 |                              |                         | 238 Waterside Dr., Grover, MO. 63040                                   |   |  |                  |             |             |      | Chiptec gasifier with Stirling engine   |
| 9/4/97  | EQUIPMENT & CONSULTING | SUNPOWER, INC.  | Small scale power from biomass; free-piston, 2.5 kW Stirling engine       | USA     | Neill W. Lane         | 614 594 2221<br>614 593 7531 | lane@sunpower.com            | http://www.sunpower.com | Box 2625, Athens OH, 45701   | Active development  |  |                  |             |             |      | Simple Stirling engine system   |

Biomass Energy Foundation: Database

|         |                        |   |   |         |                     |                                    |                            |                            |   |  |   |                            |   |   |  |
|---------|------------------------|---|---|---------|---------------------|------------------------------------|----------------------------|----------------------------|---|--|---|----------------------------|---|---|--|
| 8/1/97  | EQUIPMENT & CONSULTING | SUSTAINABLE ENGINE SYSTEMS (SES) LTD  | Stirling engine development for biomass operation   | UK      | Drummond Hislop     | 44 71 792 2241<br>44 71 792 2543   |                            |                            | 51 Artesian Rd., London W2 5DB, UK  |  |   | 6                          |   |   |  |
| 1/27/98 | EQUIPMENT & CONSULTING | T. R. MILES, TECHNICAL CONSULTING, INC.                                       | Biomass Councing, wide experience feeding, gasification, combustion wood, ag residues                   | USA     | T. R. Miles         | 503 646 1198<br>503 605 0208       | @teleport.com              | www.teleport.com/~trmiles  | 1470 S. W. Woodward Way, Portland OR 97225  |  |   | >50                        |   |   |  |
| 9/20/99 | EQUIPMENT & CONSULTING | UMSICHT (Fraunhofer-Institute for Environmental Safety and Energy Technology) | CFB gasification for gas engines  | GERMANY | Markus Ising        | 49 208 8598 189<br>49 208 8598 290 | info@umsicht.fhg.de        | www.umsicht.fhg.de         | Osterfelder Strasse 3, D-486047 Oberhausen, Germany                                 | Wood chips                                   | 0.5 MWe plant operating since 1995, 12 MW planned | 2                          | \$2800/kWe  | Has operated a 0.5 MWe pilot plan since 1996, now planning 12 MW commercial plant   |  |
| 9/30/97 | EQUIPMENT & CONSULTING | VALMET AUTOMATON INC. (Energy product line)                                   | Control and information management sstems for atmospheric and pressurized gasification systems          | FINLAND | Markku Tuovinen     | 358 3 266 8592FX                   | markku.tuovinen@valmet.com | www.valmet.com/automation/ | Lentokentankatu 11, Box 237, FIN-33101 Tampere, FINLAND                             | Active                                       |   |                            |   |   |  |
| 9/1/97  | EQUIPMENT & CONSULTING | WARREN & BAERG MFG. CO.   | Manufacture cubing eqpt.  | USA     | Jim Pennington      | 207 591 6790<br>207 591 5728       |                            |                            | 39950 Rd. 108, Dinuba, CA 93618   | Active                                       |   |                            |   | W & B took over the John Deere cuber, making it stronger for fuel use   |  |
| 3/1/97  | GASIFIER SYSTEMS-LARGE | AMBIENT ENERGY LTD.   | Build large biomass power plants in UK  | UK      | Gerry Swarbrick     | 44 117 914 7158<br>44 117 949 3063 | gjswarbr@netcomuk.co.uk    |                            | 33 Upper Cranbrook Rd., Bristol BS6 7UR, UK   | Holding 15 year contracts, seeking gasifiers | 5.5 MWe   | \$1800/kW                  | Ambient owns power sale contracts for 2 projects and is actively seeking a supplier of gasification plants for construction at location in the UK |   |  |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | AERIMPIANTI (Ansaldo, TPS)  | Fuel gas for cement kiln of power, 2 Circulating TPS FBs  | ITALY   | G. Campagnola       | 39 2 54 97241<br>39 2 54 97300     |                            |                            | Aerimpianti Spa, V. Bergamo 21, Milano 21135, Italy                                 |  |   |                            |   |   |  |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | ARBRE (TPS)   | 8MW CFB demonstration of IGCC & Short rotation forestry   | UK      | Keith Pitcher       | ?<br>44 113 224 42384              |                            |                            | Yorkshire Environmental Ltd., 2 The Embankment, Sovereign St., Leeds LS1 4BG, UK    |  |   |                            |   | 8MWe plant using short-rotation forestry, and demonstrating hot gas cleanup. Pilot plant test '95-96 on willow feedstock.   |  |
| 12/97   | GASIFIER SYSTEMS-LARGE | ASSIDOMN KRAFTLINER   | 94186 Pitea   | SWEDEN  | Gunnar Lundkvist    |                                    | Gunnar.lundkvist@asdo.se   |                            |   |  |   |                            |   |   |  |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | BIG-GT (State Bahia, Brazil, Electro-Braz, Shell, World Bank)                 | Biomass Integrated Gasification with combined cycle to prove commercial viability of atmospheric BIG-CC | BRAZIL  | Eduardo Carpentieri | 55 81 228 2605<br>55 81 227 2785   | carpent@elogica.com.br     |                            | CHESF, Rua Delmiro Gouveia, 333-1-B-3; Bongl-50761-901,Recufile, Pernambuco, Brazil | Design completed,                            | Wood, Eucalyptus plantation                       |                            | (\$1400/kWe projected)  | Still in planning stage. TPS Termiska chosen contractor, see Eric Rensfelt. System expected to approach 47% efficient (LHV) |  |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | BIOELETRICA (Energy Farm project of E.C. in Italy)                            | Demonstration of short rotation forestry, using Lurgi CFB gasifierIGCC                                  | ITALY   | Costantino Panzani  | 39 50 535 499<br>39 50 535 477     | delange@bioelettrica.it    |                            | Bioelettrica, Via Cesare Battisti 47, Pisa 56125, Italy                             | Active                                       | Short rotation wood                               | 8-12 MW                    | Planning  | Planning began in 1994, European Union, extended details in [Overend, 1999]   |  |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | BIOMASS GASIFICATION FACILITY (BGF) (Westinghouse, PICHTR/IGT, US DOE)        | Pressurized Bubbling FB, Renugas Process, for IGCC  | USA     | Ben Wiant           | 808 579 8020<br>808 579 9812       | bgfmaui@maui.net           |                            | Hawaiian Commercial and Sugar Co., Paia, Maui, Hawaii                               | Permitted, Testing Aug-Nov '97               | Bagasse, plantation wood                          | Bagasse, 100 TPD dry basis |   | Program on hold Jan 1998  |  |

Biomass Energy Foundation: Database

|         |                        |  |  |             |                       |                                    |   |   |  |   |  |                |    |     |                  |  |
|---------|------------------------|--|--|-------------|-----------------------|------------------------------------|---|---|--|---|--|----------------|----|-----|------------------|--|
| 8/1/97  | GASIFIER SYSTEMS-LARGE | BIOSYN   | Oxygen gasifier for methanol production  | CANADA      | Prof. Esteban Chornet | 819 821 7171<br>819 821 7955       | echornet@coupal.gm.usherb.ca;<br>esteban_chornet@nrel.gov |   | Dept. of Genie Chimique, Univ. de Sherbrooke, PQ, J1K 2R1, Canada  | Completed                                     | Wood   |                |    |     |                  | Biosyn project for methanol. See Chapter 3   |
| 8/97    | GASIFIER SYSTEMS-LARGE | BRIGHTSTAR SYNFUELS CO.                                  | Externally heated, steam reforming of biomass. for medium Btu syngas             | USA         | Ron Menville          | 504 642 2500<br>504 642 2503       | ronmenvillejr@worldnet.att.net                            |   | Box 539 St. Gabriel, LA 70776  | Developing projects US, Australia, Europe     | Sawdust, bark, MSW, bagasse, sludge, coal                    | 6              | 1  |     |                  | Proprietary medium energy gasification technology for use for use in burners, rotary dryers, boilers, dryers, turbines, recip engines                                      |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | BURLINGTON ELECTRIC, VERMONT (FERCO, Battelle)           | IGCC Demonstration of Battelle gasifier at existing wood plant                   | USA         | John Irving           | 802 865 7482<br>802 865 7481       | jriving104@aol.com  | www.future-energy.com/<br>FERCOhomepage/A | 585 Pine St., Burlington, VT 05401-4891 (Plant at 111 Intervale Rd.  | Testing                                       | Wood   | 200 TPD, 10 MW |    |     |                  | Battelle Columbus Double Fluid Bed Process, see Chapter 3  |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | CARBONA (Formerly Tampella, Enviropower, and Vattenfall) | Pressurized Fluidized Bed  | USA         | Kari Rasanen          | 358 93 358 0300<br>358 93 358 0325 |   |   | Carbona Corp., USA, 4501 Circle 75 Pkwy, Su E 5300, Atlanta, GA 30339; Box 610, FIN-33101 Tampere, Finland |   |  |                |    |     |                  | Gasification based power plants, see Chapter 3   |
| 9/20/99 | GASIFIER SYSTEMS-LARGE | CESP (Companhia Ebergetica de San Paulo)                 |  | BRAZIL      |                       |                                    |   |   |  |   |  |                |    |     |                  | Electrically heated gasifier for making methanol   |
| 12/97   | GASIFIER SYSTEMS-LARGE | COMBUSTION CONSULTANTS LTD                               | Fixed bed close coupled gasifiers to supply clean combustion gas at over 2,000 F | NEW ZEALAND | Paul D. Williams      | 64-6 875 0734<br>64-6 875 0098     | enquiries@waterwide.co.nz                                 | www.waterwide.co.nz                       | 37 Parkhill Rd., Hastings, New Zealand   | 600 units in commercial operatin              | Wood (chips, sawdust, shavings, etc.) paper sl, Ag, bark etc | 2-60 Mbtu/hr   | 20 | 600 | \$100,000/MW(th) | The Waterwide Close Coupled Gasifier is a proven system able to accommodate raw waste, gasify it, then clean and combust the gas. Output is clean flue gas at over 2,000F. |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | ELSAM/ELKRAFT  | Fluidized Bed for Biocycle project; coal-straw cogasification                    | DENMARK     | Michael Madsen        | 45 44 66 00 22<br>45 44 65 61 04   |   |   | SK Power Co., Project Div., Lautruphoj 5-7, DK-2750 Ballerup, Denmark                                      |   | Biomass, coal, straw   |                |    |     |                  | IGCC, Press. Circ FJ Bed from Enviropower, see Chapter 3   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | ENVIROPOWER (Tampella, IGT)                              | Recirculating Fluidized Bed Gasification   | FINLAND     | Kari Salo             | 46 8 739 60 00<br>46 8 739 68 02   |   |   | Teknikantie 12 S-162 87, Stockholm, Sweden   |   |  |                |    |     |                  | Process for large, central power plants and IGCC, see Chapter 3.   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | EPI (Energy Products of Idaho, formerly JWP)             | Steam, power Fluidized Bed   | USA         | Michael L. Murphy     | 208 765 1611<br>208 765 0503       | EPI@EnergyProducts.com                                    |   | 4006 Industrial Ave., Coeur d'Alene, ID 83814, USA   | Company active in comb, few gasifier projects | Wood, Ag res, sludge, rice hulls, RDF                        | 25MWth         |    | 3   |                  | 3 Fluidized bed gasifiers for wood in Oregon, California and Missouri, see Chapter 3.  |
| 1/20/98 | GASIFIER SYSTEMS-LARGE | FERCO (Future Energy Resources Corp.)                    | Developers of large gasifier systems for efficient power (Burlington, Binaga)    | USA         | Sim Weeks             | 404 831 9355<br>404 814 0549       |   | www.future-energy.com                     | FERCO, 950 E Paces Ferry Rd., NE., SU 810, Atlanta, GA 30326   | Active  | Wood chips, general  | 5 MWe          | 3  |     |                  | Plant currently under test   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | FOSTER WHEELER (Formerly Ahlstrom, AB)                   | Circulating Atmospheric & Pressurized FBs for power                              | FINLAND     | Ragnar Lundqvist      | 358 5229 3314<br>358 5229 3309     |   |   | Foster Wheeler R&D Center, SF-48601 Karhula, Finland   |   | Wood chips, bark, peat                                       | 2 t/h-27t/h    |    |     |                  | Now Foster Wheeler. Circulating Fluidized Bed Gasifier, full scale in Sweden, pilot on MSW. Exceeds 300 hr commercial operating, see Chapter 3                             |
| 9/30/97 | GASIFIER SYSTEMS-LARGE | GLOBAL ENERGY (AFT-IGCC)                                 | Combining Coal, MSW IGCC for clean power   | USA         |                       | 513 621 0077<br>513 621 5947       |   |   | 1500 Chiquita Centre, 250 E. fifth St., Cincinnati, OH 45202   | Planning                                      | Coal, MSW  |                |    |     |                  |  |

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| 12/15/98 | GASIFIER SYSTEMS-LARGE | HERMAN RESEARCH PTY, LTD                          | IDGCC Gasification system for power generation from high moisture fuels          | AUSTRALIA | Anthony Campisi<br>Alf Ottrey | 61 2 9565 9760<br>61 3 9565 9777   | campa@hrl.com.au<br>hrl@hrl.com.au | www.hrl.com.au                     | HRL Technology, 677 Springvale Rd., Mulgrave, Victoria, Australia 3179 | Development                     | Low rank coals, considering biomass partners                            | Up to 300 MW                     | 2  | 10 t/h (10 MW demo)  | Fluid-bed gasifier with integrated gas-cooling/fuel drying system and 5 MW gas turbine. New Lahti gasifier being developed. Also R&D, Equipment and Consulting (Alf Ottrey). |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | HURST BOILER & WELDING CO.                        | Underfed stoker gasifier-combustor for Heat, power, steam                        | USA       | Gene Zebley                   | 912 346 3545<br>912 346 3874       | hboiler@rose.net                   | www.thomasregister.com/hurstboiler | 21971 US Hwy 319 South, Coolidge, GA 31738-0529                        | active                          | >600 types; Up to 55%MC wood, MF, tires, sludge, paper                  | 0.4 to 56 MBTU/hr per unit       | 30 | >400                 | \$1M/MWt   | Leading mfr of fixed bed gasification systems for heat and power. R&D and support. Provide engineering, fabrication and mfg "in house". 200+ employees, see Chapter 3.                       |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | IMTRAN VOIMA                                      | Combined cycle powerprocess using steam drying, injection                        | FINLAND   | S. Hulkkonen                  | 358 9 8561 4612<br>358 9 563 2225  | weppo.hulkkonen@ivo.fi             |                                    | IVO, Rajatorpantie 8, Vantaa, 01019 IVO Finland                        | Pilot plant for steam drying... | High moisture wood, peat, paper sludge                                  |                                  |    | 1 pilot dryer        | High pressure fuel drying and steam injection, air blown pressurized gasification, combined cycle  |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | KVAERNER ENVIROPOWER INC.                         |  | USA       | Herbert J. Fruth              | 410 356 1111                       |                                    |                                    | 10055 Red Run Blvd., Owings Mills, Md 21117                            |                                 |   |                                  |    |                      | Used in Elsam Gasifier, Euro. Comm. .  |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | LURGI UMWELTTECHNIK GMBH                          | Circulating Fluid Bed Gasifier for power generation, cement or lime kilns        | GERMANY   | Rainer Reimert                | 49 69 5808 3530<br>49 69 5808 2628 |                                    |                                    | Lurgi-Allee 5, P.O. Box 11 12 31, D-60295 Frankfurt am Main.           | In design, tested pilot scale   | RDF, wood, bark, carbon ash, waste                                      | 14 MW el, 50-100 MW(th)          |    |                      | Fixed & fluidized bed gasifiers, see Chapter 3.  |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | NEW ENGLAND POWER SERVICE                         |  | USA       | Raymond L. Cox                | 508 366 9011 X 3120                |                                    |                                    | 25 Research Drive, Westborough, MA, 01582                              |                                 |   |                                  |    |                      | See TBR letter, brochure, planning 500-5MW gasifier demo   |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | POWER GASIFIERS INTERNATIONAL                     | Complete gasification systems, 40-5000kW   | UK        | Nigel Viney                   | 44 767 680 351<br>44 767 683 298   |                                    |                                    | 29 St. Neots Rd., Sandy, Bedfordshire, SG19 1LG, U.K.                  |                                 |   | 40-5,000 kW                      |    |                      | Complete gasification systems, 40-5000kW   |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | POWER SOURCES, INC.                               | Owner operator of Various commercial gasifiers for steam, hot air, power         | USA       | Dennis C. Williams            | 704 525 5819<br>704 527 1218       | powersou@aol.com                   |                                    | 9140 ArrowPoint Plvd., Su 370, Charlotte, NC 28273                     | 7 Gasification and combustion   | Wood, paper sludge, rice hulls, other biomass                           | To 330 tpd                       | 12 | 3 Gasifiers, 4 combu | 2 wood waste gasifiers, one rice hull gasifier   |  |
| 1/20/98  | GASIFIER SYSTEMS-LARGE | PRM ENERGY SYSTEMS, INC - FABRICATION AND TESTING | Multi zone, fixed grate, co-current Large gasifier systems for heat, steam power | USA       | W. N. (Bill) Scott            | 918 835 1011<br>918 835 1058       | sales@prmenergy.com                | www.primenergy.com                 | Box 581742, Tulsa, OK 74158  | Many units around the world     | Rice husk/straw, bark, sawdust, RDF, etc...                             | 10-1,000 t/d                     |    |                      | \$1,500 - \$2,500/kWe;\$1.4M for 100 t/d   | Licensed for design and construction of PRIMES type gasifiers  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | PRM ENERGY SYSTEMS, INC.- CORPORATE OFFICES       | Multi zone, fixed grate, gasifier for process heat, steam, power.                | USA       | Ron Bailey Jr.,               | 501 767 2100<br>501 767 6968       | info@prmenergy.com                 | www.primenergy.com                 | PRMES, 504 Windamere Terrace, Hot Springs, AR 71913                    | Many units around the world     | Rice husk/straw, bark, sawdust, RDF, etc...                             | 10-1,000 t/d                     | 15 | 18 gasifiers, 15 pla | \$1,500 - \$2,500/kWe  | 18 operating systems in US, Australia and Malaysia, Costa Rica, many new plants building, PRIMES (see also PRIMENERGY) over 500,000 tons/yr installed capacity, planning MSW, see Chapter 3. |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | PROLER INTERNATIONAL                              | Reforming HC waste to syngas   | USA       | Dennis Caputo, VP             | 713 627 3737<br>713 627 2737       |                                    |                                    | 4265 San Felipe, # 900, Houston, TX 77027                              |                                 |   | 1800 kg demo plant               |    |                      | Developed a 50 t/d pilot unit for MSW, producing 300 Btu/scf -synthesis gas!. Have 100 hr continuous   |  |
| 8/1/97   | GASIFIER SYSTEMS-LARGE | PUROX   | Fixed bed updraft slagging gasifier for disposal of MSW, steam, syngas           | USA       | Hiroshi Tamura                | 415 345 1338                       |                                    |                                    | 951 Mariners Island Blvd., San Mateo, CA 94404                         | Closed, 1997                    | MSW   | 200 t/d                          |    | 1 in Chichibu, opera | An advanced, slagging oxygen gasifier, closed for political reasons, see Chapter 3.  |  |
| 12/15/98 | GASIFIER SYSTEMS-LARGE | QBEG LTD (Queensland Biomass Energy Group Ltd.)   | R&D & Commercialization of IGCC power cogen for sugar processing operations      | AUSTRALIA | Terry Dixon                   | 61 7 4952 7600<br>61 7 4952 1734   | terry@sri.org.au                   |                                    | QBEG, C-/SRI, Box 5611 Mackay Mail Centre, Australia 4741              | Planning                        | Sugar cane bagasse, trash, in 2,000; wood chips, coal cofire, post 2002 | 5 MW IGCC (Long term 50-200 MWe) |    | 5 Mwe under Constr   | \$2400/kWe<br>\$1020 nth pl  | Sugar industry in Australia has 3400 MWe potential; building on Maui gasifier; plant to be constructed near sugar site by 2004.  |

