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SERVO MAGAZINE

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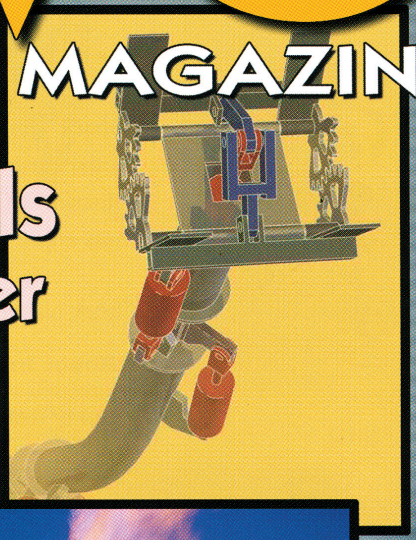
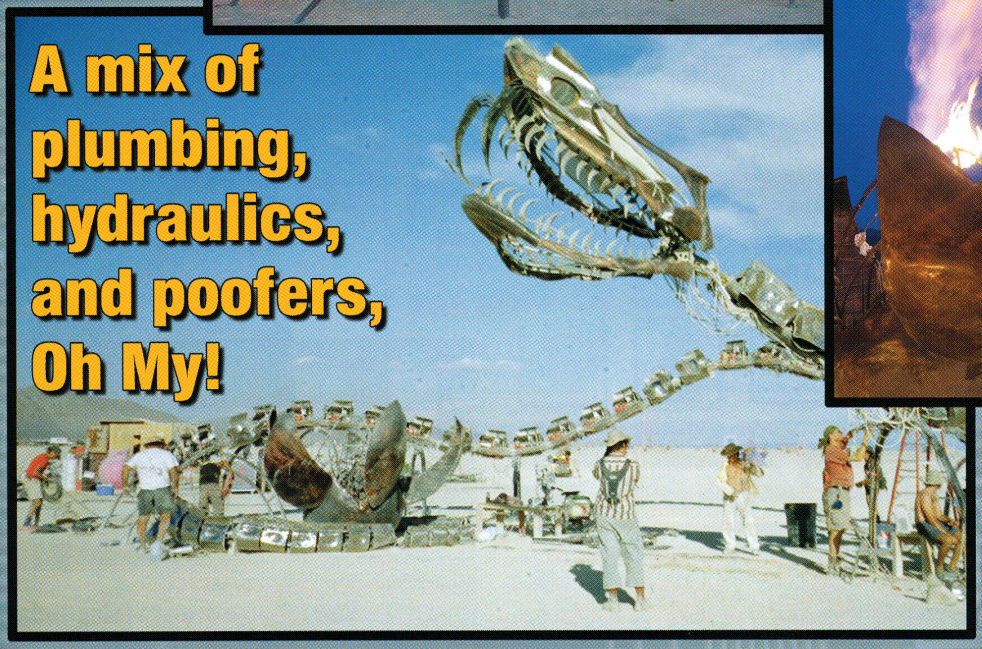
FEBRUARY 2007

The Flaming Lotus Girls and The Serpent Mother



A mix of plumbing, hydraulics, and poofers, Oh My!



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THE FLAMING LOTUS GIRLS

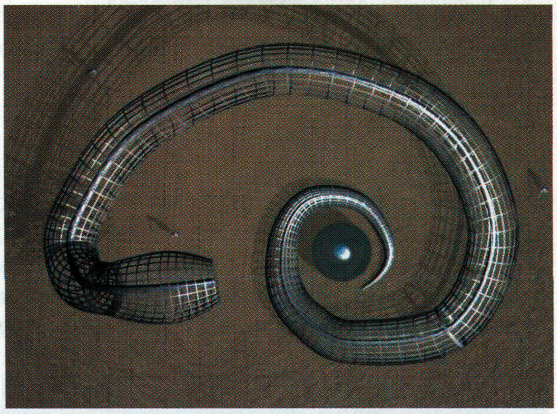
by Steven Kirk Nelson

AND THE SERPENT MOTHER

I first met Charlie Gadeken in May, 2004. My father and I went to the Box Shop in San Francisco, CA, for a Power Tool Drag Racer test and build day. While wandering around the yard, I noticed a large collection of what had to be flame-producing technology and art. I asked Charlie, "What the heck is all of this stuff for?" Charlie told me that this was the home for The Flaming Lotus Girls. He then explained to me that there was a group of women and men that worked together to build LARGE art projects for events like the Burning Man.