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|---------|------------------------|--|--|---------|-------------------------------|------------------------------------|--------------------------------|---------------|--|---|---|---------------------------------------|----|----------------------|------------------|---|
| 8/1/97  | GASIFIER SYSTEMS-LARGE | SKYGAS VENTURESEARCH (Unitel)  | Electric Arc Fixed Bed Gasifier for Syn-gas, methanol  | USA     | Ravi Randhava, Serge Randhava | 847 297 2265<br>847 297 1365       |                                |               | Unitel Technologies, Inc., 411 Business Center Dr., Su 111, Mount Prospect, IL 60045 |   | Wc  | 96t/d                                 |    |                      |                  | Electric arc pyrolysis with 3 electrodes in bed; secondary reactor in coke bed also electrically heat, see Chapter 3. |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | SOFRESID/CALIQUA (Andco Torrax, Ascab-Stein)                             | Slagging updraft air gasifier  | FRANCE  | M. J. Vigouroux               | 33 1 48 70 4692<br>33 1 48 70 4444 |                                |               | 59 Rue de la Republique, 93104, Montreuil, Cedex, France                             | Many built, 1 still in operat                         | MSW   |                                       |    |                      |                  | Novel MSW slagging gasifier, see Chapter 3.   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | SUR-LITE CORP.   | Fluidized Bed for Gas, Steam   | USA     | Edward G. Gjerde              | 562 693 0796<br>562 693 7564       | sur-lite@deltanet.com          |               | 8124 Allport Ave., Santa Fe Springs, CA 90670  |   | Chips, cotton waste, rice hulls, auto waste | 120 t/d                               | 40 |                      |                  | Have 4 or 5 commercial units, see Chapter 3   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | TERAMETH INDUSTRIES (TMI)  | Landfill gas reforming to methanol, DME H2, CO2  | USA     | Gil Cervantez                 | 510 939 2020<br>510 939 2052       |                                |               | Box 4689, Walnut Creek, CA 94596   | Under construction                                    | 3.7 M cf/d landfill gas                     | GASIFIER SYSTEMS-LARGE                |    | 1                    | Site specific    |   |
| 9/29/99 | GASIFIER SYSTEMS-LARGE | THERMOCHEM (MTC)   | Pulse combustor steam fluidized bed  | USA     | Ravi R. Chandran              | 410 354 0420<br>410 354 0471       | rchandran@mecionline.net       | www.tchem.net | MTCI, 6001 Chemical Rd., Baltimore, MD, 21226  | Actively building several systems, see text Chapter 3 |   | 20TPD, Balt, 50TPD, New Bern, NC      |    |                      |                  | Produces high energy gas with Indirectly Heated Fluidized Bed Gasification using pulsed combustion, see Chapter 3.    |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | THERMOSELECT, SA   | Solid waste treatment; high temperature oxygen gasifier, turnkey plant                                 | USA     | David Runyon                  | 248 689 3060<br>248 689 2878       |                                |               | 201 W. Beaver, Ste 230, Troy, MI 48084   | 6 units contracted, 2 under construction              | MSW, commercial wastes, sludge, medical     | 50,000 t/y and 100,000 t/y; multiples | 10 | 2 under construction |                  | Have a 100 ton/day proto type with 30k hrs operation MSW yielding Snygas, frit, S, metal pellets.                     |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | TPS TERMISKA PROCESSOR, AB (Formerly Studsvik, see Greve, BIG-CC, ARBRE) | Major CFB gasifier manufacturer for IGCC, Greve plant in Chianti, IT, IGCC Brazil, UK                  | SWEDEN  | Eric Rensfelt                 | 46 155 22 13 00<br>46 155 26 30 52 | tps@tps.se                     |               | Studsvik, 611 82 Nykoping, Sweden  | Operating plants                                      | Wood, bark, peat, straw RDF                 | Up to 50 MWe                          | 15 | 2                    | Project specific | Circulating Fluidized Bed Gasification, formerly Studsvik, the parent company of many systems, see Chapter 3.         |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | UHDE GMBH  | Gasification of biomass, co-generation.  | GERMANY | Jochen Keller                 | 49 231 547 2335<br>49 231 547 3032 |                                |               | Friedrich-Uhde strasse 15 44141  |   |   |                                       |    |                      |                  | Gasification of biomass, co-generation.   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | VARNAME IGCC PLANT, SYDKRAFT (Sydkraft, Foster Wheeler)                  | IGCC, recirculating pressurized fluid bed for First biomass IGCC pressurized fluid bed plan operating. | SWEDEN  | Krister Stahl                 | 46 40 25 59 63<br>46 40 611 5184   |                                |               | S-205 09, Malmo, Sweden  | Operating   | Wood Waste                                  | 6MW + 9 WMth                          | 1  | 1                    |                  | First successful IGCC plant, 1000 hours by mid 1997, see Chapter 3.   |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | VOLUND R&D CENTER (Ansaldo)  | Updraft Gasifier for straw, wood-chips, heat, power  | DENMARK | Knud E. Holm                  | 45 75 56 8874<br>4575 56 8873      | keh@ave.dk                     | www.volund.dk | Ansaldo Volund A/S, Falkevej 2 KD-6705 Esbjerg, DENMARK                              | Comercial   | Wood chips, bark, straw                     | 1-15 MWth                             | 11 | 3                    |                  | Updraft Straw Gasification, district heat in Harboere; gas cleanup permits power production, see Chapter 3.           |
| 8/1/97  | GASIFIER SYSTEMS-LARGE | WELLMAN PROCESS ENGINEERING  | Updraft Fixed Bed Gasifier for generation of fuel & process gas from solid fuel                        | UK      | Richard McLellan              | 44 121 601 3000<br>44 121 601 3123 | wellman.process@dial.pipex.com |               | Cornwall Rd., Smethwick, Warley, West Midlands, UK B66 2LB                           | Commercial  | Wood, lignite, petcoke, Coal, coke          | To 3 m diameter                       | 75 | 1700                 |                  | Gasifiers and clean up systems individually designed to meet the customer's requirements, see Chapter 3.              |
| 8/1/97  | GASIFIERS - SMALL      | ADVANCED ALTERNATIVE ENERGY CORPORATION                                  | Gasification systems for demand or supply of heat and power  | USA     | Les Blevins                   | 785 842 1943<br>785 842 0909       | lbj@cjnetworks.com             |               | 1207 N 1800 Rd, Lawrence, KA 66049   | Active, for profit                                    | Wide variety, depending on gasifier         | Gasifier dependent                    | 16 | 4                    | Type specific    | AAEC is seeking partners, distributors, investors, licensees  |

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|----------|-------------------|--|--|--------------|---------------------|---|---|--|---|--|---|--|----|------|----------------------|---|---|
| 3/31/98  | GASIFIERS - SMALL | COMPACT POWER  | Pyrolytic gasifier for MSW, Sludge...                                    | UK           | Nick Cooper         | 44 242<br>224 243<br><br>44 242<br>221 273          | compower33@aol.com                        |  | 33 Rodney Rd., Cheltenham, GL50 1HX, UK   | Active   | MSW, Sludge, Tires, Chicken litter                              | Modular plant, 2 tubes=6,000 t/yr, 8 tubes, 30,000t/yr in planning | 6  | 3    |                      |   | >85% of energy in waste recovered in usable heat and power. Tolerates water to 50% (more with front end drying); low profile. |
| 4/6/98   | GASIFIERS - SMALL | CRATECH  | Pressurized fluidized bed 1.2MWe gasifier for cotton trash etc.          | USA          | Joe Craig           | 806 327<br>5220<br><br>806 327<br>5570              | cratech@onramp.net                        |  | Box 70, Tahoka TX 79373   | Second stage with active support from DOE, EPA, DOD, VI., TVA, TX,                       | COTTON TRASH (many others)                                      | 1.2 MWe  | 18 | 2    | \$1500-\$2300/kWe    | Joe Craig is in final stages of construction of 1 MW unit, see Chapter 4.   |   |
| 4/6/98   | GASIFIERS - SMALL | HYDROTEST  | Down-Updraft gasifier systems  | SWITZERLAND  | Willy Gemperle      | 41 420<br>44 77<br><br>41 420<br>44 76              |   |  | Reussegrasse 17 CH 6020, Emmenbrucke, Switzerland                                 | Operating unit on display,   | Wood chips, ...   | 25 kW  |    |      |                      | See AMERICAN HI-TEMPERATURE entry   |   |
| 3/31/98  | GASIFIERS - SMALL | NEWCASTLE UNIVERSITY OF (Chemical and Process Engineering Dept.) | Fixed Bed Downdraft CHP  | UK           | Dogru, Murat        | 44 191<br>222<br>60009<br><br>44 191<br>222<br>5292 | Murat.Dogru@newcastle.ac.uk               |  | Merz Court, Chem. & Proc. Eng., U. of Newcastle, Newcastle Upon Tyne, NE1 7RU, UK | Operating  | Wood chips, hazel-nut shells, MSW, Sewage Sludge.               | 30 kW (Feed 30 kg/hr)  | 1  | 1    |                      | Working on fuel flow and ash melting  |   |
| 3/1/98   | GASIFIERS - SMALL | POWER GENERATING, INC.   |  | USA          | Bill Partnen        | 207 883<br>3052                                     |   |  | 2501 Parkview De., SU 500, Fort Worth, TX, 76102-5800                             |  |   |  |    |      |                      |   |   |
| 12/15/98 | GASIFIERS - SMALL | SYSTEM JOHANSSON GASPRODUCERS                                    | Tar free Power gasifiers - 350 kW  | SOUTH AFRICA | Gus Johansson       | 27 11<br>310<br>1008<br><br>27 11<br>8051138        | kgj@iafrica.net                           |  | PO Box 295; Halfway House 1685; Midrand, South Africa                             | 350 kW operational at ASKOM since 1997, several others long term.                        |   |  | 14 |      |                      |   |   |
| 12/15/98 | GASIFIERS - SMALL | THIRD GENERATION LTD.  | Development of fully automated fixed grate gasifiers for heating         | UK           | Jonathan Taylor     | 44 1835<br>823043<br><br>44 1835<br>822997          | admin@bbnorth.demon.co.uk                 |  | Tweed Horizons Centre, Newtown St Boswells, Melrose, TD6 0SG, UK                  | Fully automatic 100 kWth plant providing heat in Tweed Centre; 200 kW begun in Nov. 1998 | Sawmill residues, short rotation coppice (10-40% WB)            | 100, 200 kWth  | 2  | 3    | \$75-\$200/kWh       | Close coupled cross/updraft gasifier to boiler, wide variety of fuels, automatic cold starts, remote monitoring             |   |
| 8/1/97   | GASIFIERS - SMALL | AEW (Associated Engineering Works)                               | Low tar downdraft thermal and power gasifiers                            | INDIA        | G. M. Satyanarayana | 91 8819<br>22950<br><br>91 8819<br>24572            |   |  | Gamini Compound, Box 17, Tanuku 534 211, Andhra Pradesh, India                    | Heat, Steam, Power   | Wood chips, rice hulls, ...                                     | Many installed, many sizes   | 8  | 200  | \$225/kW             | Thermal gasifiers used for bulk cooking, novel rice husk gasifier, centrifugal tar separators, in House R&D, see Chapter 4. |   |
| 8/1/97   | GASIFIERS - SMALL | AMERICAN HIGH TEMP INC.  | Clean up-down draft gasifier for power                                   | USA          | Kevin McDevitt      | 603 625<br>6669<br><br>603 627<br>8670              | kip2251@aol.com                           |  | Box 5151, 1 Mack Ave., Manchester, NH 03108                                       | Sold 3 systems   | Waste fuels, demolition lumber, railroad ties, pelletized fluff | 250 kW, 500 kW (25, 50)  | 10 | 10   | \$3,000/kWe COMPLETE | 3 Systems sold 1 MW, 500 kW. Hydrotect in Lucerne, Willie Gempela. Acquired from Humbolt Deutz. Avoids tipping fees.        |   |
| 8/1/97   | GASIFIERS - SMALL | ANKUR SCIENTIFIC ENERGY TECHNOLOGIES                             | Low tar downdraft gasifiers for Steam, Power, thermal energy, irrigation | INDIA        | B. C. Jain          | 91 48<br>1021<br><br>91 48<br>1042                  | ankur.energy@smn.sprintpg.ems.vsnl.net.in |  | Ankur, near old Sama Jakat Naka, BARODA-390 008, India (now Vadodara)             | Many commercial installations, IN, other   | Wood, stalks, cobs, shells, rice husks                          | To 500 kW  |    | >400 | \$400/kkWh           | Largest manufacturer of gasifier systems in India, represented in US by P. DeLaquil, see Chapter 4.                         |   |
| 10/8/97  | GASIFIERS - SMALL | B9 Energy Biomass Ltd.   | Demonstration of Gasification at Museum                                  | IRELAND      | Debra Jenkins       | 44 0504<br>271520<br><br>44 0504<br>308090          |   |  |   |  |   | 200 kW   |    |      |                      |   |   |
| 8/1/97   | GASIFIERS - SMALL | BIOSYSTEMS ENERGY, LTD   | Novel design   | NEW ZEALAND  | Ian Kearney         | 64 03<br>544<br>5556<br><br>64 03<br>544<br>0374    |   |  | New Zealand   | Construction   | Wood Waste  | 1.5 MW   |    |      |                      | Building 1.5 MW pilot plant in NZ.  |   |

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|---------|-----------------|--|--|-------------|------------------------------|----------------------------------|--|--|--|---|---------------------|----|---------------|-----------------------------------|--|--|
| 8/1/97  | GASIFIERS-SMALL | BUCK ROGERS                                | Downdraft gasifier, retrofit for heat  | USA         | Bill Ayres                   | 913 599 6911<br>913 599 2121     |  | Ag Environmental Products, AEP, Kansas City                            |  |   |                     |    |               |                                   |  |  |
| 8/1/97  | GASIFIERS-SMALL | CHIPTec WOOD ENERGY SYSTEMS                | Crossdraft boiler systems, new or retrofit                                   | USA         | Robert Bender                | 802 660 0956<br>802 660 8904     | chiptec@together.net   | 48 Helen Ave., South Burlington, VT. 05403                             | Active production and install              | Clean HW and SW chips. 6%-45%MC                           | 500,000-10M Btu/hr  | 11 | 100+          | \$25,000/MBtu                     | Crossdraft gasifier retrofit for existing boilers, I, see Chapter 4.   |  |
| 8/1/97  | GASIFIERS-SMALL | CLEW (Camp Lejeune Energy from Wood)       | 1 MW Downdraft gasifier power system   | USA         | Carol Purvis (John Clelland) | 919 541 7519<br>919 541 7885     | purvis.carol@epa.gov<br>www.epa.gov/appcd                                  | U.S. EPA Ctr., MD-63, Research Triangle Park, NC, 27711                | Active, refinancing                        | Hogged wood at Camp Lejeune, pelletized wood, stumps, ... | 1 MW                | 3  | 1             | \$600-\$1200 per kWh              | Installed and operated > 500 hr a 1 MW gasifier at camp LeJeune, NC. Gasifier technology owned by Thermotec, Omaha NB, I, see Chapter 4. |  |
| 9/27/99 | GASIFIERS-SMALL | COMMUNITY POWER CORPORATION                | 25 kW Small Modular Biomass Power micro-utilities                            | USA         | Robb Walt                    | 303 690 7869<br>303 617 1280     | robbcpc@aol.com  | 15796 E. Chenango Ave., Aurora, CO 80015                               | Active                                     | Agricultural residues                                     | 25 kW               | 2  | 1             | <\$1000/kWhe                      | Built 12 kW gasifier prototype of 25 kW micro-utility, I, see Chapter 4.   |  |
| 8/1/97  | GASIFIERS-SMALL | CRATECH                                    | Developing pressurized fluidized bed gas turbine system for Ag residues      | USA         | Joe D. Craig, Pres.          | 806 327 5220<br>806 998 5570     | cratech@onramp.net   | Cratech, Box 70, Tahoka, TX 79373                                      | Constructing 1 MWe plant                   | Bagasse, r hulls, cotton trash tested                     | 1-20MWe             |    | 2 development | \$2300/kWe for 1 MWe proj.        | Funding BRBEP, EPA, DoD, VT, TX, TVA.  |  |
| 8/97    | GASIFIERS-SMALL | DASAG (Dasad Energy Engineering Ltd.)      | Stratified downdraft for woody, and ag residues for decentralized power      | SWITZERLAND | H.Sharan                     | 41 52 335 3500<br>41 52 335 1442 | 100343.210@compuserve.com  | Birchstrasse 6, 8472 Seuzach Switzerland                               | Swiss private Ltd. Co., Joint ventures, IN | Woody and Ag biomass                                      | 50-2500kWh          | 18 |               | ~200 5 kW, other larger in SW, IN | Commercial plant in India with over 2500 hours; Indian company building 20 new plants  |  |
| 9/19/97 | GASIFIERS-SMALL | DECENTRALIZED ENERGY SYSTEMS, INDIA (DESI) | Development of Fixed bed downdraft (low tar) gasifiers for village power use | INDIA       | P. K. Bhatnagar              | 91 11 696 7938<br>91 11 686 6031 | desi@sdat.ernet.in   | B-32, Tara Crescent, Qutab Institutional Area, New Delhi 110 016 INDIA | Operational, active                        | Ipomea, biomass   | 80 kWe              |    | 1             | \$730/kWe (2.1M Indian Rupees)    | Uses the IISc (low tar) technology   |  |
| 9/20/99 | GASIFIERS-SMALL | DK-TEKNIK                                  | 150 kW gasifier development  | DENMARK     | Henrik Jakobsen              | 45 39 555 999<br>45 39 696 002   | dk-teknik@dk-teknik.dk<br>www.dk-teknik.dk                                 | 15 Gladsaxe Mollevej, DK 2860 Soborg, Denmark                          | 100 hours operation Aug. 99                | Wood chips  | 150 kW              | 2  | 2             |                                   | Tested low tar gasifier 100 hours  |  |
| 8/1/97  | GASIFIERS-SMALL | ENERGIE-TECHNIK FROMM                      |  | GERMANY     | Jurgen Fromm                 | 49 201 30 53 00                  |  | Schalke Strasse 68, 45327 Essen 12, Germany                            |  |   |                     |    |               |                                   | Manufacture and development of wood gasifiers  |  |
| 8/1/97  | GASIFIERS-SMALL | ENERTECH ENVIRONMENTAL, INC.               |  | USA         | Kevin Bolin                  | 404 892 9440                     |  |  |  |   |                     |    |               |                                   | >1000 hours with sewage sludge - 300 with MSW  |  |
| 1/20/98 | GASIFIERS-SMALL | EVN (Energie Versorgung Nord)              | Decentralized Power and heat Production with twin-fire gasifier              | GERMANY     | U. Rehling                   | 49 46 316 2147<br>49 46 316 2148 | evn.de5 t-online.de<br>www.evn.de/<br>www.gasifier.com/<br>www.biomass.net | EVN, Schwennastrasse 19, D24960 Glucksburg, Germany                    | Active                                     | Wood chips, ag pellets                                    | 50-350 kWe          | 10 | 5             | Do planning and investment        | Building gasifier with combustor for 450 houses for EXPO 2,000 in Hanover; waste wood gasifier for 1500 tons/yr                          |  |
| 8/1/97  | GASIFIERS-SMALL | FLUIDYNE                                   | Downdraft gasifiers and engines for power                                    | NEW ZEALAND | Doug Williams                | 64 9 838 6132<br>64 9 838 6132   | graeme@powerlink.co.nz,<br>p-h-energy@clear.net.nz                         | Box 21583, Henderson, Auckland 8, New Zealand                          | Gasifiers mfd to order                     | Wood blocks and chips, coppice, willow chips              | 45 Kg/r for 35 kWel | 21 | 14            | \$22,750/ kW                      | New model, 500 kWe in preproduction stage, 4 projects  |  |
| 9/30/97 | GASIFIERS-SMALL | HEURISTIC ENGINEERING INC.                 | Wet wood, 2 stage gasifier or Combustor                                      | CANADA      | Malcolm D. Lefcort           | 604 263 8005<br>604 263 0786     | mlefcoort@compuserve.com   |  |  |   |                     |    |               |                                   |  |  |

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| 8/1/97  | GASIFIERS-SMALL | HTV ENERGY   | Downdraft gasifier, engine, turnkey operation                                   | SWITZERLAND  | P. Juch                  | 41 62 216 5844<br>41 62 216 5109     |                                       | Mittelgastrasse 205, CH-4617 2Gunzgen, Switzerland                                | Commercial plant startup 8/97 | Wood, wood waste                                 | 0.25-4MW                               |                              |    | 6 Testing, 1 comm, 3 | \$4,000/kWe                    | Exceeds German engine emission requirements, see Chapter 4.  |
| 8/1/97  | GASIFIERS-SMALL | HYDROMAX   |   | USA          | Marc Kalish              | 212 385 7560                         |                                       |   |                               |  |  |                              |    |                      |                                | 150 t/hr pilot plant   |
| 8/1/97  | GASIFIERS-SMALL | IDAHO ENERGY DIVISION  | Demonstrate gasification for home energy needs with residential pellet gasifier | USA          | Gerald Fleischman        | 208 327 7959<br>208 327 7866         | gfleisch@idwr.state.id.us             | Box 83720, Boise ID 83720-0098  | Planning                      | Wood pellets                                     |  |                              |    |                      |                                | Fred Beierle experienced in gasifiers  |
| 10/5/97 | GASIFIERS-SMALL | LESLEY MFG. CO.  |   | USA          | 913 842 1943             |                                      |                                       |   |                               |  |  |                              |    |                      |                                |  |
| 8/1/97  | GASIFIERS-SMALL | LESLEY MFG. CO.  |   | USA          | Les Blevins              | 913 842 1943<br>913 842 0341         |                                       | 1207 N 1800 Rd, Lawrence KA 66049   |                               |  |  |                              |    |                      |                                |  |
| 1/20/98 | GASIFIERS-SMALL | LOTARIOS (Waste reclaim Loterios)                            | MSW pyrolysis gas for MSW processing, disposal                                  | USA          | Gail A. Brichford        | 713 977 5854<br>713 977 6426         |                                       | 10555 Richmond Ave., SU 301, Houston, TX 77042                                    | Active                        | MSW  | 3 ton MSW/hr                           | Since 1926 (charcoal, Italy) |    |                      |                                | Italian charcoal process modified for MSW  |
| 3/1/98  | GASIFIERS-SMALL | MARTEZO  | Downdraft Gasifier for SI Engines   | FRANCE       | Marielle Touillet        | 33 5 49 37 02 03<br>33 5 49 37 39 79 | Martezo@cyberscope.fr                 | 237, 4ou53 de Paris, B. P. 419, 86010 Poitiers Cedex, France                      |                               | Wood, Ag-wastes                                  | 100-600 kWe                            |                              |    |                      | \$3,000kW (1987)               | See brochure; WIBA   |
| 10/5/97 | GASIFIERS-SMALL | MORBARK INDUSTRIES   | Cyclonic Gasifier   | USA          | Jerry Demslow            | 517 866 2381                         |                                       | 8507 S. Winn Rd., Winn, MI 48896  | Active                        | Sawdust  | 1-4 M Btu/hr                           | 20                           |    |                      |                                | Entrained cyclonic gasifier  |
| 3/1/98  | GASIFIERS-SMALL | NEWCASTLE, UNIVERSITY OF                                     | Downdraft, CHP gasifier   | UK           | Murat Dogru              | 44 191 2226 0009<br>44 191 222 5292  | murat.dogru@newcastle.ac.uk           | Merz Court, Chemical & Proc. Eng., U. of Newcastle, Newcastle Upon Tyne, NE1 7RU  | Active                        | Wood chips, hazel-nut shells, MSW, sewage sludge | 30 kWh (30 kg/hr)                      | 1                            |    |                      |                                | Solving fuel flow and Ash melting problems   |
| 8/1/97  | GASIFIERS-SMALL | SHAWTON ENGINEERING)   | Downdraft gasifier/gas engine for power, heat                                   | UK           | Donald C. Patrick        | 44 1925 220338<br>44 1925 220135     |                                       | Unit 1, Junction Lane, Sankey Valley Estate, Newton le Willows, WA12 8DN, England | Active                        | Industrial and Ag wastes                         | 300 kWe                                |                              | 1  |                      |                                | Patrick is expert in converting engines for producer gas, see Chapter 4.   |
| 8/1/97  | GASIFIERS-SMALL | SRC-GAZEL (At UCL, Universite Catholique de Louvain)         | Pilot project for small scale power with short rotation coppice                 | BELGIUM      | J. Martin (F. Bourgeois) | 32 10 47 2200<br>32 10 45 2692       | bourgeois@term.ucl.ac.be<br>martin@te | UCL, 2 Place du Levant, B-1348 Louvain-la-Neuve, Belgium                          | Active                        | wood chips from coppice                          | 160kWe                                 |                              |    |                      | \$1200/kWe Excludes grid,civil | Aiming at high reliability, low cost industrial system for decentralized power plants  |
| 10/5/97 | GASIFIERS-SMALL | STWALLEY ENGINEERING (Division of Paradoxs Enterprises,Inc.) | Downdraft channel gasifier for ag waste gasification                            | USA          | R. M. Stwalley           |                                      |                                       | 516 Main St., Suite #1, Lafayette, IN 47901 1445                                  | Active                        | Wood chips, corn cobs                            | 40 kW                                  | 2                            | 1  |                      |                                | 40 kW demo at Burch Mfg., W.Va. Funded by SERBEP. Paper "Operation of a Piston Engine with a Downdraft Channel Gasifier" in Bioenergy '96, p. 612.                                   |
| 9/30/97 | GASIFIERS-SMALL | SYNGAS INC.  | Air/Oxygen fixed bed downdraft gasifier operated 1985-89 for power, syngas      | USA          | Tom Reed                 | 303 278 0560                         | tombreed@comcast.net                  | 1810 Smith Rd., Golden, CO 80401  | Inactive, can be revived      | Urban waste wood                                 | 25, 75 t/d; 350 kW                     | 4                            | 2  |                      |                                | GASIFIER SYSTEMS-LARGE st fixed bed gasifier ever built, oxygen operation, described in (The Air-Oxygen Stratified Downdraft Gasifier), T. B. Reed et al                             |
| 1/20/98 | GASIFIERS-SMALL | SYSTEM JOHANSSON GAS PRODUCERS                               | Downdraft low tar gasifier for power production, primarily from wood            | SOUTH AFRICA | K. G. Johansson          | 27 11 310 1008<br>27 11 805 1138     |                                       | Box 295, Halfway House, 1685 Midrand, South Africa                                | Active                        | Wood blocks, chips, briquettes                   | 30-500 kWe (1,000 kW design available) | 13                           | 10 |                      | \$750/kWe                      | SJG is a responsible engineer/manufacturer in SA, the manufacturing power house of Africa; Systems marketed through CARBO Cons. Eng., 27-11-8866721 in Bryanston, SA, see Chapter 4. |