Little did I know, that this was the beginning of a relationship with the ultimate group of industrial fire artists, free thinkers, and builders I have ever had the privilege to work with. In May, 2006 we did the Power Tool Drag Races again. Of course, I met up with Charlie and mentioned that I needed to do a little welding on one of my racers. He told me to take it to the Box Shop.

The Box Shop is located at 951 Hudson Ave., near Hunters Point in San Francisco. The Shop is basically a large yard filled with shipping containers that are available for rent. They are usually used to store materials for folks that like to build mechanical things like art cars, intricate sculptures of industrial art, and assorted pyrotechnic devices. It is a magical place, filled with imagination, fabrication, multiple personalities (sometimes in the same person), periodic flashes of fire, plasma arcs, and other assorted mayhem. The Box Shop contains a large welding and fabrication facility, and teaches classes in welding, metal shaping, and art fabrication for comparatively modest fees. It is also the home



Disclaimer

Building fire art can be very dangerous. The skills in plumbing, welding, fire control, and fire safety demonstrated by the Flaming Lotus Girls were developed over years of consulting with experts in many different industrial disciplines and a lot of learning from mistakes. In no way should you try and/or duplicate their efforts at home. The Flaming Lotus Girls, the author, and SERVO Magazine bear no responsibility for your efforts or mistakes made using this technology.

Lynn Bryant taking hammer marks out of the copper egg shell on the English wheel. Lynn and her team were also responsible for the construction and design of the Egg. Lynn told me that she's real good at making wagon wheels and elbow macaroni after bending all of the steel tubing used in the egg's framework.

Rebecca "Hot Metal" Anders and Charlie Gadeken weld yet another stainless steel vertebrae together. The respirators are worn to protect the Girls from the dust, gasses, and nasty chromium by-products that are produced when grinding or welding stainless steel. It gives you a bad headache. The manufacturer painted them pink for some reason. Although, hot pink is the official color of any tool or part claimed (often by convenience) by the Girls at the Box Shop.

of the Flaming Lotus Girls.

The Serpent Mother

That's where I saw *it*! On one of the work tables was the first prototype of a vertebra made out of mild steel. Taped to the walls of the Box Shop was an endless collection of "to do" lists, parts lists, drawings, schematics, plumbing diagrams, etc. Also, there was a small detailed model of the Serpent Mother with its tail wrapped around an egg. When I saw Charlie at the races, I asked him "How big is this thing?" He said, "about 165 feet long." I asked him how long it took to make that vertebra. He said "About two days, but the real ones will be made from stainless steel." I then asked how many were going to be made, to which he replied "about 45 of the large vertebrae and about 30 smaller ones, plus four or five simpler ones to cover the hydraulics for the neck going to the head."

"You're going to cut, bend, shape, and weld all of that stainless steel sheet metal, build a heavy pipe frame, add 41 propane poofers, a five-axis hydraulic powered head, plumb this machine, and build the electronic controls and write the control software in less than three months?" I asked in astonishment. "Yep," Charlie replied. I told him "you're crazy man!" and he just smiled.

Fortunately, Charlie has a lot of talented, motivated artists, engineers, structural welders, metal sculptors, pyro plumbers, electronic engineers, and programmers to help make the Lotus Girls dreams come true. The design drawings, parts lists, and budget (plus a "miscellaneous lipstick fund") were written up in a proposal and submitted to the Burning Man in January. Most of the funding for this project came from a $60,000 grant from Burning Man which didn't arrive until May. Nothing like a little time pressure to get the Girls motivated.