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|         |                       |  |   |             |                         |  |                               |  |  |   |  |                                  |    |        |             |  |  |
|---------|-----------------------|--|---|-------------|-------------------------|--|-------------------------------|--|--|---|--|----------------------------------|----|--------|-------------|--|--|
| 3/1/98  | GASIFIERS-SMALL       | TERMOQUIP ENERGIA ALTERNATIVA LTDA                   | Downdraft gasifier  | BRAZIL      | Saul D'Avila            | 55 19 242 0371<br><br>55 19 242 0371             |                               |  | Rua Projetada, 260-<br>jd., Sta. Genebra,<br>Campinas, SP-CEP<br>13080-290, Brazil                           |   |  |                                  |    |        |             |  | Downdraft gasifier for heat  |
| 8/1/97  | GASIFIERS-SMALL       | THERMOGENICS   | Bottom fed inverted<br>downdraft gasifier,<br>improved ESP<br>cleaning for steam<br>and power | USA         | Stephen C.<br>Brand     | 505 344<br>4846<br><br>505 344<br>6090           | thermogenics@worldnet.att.net | www.thermogenics.com                   | 7100-F Second St.,<br>NW, Albuquerque,<br>NM 87107   | 12 t/h; 3 t/h<br>under<br>construction  | Wood, RDF,<br>tires,<br>sludge, Ind<br>wastes      |                                  |    | 3+     |             |  | Novel design, innovative ESP gas<br>cleaning, see Chapter 4.   |
| 8/1/97  | GASIFIERS-SMALL       | WASTE<br>CONVERSION<br>SYSTEMS                       | Close coupled<br>gasifier   | USA         | Stan Abrams             | 303 690<br>8300                                  |                               |  | 14590 E. Fremont<br>Ave, Englewood,<br>CO 80112  |   |  |                                  |    |        |             |  |  |
| 8/1/97  | RESEARCH &<br>SUPPORT | ALABAMA,<br>UNIVERSITY OF                            | Pyrolysis and<br>gasification   | USA         | Michael Eley            | 205 895<br>6361                                  |                               |  |  |   |  |                                  |    |        |             |  | 65 t/d plant;  |
| 10/5/97 | RESEARCH &<br>SUPPORT | ASIAN INSTITUTE<br>OF TECHNOLOGY<br>(AIT)            | Research in<br>alternate energy,<br>gasification  | THAILAND    | Prof.<br>Bhattacharya   | 66 2 524<br>5403<br><br>66 2 524<br>5439         | bhatta@ait.ac.th              | www.ait.ac.th                          | Asian Inst. Of<br>Technology,<br>Energy Program,<br>Box 4, Klong<br>Luang,<br>Pathumthani<br>12120, Thailand |   |  |                                  |    |        |             |  | AIT in an International post-graduate<br>educational Institute, courses in power,<br>energy economics and energy<br>technology. Working on low tar gasifiers   |
| 9/1/97  | RESEARCH &<br>SUPPORT | ASTON UNIVERSITY                                     | Research and<br>evaluation of<br>gasification,<br>pyrolysis                                   | UK          | Tony<br>Bridgwater      | 44 21<br>359<br>3611<br><br>44 21<br>359<br>4094 | a.v.bridgwater@aston.ac.uk    | www.pyne.co.uk                         | Aston University,<br>Aston Triangle,<br>Birmingham B4<br>7ET, UK   | Active  | General  |                                  |    |        |             |  | Tony Bridgwater has been a major host<br>and editor of many international<br>conferences   |
| 8/1/97  | RESEARCH &<br>SUPPORT | BATTELLE<br>COLUMBUS<br>LABORATORIES,<br>BCL         | Research gasifier for<br>2 FB pyrolytic<br>gasifier   | USA         | Mark A Paisley          | 614 424<br>4958<br><br>614 424<br>3321           | Paisley@battelle.org          |  | Battelle Columbus<br>Laboratories, 505<br>King Avenue,<br>Columbus, Ohio                                     | Active, catalyst<br>testing   | Wood chips,<br>RDF,<br>bagasse                     | 24 t/d                           |    |        |             |  | Double fluidized beds pyrolyse in one,<br>combust charcoal in the other to produce<br>medium energy gas. See Chapter 3   |
| 4/6/98  | RESEARCH &<br>SUPPORT | BERA (The Biomass<br>Energy Research<br>Association) | Lobby for biomass<br>utilization in U.S.<br>Congress  | USA         | Donald L.<br>Klass      | 202 785<br>2856                                  |                               |  | 1825 K St., N.W.,<br>Su 218,<br>Washington, D. C.,<br>20006.   |   |  |                                  |    |        |             |  |  |
| 9/1/97  | RESEARCH &<br>SUPPORT | BIOMASS ACTION<br>RESEARCH<br>CENTRE                 | Consulting pyrolysis<br>and gasification  | INDIA       | P. D. Grover            | 91 65 65<br>4189<br><br>91 65 66<br>7088         | pdgrover@netearth.ernet.in    |  | 7, Street-C, IIT<br>Campus, New Delhi<br>110016  | Retired from IIT,<br>actively<br>consulting                                   |  |                                  |    |        |             |  | Prof. Grover is well known for producing a<br>number of excellent students and theses<br>in the field of biomass. Now retired and<br>consulting  |
| 1/20/98 | RESEARCH &<br>SUPPORT | BIOMASS ENERGY<br>FOUNDATION (BEF)                   | Gasification<br>research, studies<br>and publication of<br>books                              | USA         | Thomas B.<br>Reed       | 303 278<br>0558                                  | tombreed@comcast.net          | www.webpan.com/BEF                     | 1810 Smith Rd.,<br>Golden, CO 80401  | Active  |  |                                  | 13 | 30     | \$1 - \$2M  |  | A 501 C-3 Corporation established in<br>1983 by Dr. Harry LaFontaine, now<br>operated by T. Reed to promote the use<br>of biomass, especially biomass<br>gasification. See WWW page at<br><a href="http://www.webpan.com/BEF">www.webpan.com/BEF</a> |
| 9/20/99 | RESEARCH &<br>SUPPORT | BTG (Biomass<br>Technology Group)                    | Fluidized and Fixed<br>bed DD, CHP, and<br>other gasification<br>research, Consulting         | NETHERLANDS | H. Knoef                | 31 53<br>489<br>2897<br><br>31 53<br>489<br>3116 | knoef.btg@ct.utwente.nl       | http://btg.ct.utwente.nl               | Box 217, 7500 AE<br>Enschede, The<br>Netherlands   | Planning,<br>building,<br>operating,<br>commercial with<br>construction firms | Wood chips,<br>briquettes,<br>miscanthus,<br>straw | 25 kW to 1<br>MWe                | NA | 10     | \$1500-3000 |  | Involved in design and construction with<br>KARA energy systems and Stork<br>Thermeq. Currently testing 150 kW<br>gasifier. Designing novel crossdraft/O2<br>gasifier, see Chapter 5.  |
| 9/1/97  | RESEARCH &<br>SUPPORT | CALIFORNIA<br>ENERGY<br>COMMISSION                   | Energy support and<br>development of<br>gasifiers   | USA         | Valentino M.<br>Tiangco | 916 654<br>4664<br><br>916 653<br>6010           | valen@ns.net                  |  | Energy Tech. Dev.<br>Division, 1516 9 <sup>th</sup><br>St. MS-43,<br>Sacramento, CA<br>95814-8512            | Active  |  |                                  |    |        |             |  | CEC and developing small power<br>gasifiers in the Philippines   |
| 9/1/97  | RESEARCH &<br>SUPPORT | CASCADE<br>RESEARCH, INC.                            | Consulting,<br>evaluation of<br>technologies, IEA<br>representative US                        | USA         | Don J.<br>Stevens       | 509 375<br>3124<br><br>509 375<br>3267           | c.refrch@televar.com          | http://www.abdn.ac.uk/<br>leabioenergy | 2952 George<br>Washingto Way,<br>Richland, WA<br>99352   | Active  |  |                                  |    | 5 (25) |             |  | Stevens worked at PNL during the 1980s<br>and prepared an overview of all the work<br>in the thermal conversion program. He is<br>the operating agent for task 13 (biomass<br>utilization) for the International Energy<br>Agency                    |
| 9/4/97  | RESEARCH &<br>SUPPORT | CEMIG (Companhia<br>Energética de Minas<br>Gerais)   | Power generation<br>from charcoal-blast<br>furnace gas  | BRAZIL      | E. C.<br>Vasconcelos    |  |                               |  | Av. Barbaena,<br>1200-20, Al-Santo<br>Agostinho, Belo<br>Horizonte-MG-<br>CEP, 30161970,<br>Brazil           | Testing small<br>system   | Charcoal   | 15 kW test,<br>1-2 MW<br>planned | 1  |        |             |  | Paper USE OF CHARCOAL BASED<br>BLAST FURNACE GAS... in 3 <sup>rd</sup> Biomass<br>of Americas Proceedings  |

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| 8/1/97   | RESEARCH & SUPPORT | CHINESE ACADEMY OF AGR. AND MECHANICAL SYSTEMS (CAAMS)               | Chinese Central Gasification Research   | CHINA       | Gao Xiansheng                     | 86 10 2017131<br>86 10 2017326     |                             |   | Renewable Resources Technology Development Co., Ltd., No. 2 Beishatan, Deshengmen Wai, 10083, Beijing |  |                                 |  |    |           |                  |  | CAAMS Manufactures two downdraft gasifiers, one industrial (100 kg/hr) 1 domestic cooking (10 kg/hr).  |
| 9/1/97   | RESEARCH & SUPPORT | CONEG (Coalition of Northeastern Governors)                          | Support of Energy projects  | USA         | Rick Handley                      | 202 624 8450<br>202 624 8463       |                             |   | 400 North Capitol St., NW, Su 382, Washington, D. C. 20001  |  |                                 |  |    |           |                  |  |  |
| 1/20/98  | RESEARCH & SUPPORT | CONEG (Northeast Regional Biomass Program)                           | Regional biomass energy program of the US DOE   | USA         | Richard Handley                   | 528 899 9572<br>528 899 9574       | rhandley@capital.net        |   | 400 N. Capital St., SU 382; Washington, D. C. 20001   | Active                                 |                                 |  |    |           |                  |  |  |
| 1/20/98  | RESEARCH & SUPPORT | DAIMLER BENZ AEROSPACE AG  | Gasifier research   | GERMANY     | S. Girges                         | 49 5055 598 258<br>49 5055 598 202 | suaaraf.girges@ri.dasa.de   |   |   |  |                                 |  |    |           |                  |  | Ask if actively participating in gasification  |
| 8/1/97   | RESEARCH & SUPPORT | DANISH TECHNICAL UNIVERSITY (DTU) (Department of Energy Engineering) | Conversion of biomass, straw to gas for power, experimental systems   | DENMARK     | Henriksen, Ulrik                  | 45 45 93 37 57<br>45 45 93 57 61   | gaspro@inet.uni-c.dk        |   | Dept. of Energy Engineering, DTU, Bldg 403; DK-2800 Lyngby, DK  | Active, looking for industrial partner | Woodchips, straw, pellets       | 0.5 to 450 kW                                  |    |           |                  |  | Downdraft gasifier with engine, plus parallel basic experiments, TGA, ash melting, and computer models, see Chapter 5.                       |
| 8/1/97   | RESEARCH & SUPPORT | DELFT UNIVERSITY OF TECHNOLOGY                                       | 1.5 MWt process development unit with pressurized fluidized bed gasifier, hi T ceramic filter and gas turbine combustor | NETHERLANDS | Jans Andries                      | 31 15 278 5410<br>31 15 278 2460   | j.andries@wbmt.tudelft.nl   | <a href="http://www-pe.wbmt.tudelft.nl/~andries/innex.htm#">http://www-pe.wbmt.tudelft.nl/~andries/innex.htm#</a> | Laboratory for Thermal Power Engineering, Delft Univ. Mekelweg 2, 2628 Delft, The Netherlands         |  |                                 |  |    |           |                  |  | Gasification modeling, LCV gas combustion, trace components, control, micro-turbines, conversion of LCV gas in cat combustors and fuel cells |
| 8/97     | RESEARCH & SUPPORT | DEMONTFORT UNIVERSITY  | Hybrid Biomass-Wind for rural electric power  | UK          | Andrew P. Chick                   | 44 1400 275624<br>44 1400 273708   | apchick@dmu.ac.uk           |   | School of Agriculture, DeMontfort Univ., Caythorpe, Lincolnshire, NG32 3EP, UK                        | Active                                 | Biomass                         |  |    |           |                  |  |  |
| 9/20/99  | RESEARCH & SUPPORT | DK-TEKNIK  | Danish Energy Agency; all aspects of gasification R & D   | DENMARK     | Soren Houmoller                   | 45 39 69 65 11<br>45 39 69 60 02   | houmoller@DK-Teknik.dk      | <a href="http://www.dk-teknik.dk">www.dk-teknik.dk</a>  | DK-TEKNIK, Gladsaxe Mellevvej 15, 2860 Søborg, Denmark  | Very Active in biomass fields          | Wood, straw, all biomass, MSW   | Small to medium projects, oversite for Denmark | 80 |           |                  |  | GASIFIER SYSTEMS, large staff, very active in gasification, combustion and energy policy for Danish government, see Chapter 5.               |
| 8/1/97   | RESEARCH & SUPPORT | ECN-NETHERLANDS ENERGY RESEARCH FOUNDATION                           | Circulating Fluid Bed, 700 kWth; Downdraft 300 kWth   | NETHERLANDS | Johan Beesteheerde                | 31 224 56 4594<br>31 224 56 3489   | biomass@ecn.nl              | <a href="http://www.ecn.nl/">http://www.ecn.nl/</a>   | Renewable Energies, Box 1, 1755 ZAG Petten, The Netherlands   |  |                                 |  |    |           |                  |  | Major R&D center - biomass energy - 800 employees  |
| 9/1/97   | RESEARCH & SUPPORT | ELECTRIC POWER RESEARCH INSTITUTE (EPRI)                             | Research and Technology based solutions for the Electric Industry, testing and development                              | USA         | Evan Hughes<br>Mgr. Biomass Power | 650 855 2179<br>650 855 8501       | ehughes@epri.com            |   | 3412 Hillview Ave., Palo Alto, CA 94304   |  | Wood, other biomass, tires, MSW | 50kW-500 MW                                    | 24 | 10 tested | \$50-\$2,000/kWe |  | EPRI has longterm interest in biomass for its customers, the Electric Power Industry!  |
| 12/15/98 | RESEARCH & SUPPORT | ENERGY & ENVIRONMENTAL RESEARCH CENTER, U. of N. Dakota              | Oversite of Gasifier activities   | USZ         | Darren D. Schmidt                 | 701 777 5120<br>701 777 5181       | dschmidt@eerc.und.nodak.edu |   | Energy and Environmental Research Center, Box 9018, Grand Forks, ND 58202-9018                        |  |                                 |  |    |           |                  |  | Darren was the chief engineer on the Camp LeJeune gasifier and brings his expertise to management  |
| 9/30/97  | RESEARCH & SUPPORT | EPA RESEARCH TRIANGLE  | Demonstration of 1 MW downdraft gasifier for steam and poer, see MECHEM   | USA         | Carol Purvis                      |                                    |                             |   | Research Triangle Park, NC 27711  |  | Waste Wood                      | 1 MW   | 4  | 1         |                  |  | See Mechem   |
| 8/1/97   | RESEARCH & SUPPORT | ESMAP (Energy Sector Management Assist. Program)                     | Funding and guidance for gasification programs at UNDP/World Bank, world oversite                                       | USA         | Executive Secretary               |                                    |                             |   | 1818 H St. N.W., Washington, D. C. 20433  | Active                                 |                                 |  |    |           |                  |  | Financial assessment and technical reports on gasification projects in various countries   |

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|---------|--------------------|--|---|----------|-------------------------------|--|------------------------------|---|---|----------|--|--|---------|----|-----------------|--|--|
| 8/1/97  | RESEARCH & SUPPORT | ETSU (UK Gasification Oversight)   |   | UK       | Nick Barker (Project Officer) | 44 0235 433 511<br>44 0235 432 923     |                              |   | ETSU, B156 Harwell Laboratory, Harwell, Oxfordshire, OX11 0RA.                                    |          |  |  |         |    |                 |  | Oversite on UK gasification  |
| 1/20/98 | RESEARCH & SUPPORT | EUROPEAN COMMISSION- DIRECTORATE- GENERAL FOR ENERGY (DG XVII),THERMIE   | Support of EC Gasification gasification projects: See BIOCYLE: ENERGY FARM; ARBRE | BELGIUM  | G. L. Ferrero                 | 32 2 295 0150                          |                              |   | rue de la Loi 200, B1049, Belgium   | Active   |  |  |         |    |                 |  | May 1996 Brochure  |
| 4/6/98  | RESEARCH & SUPPORT | EUROPEAN COMMISSION BIOMASS GASIFICATION TARGETED PROJECTS               | Promote Biomass Gasification under EQUIPMENT & CONSULTING 1995 agreement          | BELGIUM  | G. L. Ferrero                 | ?                                      |                              |   | Rue de la Loi 200, B-1049, Brussels, Belgium  | Active   | Coppiced fuels   | 5.5, 11 MWe                                      |         |    |                 |  | European Comission demonstrating biomass energy projects                                     |
| 1/20/98 | RESEARCH & SUPPORT | FEE (Society for the Promotion of Renewable Energies)                    | NGO organizing R&D for biomass gasification, lobbying, PR and support             | GERMANY  | Eberhard Oettel               | 49 30 65 76 27 06<br>49 30 65 76 27 08 | FEE-eV@t-online.de           |   | Innovationspark Wuhlheide, Kopenicker Str 325, 12555, Berlin, Germany                             | Active   | Wood, waste wood, MSW, sewage sludge,                        | 25-5,000 kW, some built, some under construction | Various | 11 | Contact FEE     | FEE is a non-government organization devoted to various forms of renewable energy. Four years ago they initiated a task force "Gasification of Biomass", joining their R&D with manufacturers of gasifiers, engines and turbines |  |
| 8/1/97  | RESEARCH & SUPPORT | GASIFICATION TECHNOLOGIES COUNCIL  |   | USA      | James Childress, President    |  |                              |   |   |          |  |  |         |    |                 |  | See Dan Tyndall memo or Jane Turnbull  |
| 1/20/98 | RESEARCH & SUPPORT | GREAT LAKES REGIONAL BIOMASS ENERGY PROGRAM                              | Regional biomass energy program of the US DOE                                     | USA      | Fred Kuzel                    | 312 407 0177<br>312 407 0038           | fkuzel@cedar.cic.net         | www.cgig.org/project/biomass            |   | Active   |  |  |         |    |                 |  |  |
| 8/1/97  | RESEARCH & SUPPORT | HAMBURG, UNIVERSITY OF   |   | GERMANY  | W Kaminsky, Norbert Grittner  | 49 40 4123 3173<br>49 40 4123 6008     |                              |   | Inst. f. Techn. u. Makromol. Chemie, Bundesstr. 45, 2000 Hamburg 13, Germany                      |          |  |  |         |    |                 |  | Fluidized Bed Pyrolysis of Plastic and Rubber Wastes   |
| 8/97    | RESEARCH & SUPPORT | HAWAII NATURAL ENERGY INSTITUTE (HNEI)                                   | Research renewable energy   | USA      | Scott Q. Turn                 | 808 956 2346<br>808 956 2335           | ssturn@hawaii.edu            |   |   |          |  |  |         |    |                 |  |  |
| 8/97    | RESEARCH & SUPPORT | HAWAII, UNIVERSITY OF  | Gasification R&D  | USA      | Jiachun Zhou                  |  | jiachun@hawaii.edu           |   |   |          |  |  |         |    |                 |  |  |
| 9/19/97 | RESEARCH & SUPPORT | HYDRO-QUEBEC   | Support of renewable energy   | CANADA   | Georges Aabiad                |  | admcom@mail.dcrp.hydro.qc.ca | www.hydro.qc.ca                         | 1010, rue Sainter-Catherine ouest, Montreal, Quebec Canada H3C 457                                | Active   |  |  |         |    |                 |  | Developed 3 energy plantations, monitor forest biomass                                       |
| 9/4/97  | RESEARCH & SUPPORT | IEA BIOENERGY  | Operating agent for task 13 (biomass utilization)                                 | USA, EEC |                               |  | c.refrch@televar.com         | http://www.abdn.ac.uk/ieabioenergy      | 2952 George Washington Way, Richland, WA 99352  | Active   |  |  |         |    |                 |  |  |
| 8/1/97  | RESEARCH & SUPPORT | INDIAN INSTITUTE OF SCIENCE - BANGALORE                                  | All aspects of Gasifier Research, development and dissemination for India         | INDIA    | Mukunda, H. S.                | 91 80 348 536<br>91 80 341 683         | mukunda@cgpl.iisc.ernet.in   | http://144.16.73.100/~mukunda/home.html | Combustion, Gasification & Propulsion Lab,Dept. of Aerospace Eng., IISc, Bangalore 560 012, India | Active   | Wood chips, Ag residues (straws, husks, bagasse, coir, stalk | 3.7kWe to 5 MWe                                  | 10      | 8  | \$300-1,000/kWe | The Combustion, Gasification and Pyrolysis lab publishes many papers on various aspects of gasification, see Chapter 5.  |  |
| 8/1/97  | RESEARCH & SUPPORT | INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY (Gasification Action Res. Center) | Engine-gasifier research, 15 kW dual fuel diesel gasifier, damper.                | INDIA    | P. P. Parikh                  | 91 22 578 2545<br>91 22 578 3480       | parikh@me.iitb.ernet.in      |   | Dept. of Mechanical Engineering, IIT- Bombay, Bombay 400 076, INDIA                               | Active   | All relevant biomass   | As required                                      | 18      |    |                 | Natl. Test Facility for Gasifier Engine System. Prof. Parikh operates gasifiers and engines in laboratory for testing and student study. Many theses published in gasification field, see Chapter 5.                             |  |
| 9/1/97  | RESEARCH & SUPPORT | INRA (AFRICA Gasification)   | Development of small scale gasifiers in Africa                                    | FRANCE   | Riedacker                     | ?                                      | riedacke@worldnet.fr         |   | INRA, 118 rue d'Aleimid, 75014, Paris France  | Planning | Wood, charcoal   | 5-10 hp  |         |    |                 |  | Technology transfer to villages in Africa, also interested in GASIFIER SYSTEMS-LARGE r units |