Annealing copper with a big torch to make it soft for shaping. Once shaped, the metal is then hammered until it hardens to hold its shape and then it is soldered together to make larger pieces.

The Build

The next time I saw the Lotus Girls was in early June at The Fire Arts festival in Oakland, CA. They had already built the head, the hydraulic jaw mechanism, and the mounting for the first three hydraulic cylinders, along with about 20 feet of the spine. There were five poofers and the vertebrae, plus the teeth were burning. I couldn't believe it! They had a fully-working first section with fire and the basic hydraulic head movement done in about one month.

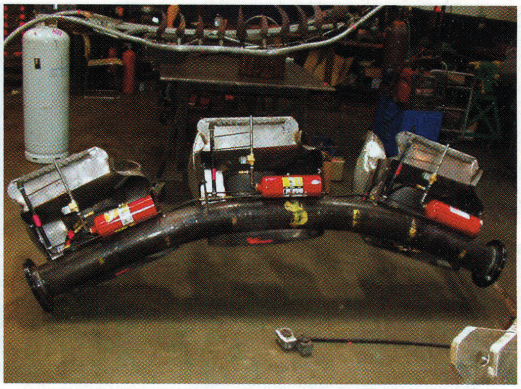
This took a maximum effort from all of the Girls and they worked on the project day and night whenever they could get time to go to the shop. (Keep in mind that these folks have jobs and lives like everyone else.) During this build cycle, many of their lives were put on hold and they were less than one third done. This pattern of self-sacrifice would continue for another two months of very hard work.

After the show, they put me to work disassembling the machine and loading it on the truck. The Girls have a term called VHTs (that's Lotus-ese for VERY HEAVY THINGS). Lifting 250 to 300 lb sections of the Serpent Mother into a truck is definitely "quality" time. (I never have figured out why folks think that fat guys – like me – like to lift heavy things.)

At this point, there was a lot of concern that they may not finish the project. So, they put out a call for help on the Internet. I started going to San Francisco on the weekends.

Working at the Box Shop with the girls is a unique experience. As a man, you're supposed to assist the Girls and leave your male attitude at the door. The Girls say "It takes a great man to be a Flaming Lotus Girl." The Girls are in charge of the project, so you have to ask them what needs to be need done and then you are given a task to perform. If Pouneh Mortazavi (Shop Leader) or another Girl sees that you're not busy, she will ask if you have ever cut pipe before. If you say no, she will

tell you to go grab a piece of pipe and bring it over to the saw so she can teach you how. After you cut your first piece to length, she'll look at it and tell you "that's a good job, now cut 45 more like it." (This is how your days usually go at the Box Shop. You never know what you will be doing, *but you will be doing something*.)



I should also mention that the Lotus Girls have a unique way of solving problems. They discuss their next step in groups and every person's idea is explored and possibly tested until a solution is found that is both easy and practical. Having worked in shops usually with an Alpha male telling me exactly what to do and when to do it, I found this procedural difference to be both interesting and a beautiful thing to witness and be a part of.

The majority of the Girls at the Box Shop may have never cut, drilled, shaped, ground, heated, or welded metal or created endless feet of plumbing before they joined this group. It is the goal of The Flaming Lotus Girls to empower women by teaching them skills in metal work and industrial fire art. Hopefully, they will take their new skills and abilities and continue to create their own art, as well as help out with the group's projects. The motto of the Flaming Lotus Girls hangs on the wall in the Box shop. It simply says, WE CAN DO IT!

The Girls use several types of hand drawings, blueprints, schematics, and CAD (Cardboard Aided Design) drawings. and Plywood Aided Design are used when building the templates for metal cutting. Also, steel jigs are used to hold the parts in place for tack and finish welding.

The Vertebra

Building the vertebra took hundreds of hours and lots of people. Each one is made from five pieces of stainless steel that is plasma cut using wooden guide templates. Then it is hand-hammered with a ball peen hammer on a steel shot bean bag to create the curves. The edges are rolled with a hammer over the head of a railroad spike mounted in a vice. The hammer marks are removed with a pneumatic hammer and the English wheel. Parts are curved by running them through a roller, then they are mounted in a jig and then tack-welded and hammered some more.

Following that, they are seam-welded with a tri-mix shielding gas and a MIG welder using 304 stainless steel wire. Next, the welds are ground smooth, welded again, ground some more, then polished. Countless hammer strikes and 12-hour work days make this all possible. You really wouldn't want to arm wrestle with the women and men that pulled off this little part of the project.

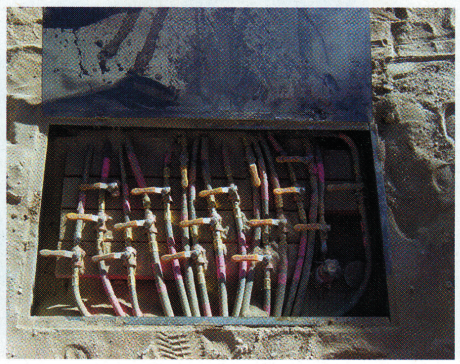
The Poofers

Fuel is provided to the Mother Serpent through two separate systems: the 'continuous flame' or burners running off two 88 gallon liquid feed propane tanks leading into a vaporizer. These devices boil the propane from the main storage tank and prevent the tank from getting cold and freezing the propane. (The freezing effect comes from the high fuel flow rates and a subsequent pressure drop created when running lots of burners or poofing.)

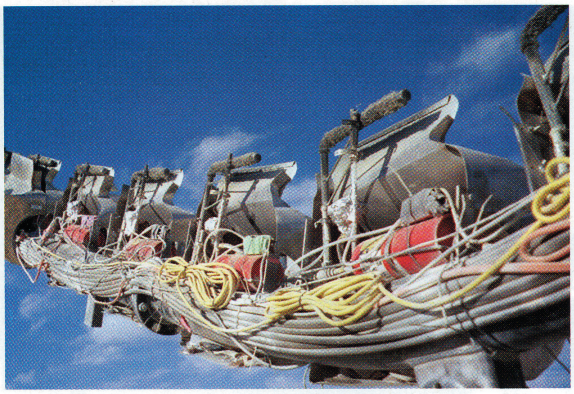
Without the vaporizers, the Serpent Mother wouldn't have worked for long. The vaporizer sucks liquid propane from the tanks and into a chamber where the liquid is vaporized, and the pressure created by the vaporization pushes the propane through three 1/2-inch feed pipes underground. The pipes split again into 1/4-inch hose before it gets to the ball valve farm. Ignition is provided by a horizontal burner that is made from 1/2-inch steel pipe about 12 inches long.

The burners are fueled from the fuel depot and their gas flow is controlled by ball valves. The multitude of ball valves was buried underground in an enclosure near the egg in the center of the sculpture. This part of the control system is called the Ball Valve Farm.

Once the valves were opened, fuel could flow to their respective burners. A pressure regulator was used at the



Every kid should have the chance to fire a flame thrower on a giant snake from time to time.



Fuel lines, wiring, and, of course, poofers!

fuel depot vaporizer to adjust the rate of flow to the burners. Some of the burners on the tail section were further controlled to reduce the size of the flames that were close to the folks standing next to them. The burner pipe is capped on one end and has several small 1/16-inch holes drilled in it to act as fuel jets. The burner pipe is covered with stainless steel wool to diffuse the fuel across the burner.

The steel wool also makes the burner mostly wind-proof. The burners were electronically lit using cannibalized stun guns. The electronics team mentioned to me that they got some very strange looks from the folks at the electronics store when they ordered 50 stun guns! Once the burners were lit, the stun guns were turned off.

The 41 propane poofers that are placed on the spine of the Serpent Mother are basically rather large (momentary) flame throwers. Propane was fed from a large 250 gallon tank to another vaporizer. The fuel from the vaporizer was plumbed underground through four 1/2-inch ball valves and hoses to fill the fire extinguishers that act as expansion tanks and allow the fuel to vaporize some more and collect as the tanks fill. The fuel in the expansion tanks is fed to a 120 VAC, electrically-controlled normally-closed gas valve through a 1/4-inch steel pipe. When the valve is opened, the gas in the tank is released almost instantly. POOF!!