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|---------|--------------------|---|---|---------|-------------------------------------|----------------------------------|----------------------------|---|---|---|--|------------------|-------|--------|-------------|---|
| 8/1/97  | RESEARCH & SUPPORT | INSTITUTE OF GAS TECHNOLOGY (IGT)                                 | Pressurized Fluid Bed tests on Renugas system; Processes for Power, Methanol                        | USA     | Suresh P. Babu                      | 847 768 0509<br>847 768 0516     | babu@igt.org               | www.igt.org                                       | 1700 S. Mount Prospect Rd., Des Plaines, IL 60018-1804                  | Active in International Energy planning | Wood chips, Bagasse, various others    | 11 t/d           |       |        |             | IGT has had a major research program, but is now involved in international planning. See Chapter 3.                               |
| 8/1/97  | RESEARCH & SUPPORT | IOWA STATE UNIVERSITY   | 5 t/d FB gasifier for agricultural wastes, corn, and switchgrass                                    | USA     | Robert C. Brown                     | 515 294 8733<br>515 294 3261     | rcbrown@iastate.edu        | #http://www.eng.iastate.edu/coe/me/homepage.html# | Dept. Mechanical Eng., 2020 H. M. Black Bldg., Ames, IA 50011           | Active                                  | Waste seed corn; switchgrass           | 5 t/d            |       | 1      |             | \$50,000 grant for gasifier, announced in April 1995 Res. Rec. Rept.  |
| 3/31/98 | RESEARCH & SUPPORT | IVD (Institute for Process engineering, Univ. of Stuttgart)       | R&D in gasification of all biomass and fossil fuels for power generation                            | GERMANY | Christian Storm                     | 49 711 685 3745<br>49 711 685 34 | storm@ivd.uni-stuttgart.de | www.ivd.uni-stuttgart.de                          | Pfaffenwaldring 23, D-79569, Stuttgart, Germany                         | Ongoing R&D                             | Wood, straw, energy crops,             | 50 kW            | 8     | 1 each |             | 1 FB reactor (Bubbling or re-circulating), 1 Entrained flow reactor both with hot gas filtration; on line tar measurement system. |
| 9/30/97 | RESEARCH & SUPPORT | KANSAS STATE UNIVERSITY   | Stratified downdraft gasifier research, theses  | USA     | Walter P. Walawender                |                                  |                            |   | Dept. Chemical Engineering, Kansas State Univ., Manhattan KS 66506      | Active                                  | Wood chips, Plantation fuels           | 100 kW           | 15    | 1      |             | Wallawender has used the "Buck Rogers" gasifier for research and generated many fine theses - and students                        |
| 9/1/97  | RESEARCH & SUPPORT | KEMESTRIE, INC.   | Development of commercial fluidized bed and other processes from Sherbrooke U. research             | CANADA  | Nicolas Abatzoglou, Dir. En. & Env. | 819 569 4888<br>819 569 8411     | kem@interlinx.qc.ca        |   | 4245 rue Garlock, Sherbrooke, Quebec, J1L 2C8, Quebec, Canada           | Active                                  |  |                  |       |        |             | E. Chornet is active in teaching, research and commercialization of biomass processes   |
| 8/1/97  | RESEARCH & SUPPORT | KTH (Kungl Tekniska Hogskolan)                                    | Research on all aspects of gasification   | SWEDEN  | Krister Sjostrom                    | 46 8 790 82 48<br>46 8 10 85 79  | Krister@chemtech.kth.se    |   | KTH, Chemical Technology, S-100 44 Stockholm, Sweden                    | Active                                  |  |                  |       |        |             | Well equipped laboratory, research on fluidized beds, tars, alkali detection, see Chapter 5.                                      |
| 10/5/97 | RESEARCH & SUPPORT | LUND INSTITUTE OF TECHNOLOGY (Dept. of Chemical Engineering)      | Operaton and ecomics of pressurized circulating and bubbling fluid bed gasifiers                    | SWEDEN  | Prof. Ingemar Bjerle                | 46 8 681 91 00<br>46 8 19 68 26  |                            |   | Dept. of Chemical Engineering, Lund Inst. Of Technology, Sweden (?)     | Active                                  | Wood chips                             |                  |       |        |             | Well equipped laboratory, pr FB gasification test facility  |
| 9/21/99 | RESEARCH & SUPPORT | MINISTRY OF AGRICULTURE OF THE PRC (MOA)                          | Evaluation of China's biomass capability and research on village gasifiers                          | PRC     | Ralph Overend                       | 303 275 4450<br>303 275 2905     | ralph_overend@nrel.gov     |   | NREL, 1617 Cole Blvd., Golden, CO 80401                                 | Active                                  | All biomass                            |                  |       |        |             | Joint DOE and MOA assessment and research program, see Chapter 5.   |
| 9/1/97  | RESEARCH & SUPPORT | MNES (MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES)                | Support of biomass gasification in India  | INDIA   | N. P. Singh                         | 91 11 436 1920<br>91 11 436 1298 | secmnes@x400.nicg.nic.in   |   | Block 14, CGO Complex, Lodi Rd., New Delhi - 110 003, India             | Active                                  |  |                  |       |        |             | India has a very large program in gasification, supported primarily by Mr. Singh  |
| 8/1/97  | RESEARCH & SUPPORT | NATIONAL RENEWABLE ENERGY LABORATORY (NREL)                       | Downdraft air/oxygen gasification, lab facilities available   | USA     | Dave Dayton                         | 303 384 6245<br>303 384 6103     | david_dayton@nrel.gov      |   | 1617 Cole Blvd., Golden, CO 80401                                       | Active                                  | Wood, MSW                              | 1 t/d air oxygen | 20    | 1      |             | TCUF, thermochemical user facility, available for testing, 22 years of gasification research, see Chapter 5.                      |
| 8/1/97  | RESEARCH & SUPPORT | NEBRASKA, UNIVERSITY OF   | Spouted Bed gasifier  | USA     | Dave Clements,                      | 402 472 0177                     |                            |   | Dept. Biological Systems Engr., ??                                      |   |  |                  |       |        |             | New Spouted bed design.   |
| 8/1/97  | RESEARCH & SUPPORT | NIMBKAR AGRICULTURAL RESEARCH INSTITUTE (NARI)                    | Use of loose biomass for thermal applications, 500 kW thermal stratified downdraft gasifier, others | INDIA   | Anil K. Rajvanshi                   | 91 2166 22396<br>91 2166 23328   | root@nimbkar.ernet.in      |   | NARI, Box 44, Phaltan 415523, Maharashtra, India.                       | Available for commercial use            | Cane, sorghum, millet, safflower trash | 500-800 kW(th)   | >1987 | 2      | \$60/kW(th) | I have visited AR in Phaltan and he visited Golden many times. Interesting R&D.   |
| 1/20/98 | RESEARCH & SUPPORT | ONTARIO HYDRO (Environmental Responsibility and Leadership Dept.) | Support of Thermogenic 6 Mbitu/h gasifier & other renewable energy options                          | CANADA  | John Russell                        | 416 207 5684                     |                            |   | ERL Dept., Ontario Hydro, 700 University Ave., Toronto, Ontario M5G 1X6 | Active                                  |  |                  |       |        |             | See SED Case Study on Thermogenics, Aug. 1997   |

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| 1/20/98 | RESEARCH & SUPPORT | Pacific Northwest and Alaska Regional Biomass Energy Program                                    | Regional biomass energy program of the US DOE   | USA         | Jeffrey James                        | 206 553 2079<br>206 553 2200         | jeffrey.james@hq.doe.gov     |                | 800 5th Ave., SU 3950, Seattle, WA 98104  | Active                      |  |                          |    |   |        |  |   |
| 8/97    | RESEARCH & SUPPORT | PAUL SCHERRER INSTITUTE (PSI)   | Bubbling fluidized bed research, research on Syn-fuel production from waste biomass                 | SWITZERLAND | Luiz Carlos de Sousa<br>C. Von Scala | 41 56 310 40 60<br>41 56 310 21 99   | desousa@psi.ch               |                | OLGA/215, CH-5232 Villigen PSI; Switzerland   | Active                      | Sawdust, scrapwood, plastics                 | 120kWt (30 kg/h sawdust) |    | 1 |        |  | Studying influence of contaminants on gasification behavior, seeking optimum conditions for methanol synthesis syngas, tar behavior |
| 9/1/97  | RESEARCH & SUPPORT | PRINCETON UNIVERSITY (Center for Energy and Env. Studies)                                       | Evaluation of energy projects   | USA         | Eric D. Larson                       | 609 258 4966<br>609 258 3661         | el Larson@princeton.edu      |                | Center for Energy and Environmental Studies, Princeton Univ., Princeton, N.J. 08544-5263  |                             |  |                          |    |   |        |  |   |
| 9/20/99 | RESEARCH & SUPPORT | PYNE  | Pyrolysis/gasification newsletter from Aston Univ.  | UK          | Tony Bridgwater                      | 44 121 359 3611<br>44 121 359 6814   | a.v.bridgwater@aston.ac.uk   | www.pyne.co.uk | Bio-Energy Research Group, Aston Univ., Birmingham B4 7ET, UK                             | Active                      |  |                          |    |   |        |  |   |
| 9/20/99 | RESEARCH & SUPPORT | PYNE  | Pyrolysis/gasification newsletter   | UK          | Tony Bridgwater                      | 44 121 359 3611<br>44 121 359 6814   | a.v.bridgwater@aston.ac.uk   | www.pyne.co.uk | Bio-Energy Research Group, Aston University, Birmingham B4 7ET, UK                        | Many activities             |  |                          |    |   |        |  | Primarily fast pyrolysis, but other gasification activities as well.  |
| 1/20/98 | RESEARCH & SUPPORT | REGIONAL BIOMASS ENERGY PROGRAMS (U.S. Department of Energy, DOE)                               | Support of biomass power in U.S. in 5 geographical regions  | USA         | Mike Voorhies                        | 202 586 1480<br>202 586 9815         | michael.voorhies@hq.doe.gov  |                | Office of Fuels Development, EE-31, 1000 Independence Ave., S. W., Washington, DC 20585   | Active                      |  |                          |    |   |        |  | Central support for the 5 regional biomass energy programs - Strategic plan, 1997-2003, July 1997.                                  |
| 9/1/97  | RESEARCH & SUPPORT | SAO PAULO, UNIVERSITY OF  |   | BRAZIL      | Suani T. Coelho                      | 55 11 818 5064<br>55 11 818 5031     | suani@iee.usp.br             |                |   |                             |  |                          |    |   |        |  |   |
| 1/20/98 | RESEARCH & SUPPORT | SARAGOSA, UNIVERSITY OF   | Developing new fluidized bed gasification and gas clean-up processes/concepts                       | SPAIN       | Prof. M. P. Aznar                    | 34 76 76 13 39<br>34 76 76 21 42     |                              |                | Chemical and Environmental Engineering Dept., Univ. of Saragossa, 40009, Saragossa, Spain | Active                      | Wood chips, energy crops, olive hulls, straw | 1050 kg/hr               | 10 | 2 | \$0.5M |  | There are several catalytic beds downstream of the gasifier in slip flow  |
| 8/1/97  | RESEARCH & SUPPORT | SHANDONG ENERGY RESEARCH INSTITUTE (SDERI)  | Development of village gasifier system  | CHINA       | Xu Min                               | 86 0531 296 5635<br>86 0531 296 1954 |                              |                | Shandong Academy of Sciences, Keyuan Rd., Jihshi Rd., Jinan 250014, PR China              |                             |  |                          |    |   |        |  | Joint program with NREL, have a demonstration village gas system operating, see Chapter 5.  |
| 8/1/97  | RESEARCH & SUPPORT | SHERBROOKE, UNIVERSITY OF   | University-driven research for fundamentals & training, Energy/Envir. centered research; 50 kg/h FB | CANADA      | Prof. Esteban Chornet                | 819 821 7171<br>819 821 7955         | echornet@coupal.gcm.usher.ca |                | Département de Génie Chimique, Université de Sherbrooke, PQ, J1K 2R1, Canada              | 1 patent, many publications |  | 2.5cm-10cm res.,         | 8  | 2 |        |  | Novel fluidized bed research, partial oxidation studies recovery metals from waste, see Chapter 5.                                  |
| 9/1/97  | RESEARCH & SUPPORT | SINTEF (Foundation for Scientific and Industrial Research at the Norwegian Inst. Of Technology) | Research in gasification, pyrolysis   | NORWAY      | Morten Gronli                        | 47 73 59 20 70<br>47 73 59 28 89     | morten.gronli@termo.unit.no  |                | N-7034 Trondheim, Norway  | Active                      |  |                          |    |   |        |  | Excellent thesis on pyrolysis   |