The Poofers will each produce about eight-foot-high fire balls for about one to two seconds. One of the interactive features of this beasty allows the kids viewing the machine to push the 41 manual buttons mounted on the ribs for controlling the poofers on demand. Every kid should have the chance to fire a flame thrower on a giant snake from time to time.

Plumbing

The plumbing team (headed by Caroline Miller and Rosa Anna Defilippis) had the daunting task of cutting, fitting, sealing, and testing about a billion feet (maybe a bit less) of LPG hose, steel gas pipe, steel and brass fittings, and a ton of valves and mounting hardware. Actually, there are hundreds of connections and many folks spent time working with these components. Imagine spending several months of your life threading pipe and dreaming about plumbing nightmares and gas leaks.

You might find it difficult to understand the dedication or obsession of this team, but their work speaks for itself. Without the Pyro Princesses, the Serpent Mother would have been a nice piece of sculpture. Because of the plumbing team, the Serpent Mother is a warm and awe-inspiring interactive experience for all who witness it in operation.

Control System

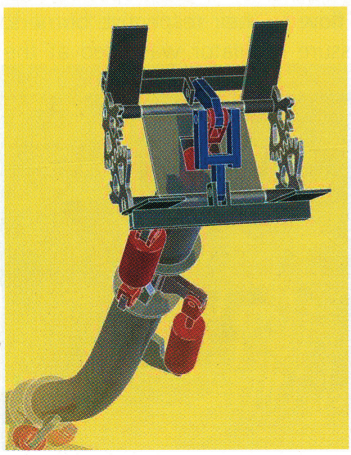
The poofers also have a computer control system that allows an operator to program firing sequences from a laptop computer. Jessica Hobbes managed the electronics team. Rich Humphrey assembled the innards of the fire controller boxes, but the boxes themselves were built by many, many hands. Tad Rollow wrote the AVR firmware that makes the boxes go. Lee Chubb wrote the computer interface software. It's a MAX/MSP patch. (Max/MSP is a graphical environment for music, audio, and multimedia. For more information about this software check out: **www.creativesynth.com/MAXMSP/maxmspmain.html**)

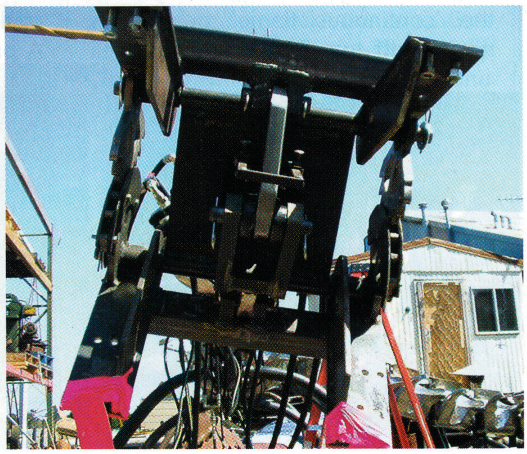
The interface that Lee created is really very easy to use and fun to play with, as well. Point and click poofing ... now that's an innovation in fire art.

The fire control boxes are ammunition boxes (painted hot pink, of course) with six 30-amp sealed mechanical relays inside. There are six outlets on the outside of each box that are independently controllable. Each box can hear all the traffic on the line. They only react for their own address. The data travels at 19200 baud. A signal has to be constantly sent to each poofer control or the poofers will shut down. This was an important safety feature.

You can also clone boxes, having more than one listen on an address. They are also completely overridden by the manual button boxes. The manual buttons are wired across the relay contacts so that a total computer failure would still provide us with a manual snake.