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| 9/19/97 | RESEARCH & SUPPORT | SOUTHEASTERN REGIONAL BIOMASS ENERGY PROGRAM (SERBEP)                         | Regional biomass energy program of the US DOE                        | USA         | Phillip Badger, Mgr | 205 386 3086<br>205 386 2963              | pcbader@tva.gov             |  | TVA, CEB 3A, BOX 1010, Muscle Shoals, AL 35662-1010   | Active  |   |                      |    |   |                                  |  |  |
| 9/1/97  | RESEARCH & SUPPORT | SWISS FEDERAL INSTITUTE OF TECHNOLOGY (ETH)                                   | Support in Gasification  | SWITZERLAND | Thomas Nussbaumer   | 41 1 632 2589<br>41 1 632 1176            | nussbaumer@iet.mavt.ethz.ch |  | Laboratory for Thermodynamics (LTNT), CH-8092, Zurich, SW   |   |   |                      |    |   |                                  |  |  |
| 8/97    | RESEARCH & SUPPORT | TERI (TATA ENERGY RESEARCH INSTITUTE)   | Development of gasifiers forsilk boiling, drying, crematorium        | INDIA       | V. V. N. Kishore    | 91 11 462 2246<br>91 11 462 1770          | vvnk@teri.ernet.in          |  | Darbari Seth Block, Habitat Place, Lodhi Rd., New Delhi, 110 003 India                                | Active  | Wood  | 2 kWth (silk); 4okWe |    |   |                                  |  | Very active program in gasifier development for commercial uses in India, see Chapter 5.   |
| 9/27/99 | RESEARCH & SUPPORT | THE BIOMASS ENERGY FOUNDATION   | Downdraft gasification R&D, 25 kW Small Modular Biomass Power System | USA         | Thomas B. Reed      | 303 278 0560                              | tombreed@comcast.net        | www.webpan.com/BEF   | 1810 Smith Rd., Golden, CO 80401  | Active  | Wood chips, pellets, biomass residues, coal | 2-25 kW              | 25 | 2 | <\$1000/kWhe                     |  | Active in R&D, pilot plant gasifiers. See Chapter 4 and 5.   |
| 9/1/97  | RESEARCH & SUPPORT | THOMAS KOCH ENERGI  | Consulting on gasification of straw etc.                             | DENMARK     | Thomas Koch         | 46 19 15 54<br>46 19 15 38                | 100711.220@compuserve.com   |  | Hovedgaden3, 4621 Gadstrup, Denmark   | Active  | Straw etc.                                  |                      |    |   |                                  |  |  |
| 8/1/97  | RESEARCH & SUPPORT | ULSTER, UNIVERSITY OF, ENERGY RESEARCH CENTRE                                 | Analysis of gasification, biomass, power plants                      | IRELAND     | John T. McMullan    |   | jt.mcmullan@ulst.ac.uk      |  |   |   |   |                      |    |   |                                  |  |  |
| 3/31/98 | RESEARCH & SUPPORT | UMSICHT (FraunhoferInstitute for Environmental, Safety and Energy Technology) | R&D on 0.5 MW pilot plant; consulting for large scale gasifiers      | GERMANY     | Markus Ising        | 49 208 8598 189<br>49 208 8598 290        | info@umsicht.fhg.de         | www.umsicht.fhg.de   | Osterfelder Strasse 3, D-46047, Oberhausen, GERMANY   | Operating 0.5 MW pilot plant, planning commercial | Wood, Ag residues, MSW...                   | 0.5 MW and >         | 3  | 1 | 2800 \$/kWe for complete process |  | Working on utilization of 1 atm air-blown CFB gasification for CHP with gas engines, leading to 12 MW deo project (CFB) + lean gas furnace and boiler system     |
| 9/1/97  | RESEARCH & SUPPORT | VERENUM   | Tar measurement, gas cleaning, water treatment                       | SWITZERLAND | Thomas Nussbaumer   | 41 1 632 2589<br>41 1 632 1176            | verenum@access.ch           |  | Langmauerstrasse 109, CH-8006, Zurich SWITZERLAND   | Active research                                   |   |                      |    |   |                                  |  |  |
| 9/30/97 | RESEARCH & SUPPORT | VIENNA, TECHNICAL UNIVERSITY OF   | Fluidized bed, dolomite catalysts                                    | AUSTRIA     | Reinhard Rauch      | 43 1 588 01 5130<br>43 1 588 01 587 63 94 | hhofba@fbch.tuwien.ac.at    | http://edv1.vt.tuwien.ac.at/AG_HOFBA/Vergaser/e_vergas.htm | Inst. Fur Chemical Engineering, 9/159, A 1060 Vienna, AUSTRIA   | Active  |   |                      |    |   |                                  |  | Use of dolomite to reduce tar to 200-300 mg/Nm3; research in methanation of producer gas   |
| 8/1/97  | RESEARCH & SUPPORT | VTT GASIFICATION R&D CENTER   | Various gasifiers and bench rigs                                     | FINLAND     | E. Kurkela          | 358 9 456 6599<br>358 9 460 493           |                             |  | VTT Energy, FIN-02044 VTT, Espoo, Finland   |   | Various, all                                |                      |    |   |                                  |  | Extensive research on large gasifiers, see Chapter 5   |
| 1/20/98 | RESEARCH & SUPPORT | WALES, UNIVERSITY OF(2)   | 200 kW fixed-bed/gas air heat exchanger for crop drying              | UK          | David Beedie        | 44 222 874 930<br>44 222 874 420          | BeedieD@cardiff.ac.uk       | http://msi2.elsy.cf.ac.uk:80/www/citsg                     | Division of Electronics, School of Engineering, Cardiff Univ. of Wales, Box 917, Cardiff, CF2 1XH, UK | Active  | Ag wastes                                   | 200 kWth             |    | 1 |                                  |  | For complete details of crop-dryer and gasifier, see thesis. See Chapter 5.  |
| 1/20/98 | RESEARCH & SUPPORT | WESTERN REGIONAL BIOMASS ENERGY PROGRAM (WRBEP)                               | Regional biomass energy program of the US DOE                        | USA         | Dave Waltzman       | 303 275 4821<br>303 275 4830              | dave.waltzman@hq.doe.gov    |  | 1617 Cole Blvd., Golden, CO 80401   | Active  |   |                      |    |   |                                  |  | Regional office also in Nebraska   |
| 9/1/97  | RESEARCH & SUPPORT | WINROCK INTERNATIONAL   | Support of gasification and biomass energy                           | WORLD       | Dan Jantzen         | 303 422 7785                              | danjantzen@compuserve.com   |  | 5906 Newcombe Ct., Arvada CO 80004  | Active  |   |                      |    |   |                                  |  | Dan Jantzen was formerly at NREL/SERI and is very knowledgeable in gasification. My co-author on GEN GAS. Recently returned to U.S. from India office of WINROCK |

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| 9/1/97  | RESEARCH & SUPPORT | WISCONSIN, STATE OF (Energy and Intergovernmental Relations) | Support of gasification  | USA   | Don Wichert           | 608 266 7312<br>608 267 6931     | wichert@mail.state.wi.us |  |   |        |  |                   |  |   |           |  |
| 1/20/98 | RESEARCH & SUPPORT | ZARAGOZA UNIVERSITY  | Downdraft air gasification R&D, 22 & 200 kW plants available; studies and expts on biomass and MSW | SPAIN | Pedro Garcia-Bacaicoa | 34 976 761 880<br>34 976 761 861 | bacalcoa@posta.unizar.es |  | Chemical and Env. Eng. Dept., Zaragoza Univ., 50015 Zaragoza, Spain | Active | Wood chips, briquettes and almond shells | 50, 100m 300 kg/h |  | 4 | \$200,000 | Downdraft air gasification R&D, 33 and 200 kW available. Studies and experiments on biomass and waste gasification, see Chapter 5. |





## OIL, ETC.

### Home

Oil, more properly "petroleum" was discovered about 1869 in Drake PA., and has changed the world dramatically.

### Biomass Energy

I was a professor at the Colorado School of Mines which has a large petroleum production department and the Hubbert Center for studying oil supplies...

### Gasification & Reforming

Long ago I worked for Shell Exploration and production in Houston Texas and shared an office with M. King Hubbert. He became famous in the 1970s for predicting that US production would peak in 1974 (it did) and then decline (it has). I met him in the 1980s for dinner and asked if he had a prediction for world oil. He declined to predict because he said that other countries didn't keep as good records as the US and they lied about their reserves in order to claim a larger share of the market.

### Liquid Fuels

### Wood

### Cooking

### Energy

### Rosetta Stone

More recently another Shell employee and friend of Hubbert, Kenneth S. Deffeyes, wrote "Hubbert's Peak: The Impending World Oil Shortage". (Princeton Univ. Press, 2001). He is a world famous geologist at Princeton, teaching "Rocks for Jocks". He has put this reputation on the line, saying "My own opinion is that the peak in world oil production may even occur before 2004. What happens if I am wrong? I would be delighted to be proved wrong. It would mean that we have a few additional years to reduce our consumption of crude oil. However, it would take a lot of unexpectedly good news to postpone the peak to 2010."

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There are 37.6 million websites dealing with OIL and only 218,000 dealing with OIL DEPLETION, such as..

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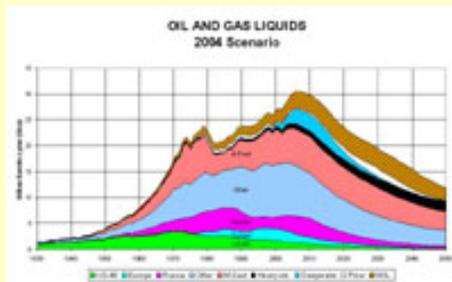
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<http://www.odac-info.org/> and <http://www.peakoil.net/>.

Here are a few excerpts...



**Peak Oil in 2008**

Colin Campbell and the [Uppsala Hydrocarbon Depletion Study Group](#) has now made the 2004 upgrade of the peak oil model. The peak is moved from 2010 to 2008 ([read more](#)).

**Welcome to MK Hubbert Center**

Hubbert Center is dedicated to Assembling and disseminating global petroleum supply data. M. King Hubbert Center for Petroleum Supply Studies. ... [hubbert.mines.edu/](http://hubbert.mines.edu/)

I could also find a lot of "experts" saying this is the old "wolf, wolf" cry and that the oil peak will not occur for 20-50 years. Whatever. It will occur in many of our lifetimes and cause a lot of disruption unless we have substitutes well under way.

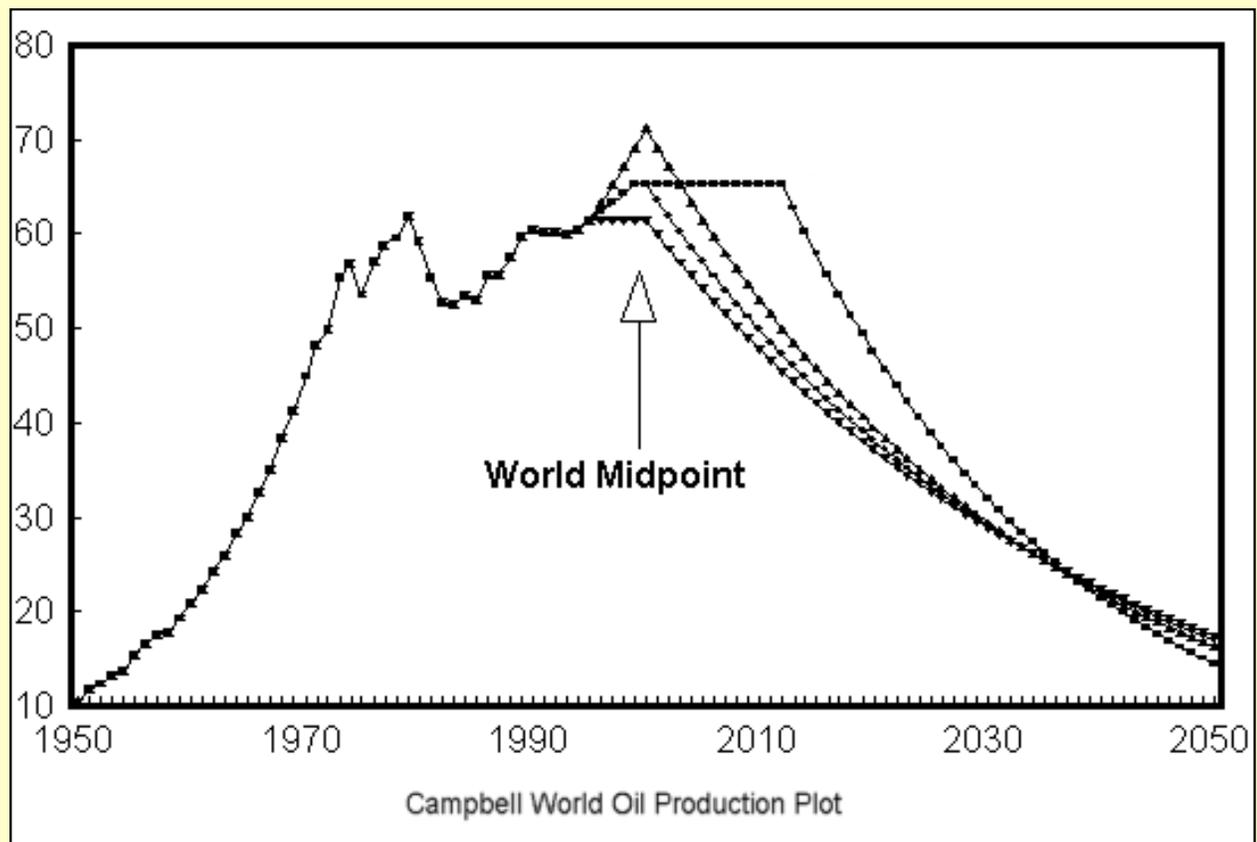


Figure 2

Graph showing Production (Mbd) against Time (Years), based on Campbell's data.

The four different lines correspond to different possible scenarios taking place from 1996 onward. It can be seen that whichever scenario actually occurs, the end result is reasonably constant. This is because the Ultimate is a constant value, so that more oil now means less in the future: whilst it may be possible to alter the shape of the curve, one cannot alter the area beneath it. The 'premature peak' in the early 1970s corresponds to the oil crisis of 1973.

Now it is time to re-examine our approach to alternative fuels and hope we can keep ahead of the **oil depletion curve**.





## BIODIESEL - McDIESEL

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In Summer, 1989, I learned about the conversion of animal fats and vegetable oils to their methyl esters for fuel purposes from some proceedings of the US Dept of Agriculture workshops held in the early 1980s and from research at the University of Idaho and others. The process is called "Transesterification", and is quite simple. It means converting the fats are oils, which are tri-esters with glycerol, to the monoester with methanol. Being interested in alternate fuels, I mulled this over in my subconscious and in November, 1989, I wondered what happened to all that good oil/fat when it was "used up". I found that there are about a billion gallons a year under the heading "yellow grease" which are used for soap, cattle feed, but has a very low value (<\$1/gallon) relative to new oil/fat.

I wondered if it could be used to make the esters for fuel. I went to our local McDonalds and got a gallon of "waste grease" from their grease dumpster in back, (UGH!). In my lab at the Colorado School of Mines I made minor adjustments in the transesterification recipe and made a gallon of beautiful fuel from (UGH) grease. Wow! As a chemist I had a wonderful time for the next few months making "transesterified waste vegetable oil" from many feedstocks. Even made it from bacon grease at Christmas in my daughter in law's kitchen from grocery store components.

If you are the kind that likes contact with reality, why not make some **Bio-diesel in the kitchen** . Just print out the file and GO. Be sure your fat/oil is dry. Bacon grease and butter contain too much water unless you boil it off and render them to a clear oil (ghee for butter).

At that time the DENVER RTD bus company was considering alternate bus fuels. We approached the bus company to see if they were interested in this alternative clean fuel. Sure, but they needed more than a gallon to test. I went to our UNIT OPS laboratory at the Colorado School of Mines and made 100 gallons (2 drums) for testing by RTD.

I didn't think "transesterified waste vegetable oil" was a very good name, so,

considering the source, I decided to call it McDIESEL. I applied for a copyright. I even approached McDonalds to see if they were interested. They were, but said they would sue me if I used that name. Later people came to call these fuels "BIODIESEL", and I now live with that. However, I would love to have had McDonalds sue me - what publicity!

We discovered that there was NO political base for using low cost waste grease for an alternate fuel. There was a tremendous base for spending much more money to make Biodiesel from Soy Oil. Now biodiesel is highly political and there is a newsletter telling of test results and new companies hoping for government subsidies courtesy of global warming. Check them out at [www.biodiesel.org](http://www.biodiesel.org).

In February 1990 we tested the fuel on a dynamometer and a bus and it ran fine and had low emissions. We have published a number of papers on Biodiesel from waste grease, but no one is particularly interested. Meanwhile biodiesel from soy is still \$3-4/gal.

If you are interested in making some biodiesel, here is our recipe for making it in the kitchen with easily available materials:

---

**May 20, 1997**

**TO: People interested in making Biodiesel**

**FROM: Thomas B. Reed, the Biomass Energy Foundation**

**SUBJECT: Making Bio-diesel in the kitchen**

Biodiesel is a new, alternative, renewable, clean diesel fuel made from Nature's triglycerides - oils, fats, waste cooking oils and many other natural products. ,

However, if you would like to try the reaction in your kitchen, here's the recipe for a simple demonstration you can try, using common household chemicals. (REMEMBER TO HANDLE ALL CHEMICALS WITH CARE! While these are common "household" chemicals, the methanol will burn with an almost invisible flame, so extinguish all fires; the lye can burn your fingers or blind you. Read the warnings on the can!)

The reaction (with the terrible names "transesterification" or "alcoholysis")

substitutes methanol (wood alcohol) for the Glycerol in triglycerides (fats, oils) to make the methyl esters called biodiesel. It uses lye as a catalyst. A junior chemist might write it:

**Triglyceride (fats or oils) + Methanol  $\rightarrow$  Biodiesel + Glycerol (+soap from catalyst)**

The lye converts a small amount of the oil to soap so that the methanol will be soluble in the triglyceride. After the reaction is over, the glycerol and soap settle to the bottom of the vessel and the biodiesel floats on top.