The brain is an Atmel ATMEGA8 programmed with AVR-GCC. Each box has an address, which is set by DIP switches inside the box. They are all listening on an RS-485 network, run over XLR microphone cables. It's terminated

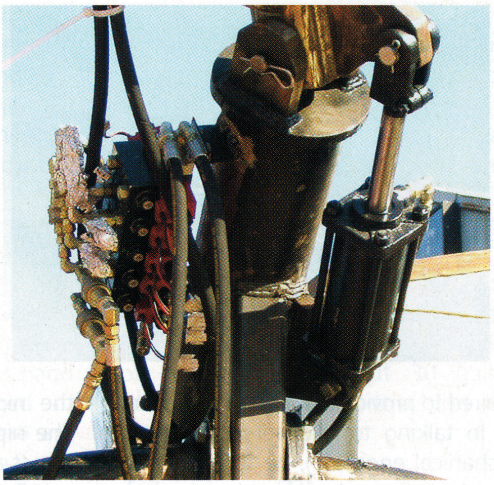


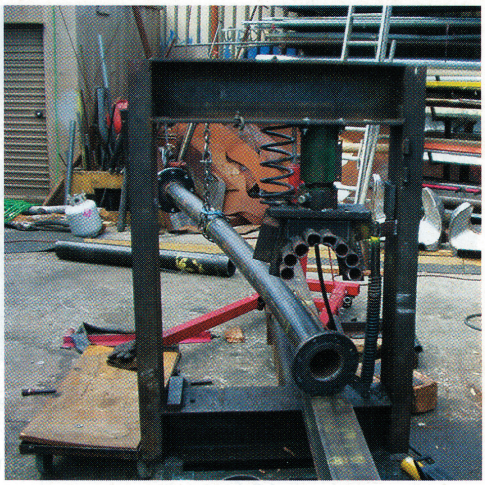


at the end by a 120 ohm resistor in an XLR plug.

There were some issues with noise in the power and control systems. We were switching coil valves with mechanical relays, so there was a lot of noise generated when we turned them on and off. There was also some noise coming from the stun gun igniters, as well as all the other problems you have out there, like generator noise and static.

The stun guns were only used to light the burners and then they were shut off. The electric gas valves on each poofer had a RC snubber circuit mounted across each coil. The nice thing about using embedded microcontrollers is, if they lock up because of noise, you can unplug them and they re-boot. They actually worked flawlessly. There was also a LED lighting effect mounted in the vertebrae. The LEDs could be flashed in multiple patterns to add even more eye-catching illumination to the sculpture.





Hydraulics

Mike Prados (P.E.) designed the mechanical and hydraulic system for the Serpent's head and neck.

Manual control was achieved with a set of mechanical relays driven by a joystick box using three separate arcade-quality joysticks. Limiting switches were attached to the hydraulic mounts and pivots to keep the cylinder from exceeding the mechanical limits of the sculpture. This kept the Serpent from eating itself.

Future control will be with an Atmel Atmega16 microcontroller, with potentiometers attached to the hydraulic mounts for position feedback.

Hydraulics for the Serpent's Head

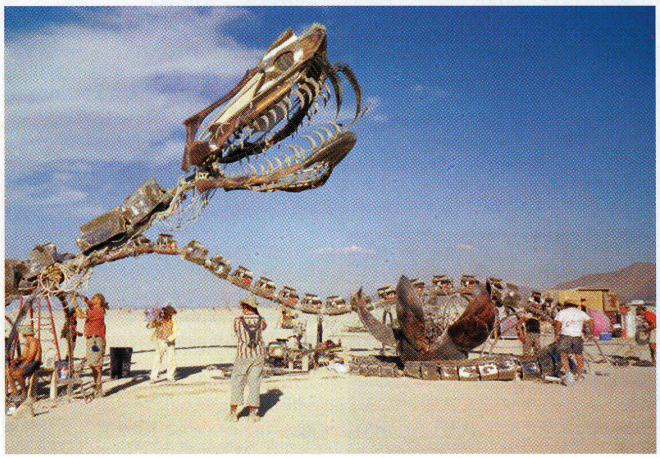
Specs of the hydraulics include:

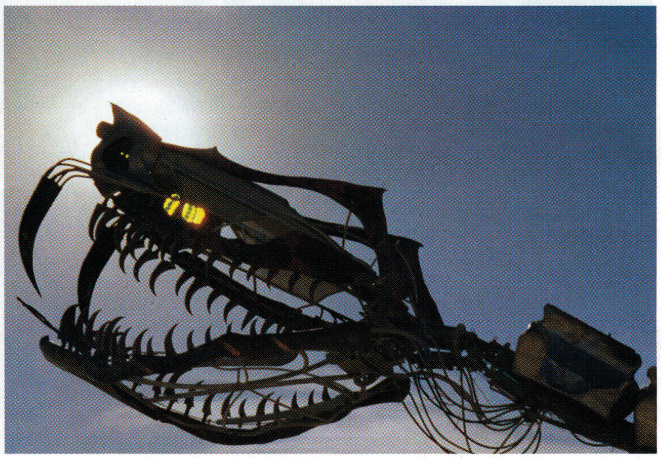
- 24,000 lbs peak force capability at 2500 PSI
- Hydraulic power pack pumps 1.3 GPM at 2,000 psi (a bit less at 2,500 psi peak)
- Power pack is a 2 HP electric pump, powered by 240 VAC
- Five double-acting cylinders at 3.5 inch bore, six-inch stroke
- Approximately 120' of 3/8" steel braided hydraulic hose
- Four CNC plasma cut gears, from 1/2 inch stainless steel plate
- Teflon coated, steel backed bronze bushings on the lower joints, rated at 36,000 lbs load

The Spine

The spine of the Serpent Mother is very massive. Even the flanges that couple the pipe sections together are about one inch thick steel. Spine specs include:

- 168 feet uncoiled length (this includes the neck with the head)
- Twenty eight-foot segments
  - Eight segments, six-inch diameter pipe
  - Six segments, four-inch diameter pipe





– Six segments, two-inch diameter pipe

• Archway, about 16 feet tall

• Eight-foot length of the six-inch pipe weighs 180 lbs (before the vertebrae, flanges, plumbing, etc.)

Steve Monahan was responsible for most of the primary bending of the pipe on a custom-built, hydraulic powered pipe bending machine. Steve also did most of the structural welding since he's a certified welder and these parts had to be very strong for safety. There is also a ladder structure that the support ribs of the serpent connect to. The ladder structure is buried underground and is required to provide stability for the spine.

In talking to Michael Prados (our mechanical engineer), he told me that several factors were considered when the dimensions for the spine were developed, including the open spans, the weight of the components, and even wind loading from the high velocity desert winds common in northern Nevada.

The Head

The Serpent's head is the size of a small automobile. It is built in two parts forming the upper and lower jaws. The support frame is made from aluminum tubing custom-formed and welded.

There are 64 hand-made curved triangular stainless steel teeth of various lengths. The teeth were first plasma cut from sheet metal in three pieces and then welded together to form a hollow triangle. Intricate slots were plasma cut in the sides of the teeth to allow propane to flow from them. The teeth are mounted to a stainless steel fuel line. Propane is fed through this line, and escapes through 1/16-inch holes under the nipple that supports each tooth. The nipples have holes drilled in them to act as air correctors.

Basically, this arrangement allows the teeth to work similar to a propane torch and produces a blue flame. "Hot Metal" Anders did quite a bit of testing and redesigning of this system. There was some discussion about making a blue flame and the intense heat produced, and its possible annealing (softening) effect on the aluminum structure. In testing with a infrared thermometer, it was found to heat the aluminum to about 350° F, which proved to be acceptable.