In a measuring cup measure 200 ml of methanol. To this add 1 level tsp of lye (sodium hydroxide). In a separate pan, heat 500 ml (1 cup) of any vegetable oil cooking oil (such as Mazola, Canola etc. to about 120F (using a candy thermometer). Put the oil in a blender and add the methanol-lye mixture to the warm oil while vigorously stirring. Stir for 30 minutes. This solution is opaque at first, but as the reaction progresses it becomes thinner than the original oil and translucent.

Allow the mixture to settle for a day in a tall thin vessel. You will see two separate layers. The biodiesel floats to the top as a clear liquid, and can be poured off into a container for display (or into your diesel car or truck). The glycerol and some soap go to the bottom and can be discarded in this experiment. In commercial practice the glycerol and soap can be further processed to other fuels.

You have now made biodiesel on a small scale and can better appreciate the use of renewable fuels from farms.



## **BIODIESEL FROM WASTE VEGETABLE OILS**

Every fast food restaurant discards large quantities of waste vegetable oils weekly. They are collected and sold as “yellow grease” and can contain fats from cooked meat and free fatty acids from the breakdown of the oil. Yellow grease is an attractive source of biodiesel, but is more difficult to convert to biodiesel because it contains 2-10% free fatty acids (the cause of the rancid taste) which consume some of the lye catalyst.

Many people are converting “yellow grease” to biodiesel or using it directly. (See [http://en.wikipedia.org/wiki/Yellow\\_grease](http://en.wikipedia.org/wiki/Yellow_grease)) and <http://www.easternct.edu/depts/sustainenergy/calendar/biodiesel/Geise%20->

[%20Biodiesel%20from%20Recycled%20Vegetable%20Oil.pdf](#) It requires additional lye to neutralize the free fatty acids and the process so more chemistry than the kitchen provides.



# Embedded Secure Document

The file [http://www.woodgas.com/hydrogen\\_economy.pdf](http://www.woodgas.com/hydrogen_economy.pdf) is a secure document that has been embedded in this document. Double click the pushpin to view.



# WOODGAS

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I recently took my WoodGas camp stove to a soccer game with my daughter. I loaded it with fuel pellets and let it burn on a camera tripod. The weather was cold, rainy and windy. Soon, most of the parents were gathered around warming their hands at my portable warming station. I was the most popular parent in the place!

On the low setting, the pellets burned a nice flame for one hour. I then kept it burning with a few pellets every 5 minutes or so. Don't go to a cold soccer game without one.

**Jim, Bonney Lake, WA**  
**Feb 15, 2007**



I love to take my motorcycle on camping trips in the Black Hills of South Dakota. I have taken your stove on many extended trips. It fits great on my 2000 Ural 2WD

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motorcycle, which is pretty loaded down when I'm out for several days. My dad didn't really think it would work, until he tried it, and now he's a believer. He threw away his WWII German cook stove, and now uses nothing but the WoodGas camp stove.

Anyone with questions can contact me at: justindorrance-at-hotmail-dot-com

**Junstin D,  
Customer SD  
Jan 5, 2007**



Using a few wood pellets and some saw dust, I was able to get the stove running well in a minute or two. Then I put on my lunch. Soup with meat balls! With the stove on high, the soup was boiling in short order. Then I put the stove on low, and it made a nice cooking fire for about 30 minutes. Then I dumped out the ashes and it was cool about 15 minutes later.

I'm pleased with your stove, and will enjoy taking it on my next camp out.

**John H, Prescott  
AZ  
Oct 4, 2006**



I use this stove practically every day. It always performs no matter what fuel I try - and I've tried many: pellets, plum seeds, split wood, pine cones and grasses.



About a year ago, the stove saved my life. I was on a kayak on a North Idaho river early in spring. After capsizing in the river, soaking all my clothes and sleeping bag, and developing hypothermia, I spent a subfreezing night huddled over 10,000BTU of WoodGas heat. It was one of the worst nights of my life - and I've seen a few. But the stove gave me the heat to survive until morning.

Thanks for a great stove!

**Chris S, Northern  
Idaho  
Aug 28, 2006**

Great stove... water boiled in under 7 minutes with pine chips and the like from the forest floor. I easily started the stove with my own recipe for a fire starter. Here is the recipe for those of you who would like to make your own:

- 1 - clump of dryer lint
- 1 - coffee filter
- 1 - string
- 1 - small pot of melted wax.

Put clump of dryer lint in coffee filter - not too tight. Tie with the string and dunk in hot wax. Cheap, easy and fun!

**Bob G  
Hi Adventure Trek Planning and Leave No Trace  
Master  
Circle Ten Council of Boy Scouts  
Dallas, TX  
June 29, 2006**



I liked the stove so much, I wanted to use it around the house for barbeque. I cut a hole in the bottom of a grill, filled it with wood pellets, and it ran for over an hour on low power. Perfect heat and perfect time for BBQ. No more charcoal to purchase!

Ribs and corn in Korean Sauce - Mmmmm!

**Shivayam E,  
Denver CO  
June 8, 2006**



Tonight I fired up the new WoodGas Campstove for the first time since receiving it a couple months ago. For fuel I used some cedar split from 1 x 6 drops from a

fence project. Using a little starting gel the wood immediately lit and after a few seconds using the low fan setting it was producing a great cooking source. In several minutes I had brought some leftover chili to a good edible temperature.

I plan to use this stove mainly for expeditions by motorcycle. With this stove, the problem of transporting flammable fuel will be eliminated.

**Karl W, Portland  
OR  
May 22, 2006**

Just thought I let you know I tried out the woodgas campstove today. I loved it! I cooked 4 hamburgers on it in about 20 minutes.

One thing that amazed me, was how fast the heat came up, less than 2 minutes after we lit it, we had the frying pan on it, and it cooked away

wonderfully. It burned up all the fuel in about 15 minutes and just to see how it worked, I reloaded the unit with wood chips. It smoked for a minute or so, so we dropped another lighted match in the top, and everything came up a nice flame and it worked nicely for another 15 minutes with nice clean burning, little or no smoke.

When it was done, I dumped out the remaining ash and let the unit cool. Start to finish, everything took less than 45 minutes.

Amazing.

**Collin C, Saskatchewan CA**  
**May 2, 2006**



I love this bullet-proof little stove. I had a huge smile on my face the whole time I was playing with it. By the way, "playing" is a misnomer - this is serious equipment. It's well worth the \$50 bucks or so to have this as an emergency stove or heat source in your survival kit (though you need to treat this like any open fire and watch out for carbon monoxide, especially indoors).

Comes with a one-year limited warranty too.

Read his entire review [here](#)

**Don B, California**  
**March 15, 2006**



The stove burned the fuel evenly and made a great flame for cooking. We easily cooked two pans of hamburgers on one stove-full of fuel. I also quickly boiled water for coffee.

As I walked around the park, all I could think of was how much fuel there was for the stove. And to think that

one medium branch was enough to cook dinner.

Congratulations on making a great, fuel efficient stove.

**Phil R, Long  
Beach, CA  
March 10,  
2006**

The XL stove arrived in the post this morning, thanks, and is very nice. I tried it out just with some Scots pine cones I'd picked up recently, and it burns very nicely. I think it will be less work to use than the LE, which I have been enjoying very much since last Sept, because of easier wood preparation as well as longer burn times of course, and I'm drying some larger chunks to try in it. I would be interested to know if you have a recommendation for optimum chunk size for the two stoves, but I'm aware of how flexible they are with a range of fuel.

I couldn't help noticeing that it is so much deeper than the LE which prompts me to wonder if the new stainless LE's are also deeper now?

If the weather picks up we may go camping in a week's time, and it will be nice to try them both out with whatever N. Wales can provide us with in early April!

**Best wishes,  
Neil Taylor**

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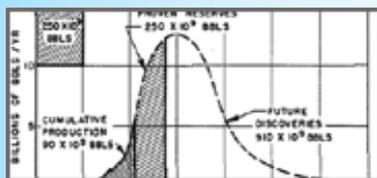
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|                                     |          | <b>Subtotal</b> | 55.00  |
|                                     |          | <b>Shipping</b> | 0.00   |
| <b>All prices are in US Dollars</b> |          | <b>Tax</b>      | 0.00   |
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|                       |          | <b>Subtotal</b> | 130.00 |
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| Encyclopedia of Biomass Thermal Conversion |          | 60.00           | 60.00  |
|  |          | <b>Subtotal</b> | 190.00 |
|  |          | <b>Shipping</b> | 0.00   |
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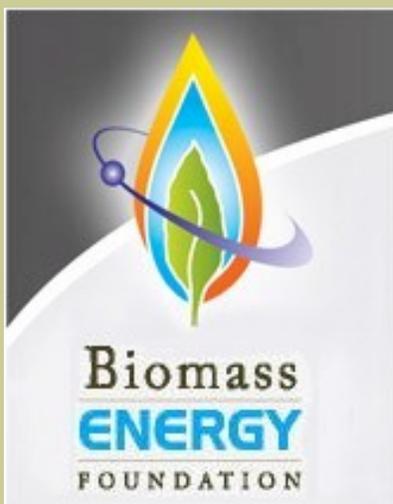
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Edited by  
**Thomas B. Reed**  
The Biomass Energy Foundation



**3<sup>rd</sup> Edition**

The Biomass Energy Foundation Press  
November, 2002



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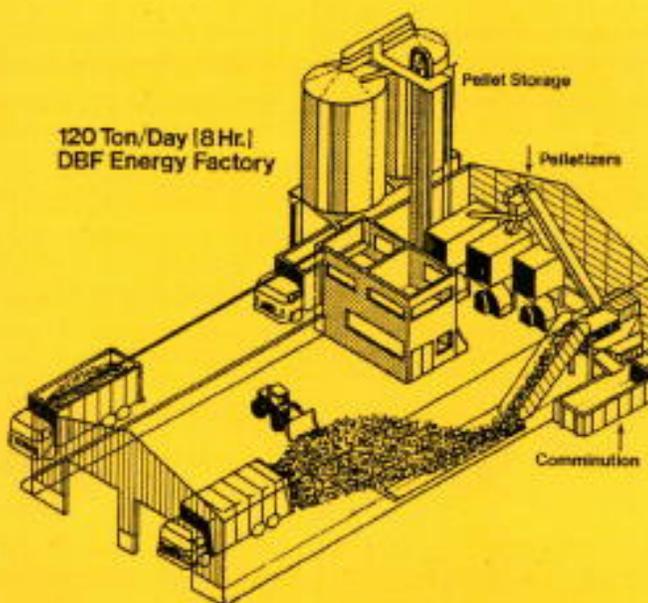
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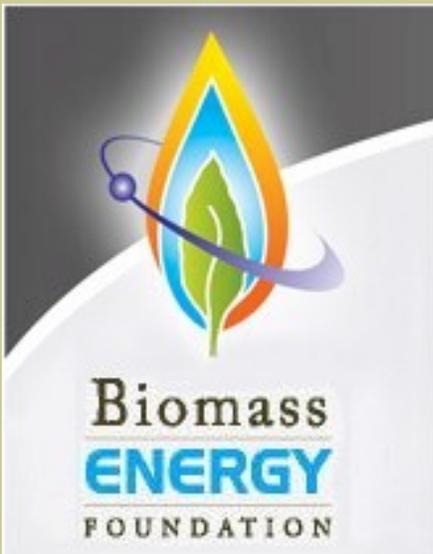
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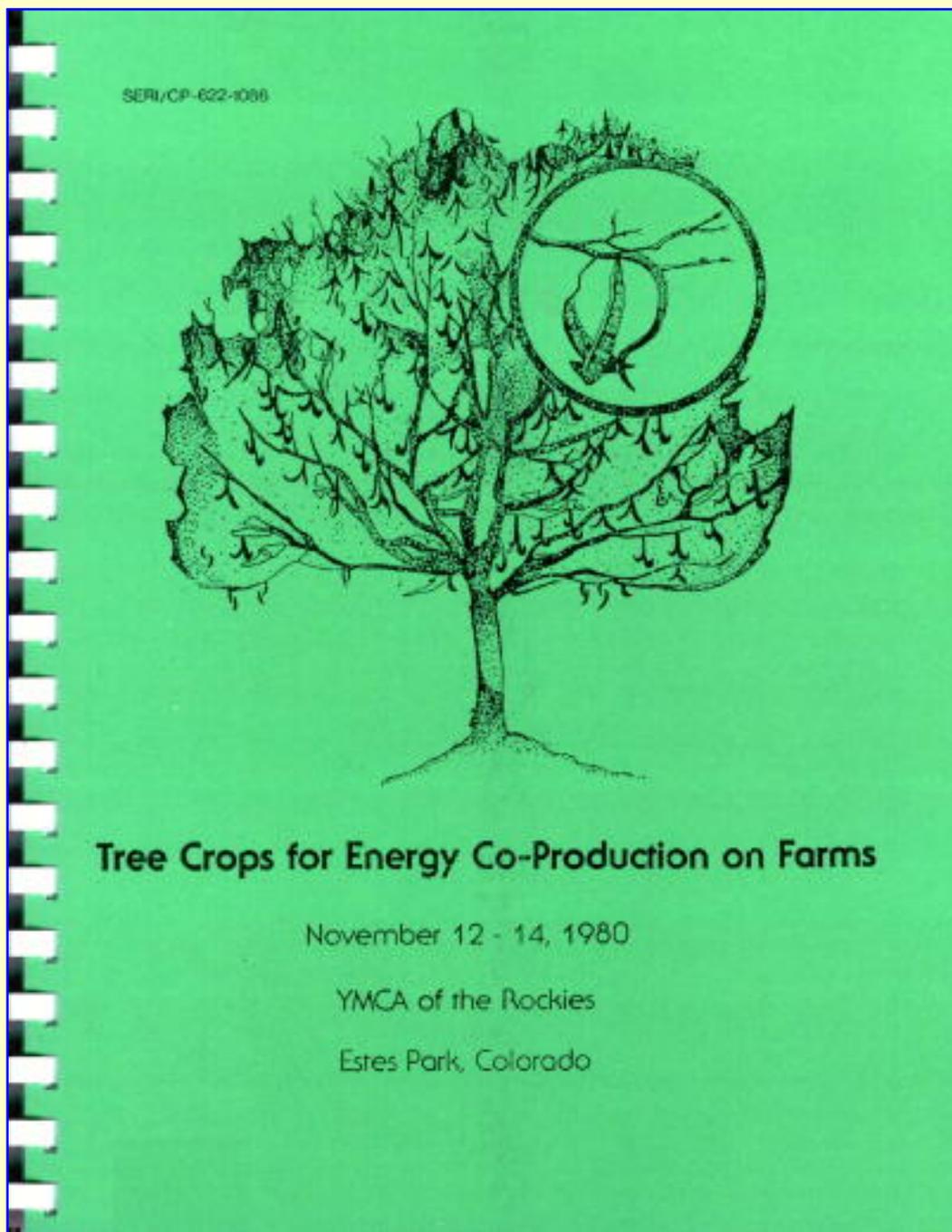
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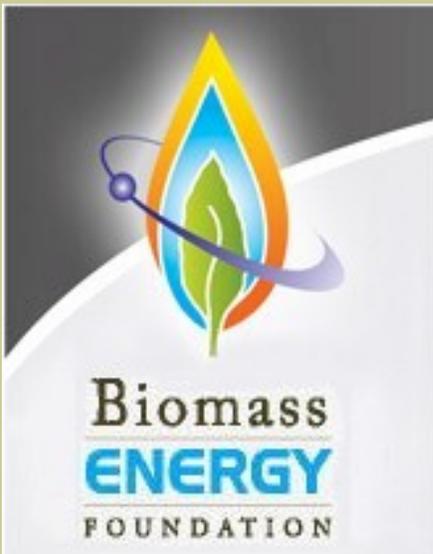
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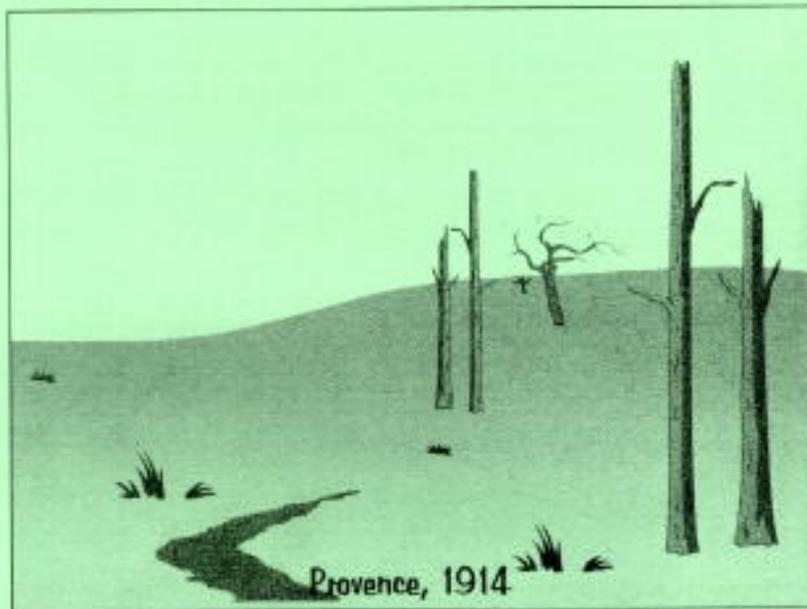
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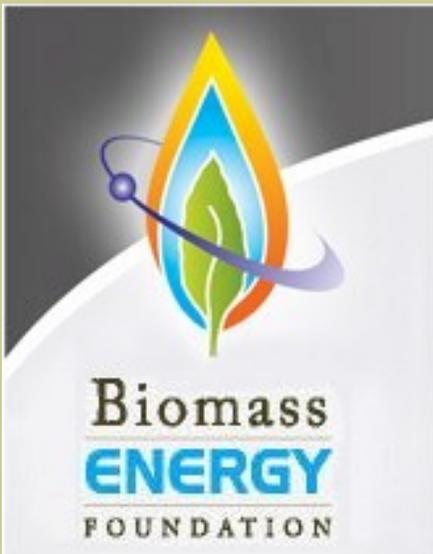