The two large fangs were fed with a separate fuel line and also burn with a yellow to blue flame. Of course, there

Introducing ... The Flaming Lotus Girls

Aimee Eade
Aly HeinEric Stahl
Angela Knowles
Annie Geluardi
Ariel & Jon Spear
Baba Frey
B'anna Federico
Brent Coons
Carly Perez
Caroline Miller
Carson Best
Catherine Lynch
Cathy Lynch
Cecelia Camenga
Charles J. Gallagher
Charlie Gadeken
Charlotte Sanford
Cheryl Fralick
Colinne Hemrich
Cory
Olivier Bonin
Dan DasMann
Dan Ramsauer
Dave Best
Dave X
David Ellsworth
Epona and Phil
Eric Smith
Flare Gaspo
Geoff Leland
Gole Mawaz-Khan
Hazmatt Snyder
India Farrier
Jack Schroll
Jacqulynn Schmitz
James Stauffer
Jen Clemente
Jeremy Travis
Jessica Bruder
Jessica Hobbs
Jill Manthei
Joe Romano
John Berens
John DeVenezia
John Wilson
Jon Foote
Jordana Joseph
Josh Hunter Judy Castro
Karen Cusolito
Kezia Zichichi
Kiki Pettit Lani
Laura Kimpton
Lee Chubb
Lee Sonko
Liam McNamara
Lynn Bryant
Mark Farrier
Marlies Tallman
Mary Newsom
Matt Cline
Michael & Lorelei
Michael Curry
Michael Prados
Michelle Palmer
Moira Mcnamara
Naemi Frey
Nick
Nicola Ginzler
Olivia Sawi
Oona Squire
Paul
Phil Spitler
Pouneh Mortazavi
Ray
Rebecca (Hot metal) Anders
Rich Humphrey
Rosa Anna Defilippis
Sara Peyrot
Scott Cotner
Scott Sparky Bartlett
Shanon
Sharon Burke
Shawna Shandrick
Simone Davalos
Simone Sigrid Marticke
Stella Rubenstein
Steve Monahan
Steve Nelson
Steven T. Jones
Sue Duesberg
Suzun Hughes
Tad Rollow
Tamara Li
Tasha Berg
Tori Tait
Vanessa Montiel Waschka
Wendy Blackburn
Will Flare
Xanat
Yasmin Mawaz-Khan

is also a forked tongue that shoots fire. The large green eyes are made from glass custom poured and formed by Peggy Wilson. The eyes are illuminated with a green laser beam. The head is fleshed out with hand-formed and hammered copper sheet.

The Egg

The tail of the Serpent Mother coils around the Egg. The Egg frame is made from steel tubing that was hand curved. The frame is covered in hand-formed copper sheet. There are five sections that open to reveal the methanol-fueled flame system. This system uses nitrogen gas to pressurize a storage tank filled with liquid methanol. The pressurized liquid is fed through underground hoses to five electrically controlled valves. Each valve can be individually fired.

The high pressure liquid is sprayed through nozzles across a propane burner and it ignites. Boric acid is mixed with the methanol to provide a green flame. When firing the Egg, no one was allowed to stand within a 150-foot radius of the sculpture. Some folks mentioned to me that they felt rain drops. I told them, "It wasn't water you felt falling from the sky, it was un-burned fuel."

Once I mentioned this fact, most folks understood the reason for the safety perimeter. The nightly fuel consumption for the Serpent Mother at Burning Man was about 500 gallons of propane and about 30 gallons of methanol (when the Egg was demonstrated).

Closing Thoughts

Ya know, if a 260 lb, redneck garage builder man can learn humility and understanding in an industrial and yet nurturing shop environment, all the while working with talented and amazing women and men, then maybe, just maybe, there's hope for us all. I've done a lot of things in my lifetime, but I will always cherish that special day when I finally became a Girl. (Well, a Flaming Lotus Girl, that is.)

It is impossible to list all of the individual work provided by all of the members of the Flaming Lotus Girls. This interactive, animatronic flaming sculpture is definitely a team effort and hopefully it will inspire others to think big. In my opinion, the Girls rock! SV

Websites

www.flaminglotus.com/

www.teamkiss.com

www.qbox.org/

Videos

- About the Girls
www.madnomad.net/film/flg/

- About the Serpent
www.madnomad.net/film/snake/

- About the Burning Man
www.madnomad.net/film/bm/