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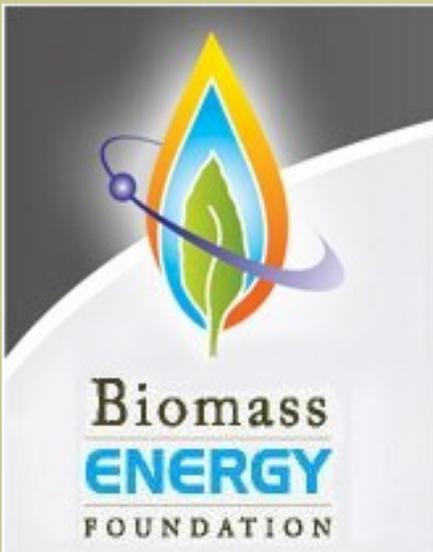
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Thomas B. Reed & Siddhartha Gaur



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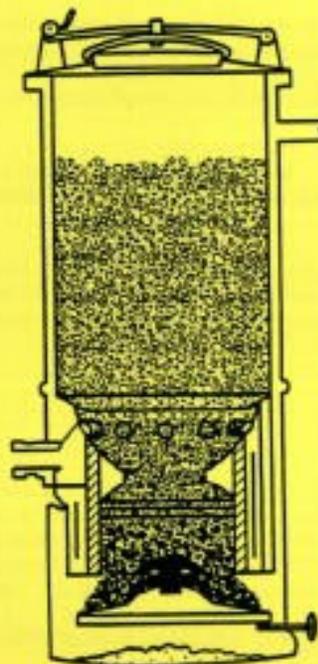
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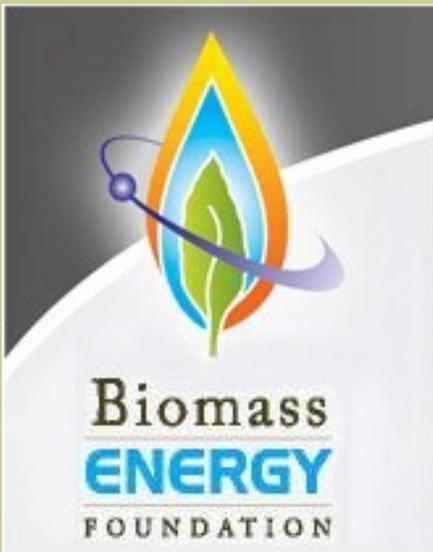
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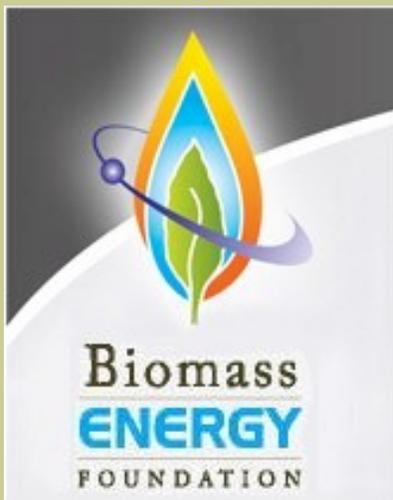
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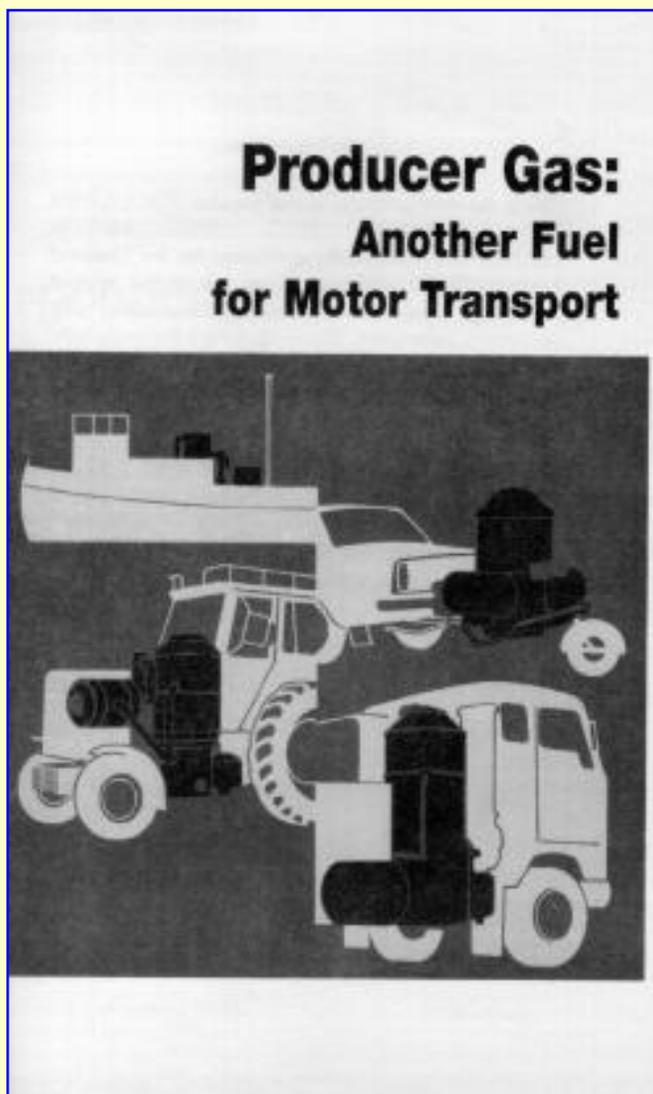
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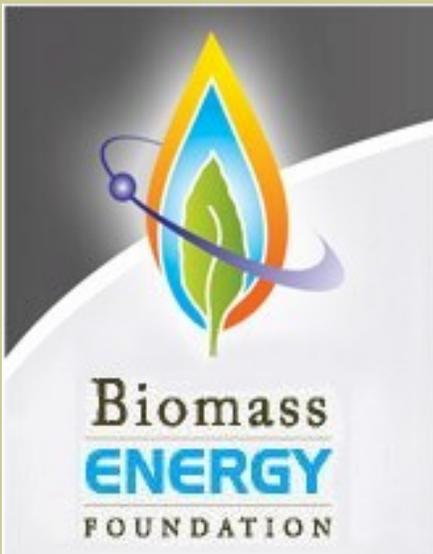
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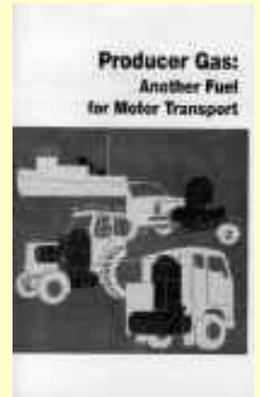
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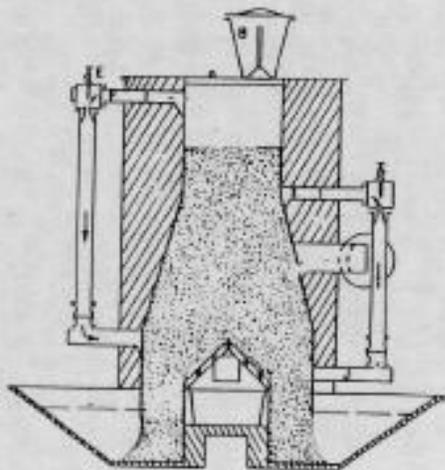
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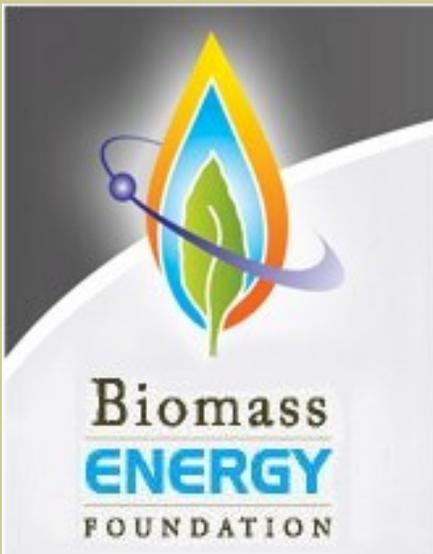
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***SMALL SCALE GAS PRODUCER-ENGINE SYSTEMS:*** A. Kaupp and J. Goss. (Veiweg,1984) Updates GENGAS and contains critical engineering data and good common sense, indispensable for the serious gasifier project. Ali Kaupp is thorough and knowledgeable.

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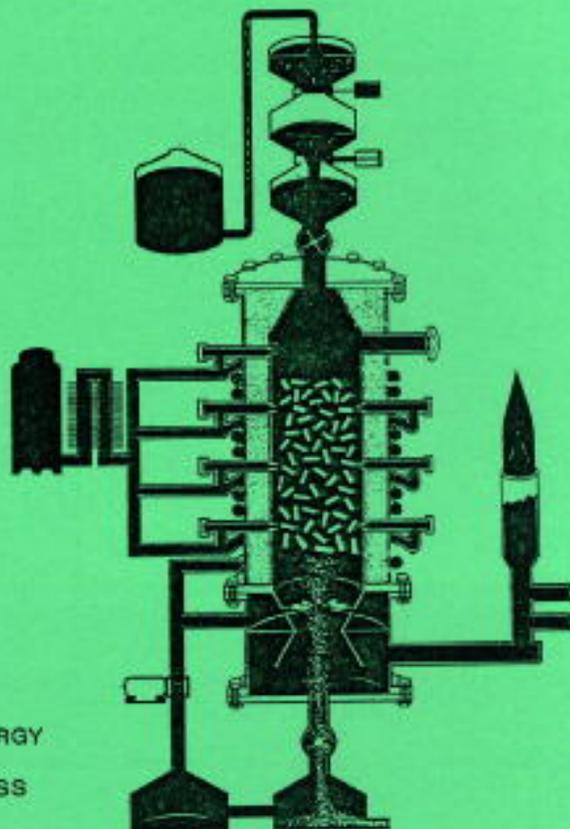
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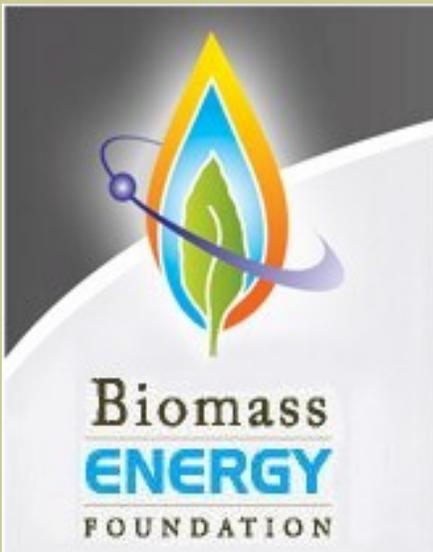
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***GASIFIER***: T. Reed, M. Graboski and B. Levie (SERI 1988). In 1980 the Solar Energy Research Institute initiated a program to develop an oxygen gasifier to make methanol from biomass. A novel air/oxygen low tar gasifier was designed and studied for five years at SERI at 1 ton/d and for 4 years at Syn-Gas Inc. in a 25 ton/day gasifier. This book describes the theory and operation of the two gasifiers in detail and also discusses the principles and application of gasification as learned over eight years by the author-gasifier team.

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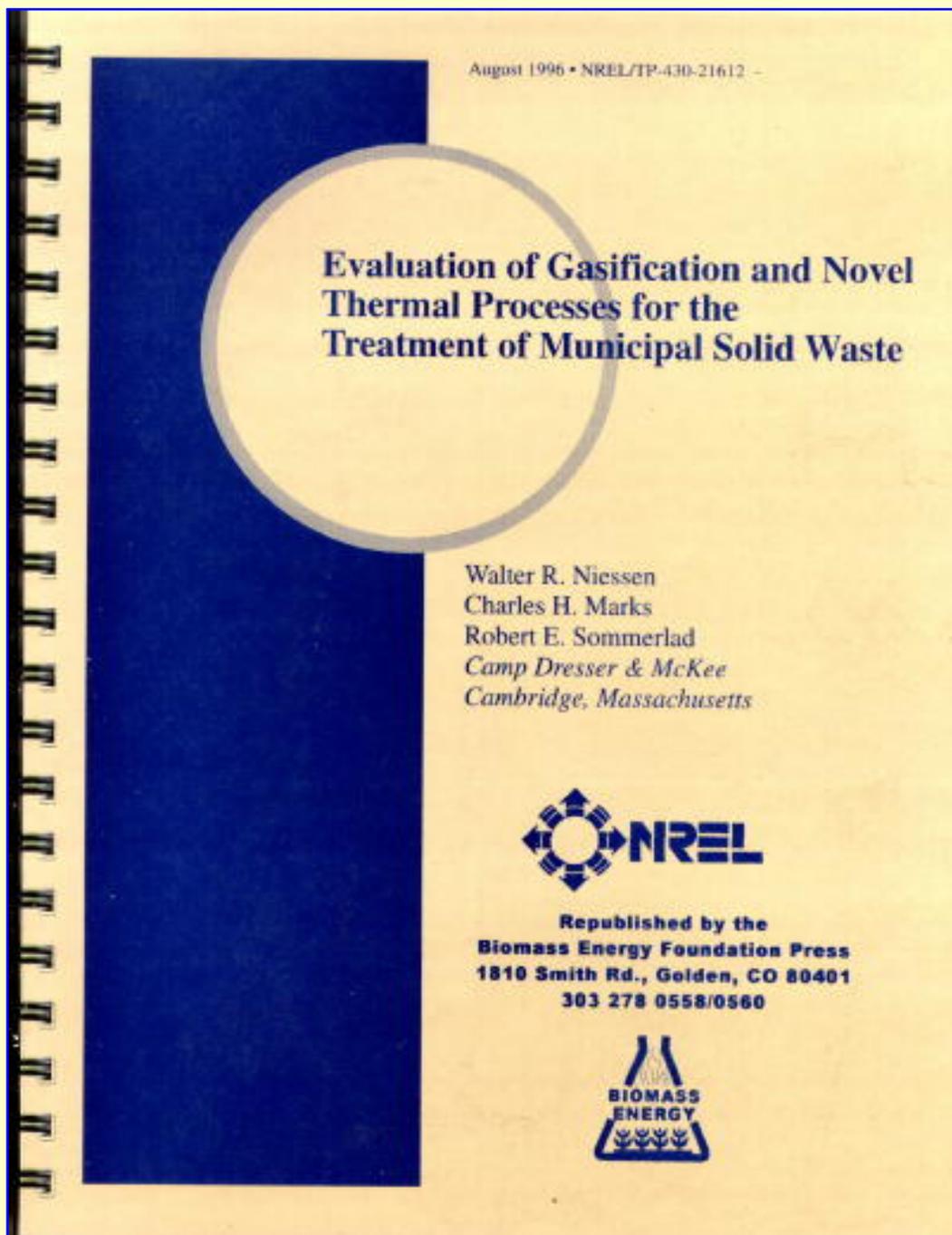
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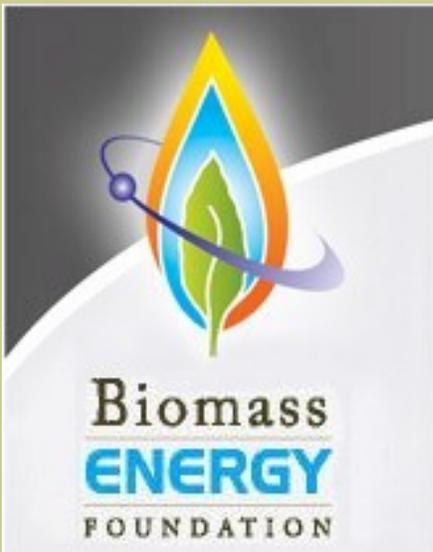
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