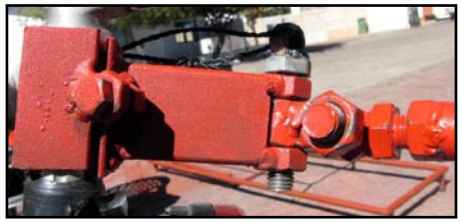
# Bicycle Pulled Ambulances in Namibia

**Bicycling Empowerment Network, Namibia**

This bicycle ambulance is in use by Ombome Oto HIV/AIDS Home Based Care volunteers in Oshandi, Ohangwena region in Namibia. These heath care workers use bicycles to reach their patients in the rural areas, and when further medical attention is required but other traditional or motorized transport is unavailable, they transport their patients on the bicycle ambulances.



Above: The hitch and U-joint, made from nuts and bolts.
Right: The Bike Bakki, similar to the "chariot model" is designed for manufacture and use in Namibia for transport of goods, water, firewood, and passengers. Lolo is getting a lift from Tate Eliaser, the bicycle ambulance fabricator at BEN Namibia.

From October 2006 to October 2007 I was working in Namibia with the organization Bicycling Empowerment Network Namibia, designing a bicycle ambulance appropriate for use in rural areas of Namibia, and training local fabircators in the design, manufacture, and repair of ambulances and trailers. BEN Namibia also facilitates the donation of bike to Namibians working as HIV/AIDS home based care volunteers, and coordinating programs for Orphans and Vulnerable Children (OVC). We also provided training on safe use, operation, repair, and management of the bike ambulances. To find out more or to support this project, see my weblog http://namibikes.wordpress.com
and BEN Namibia at http://benbikes.org.za/namibia



# "FLATSY" FABRICATION MANUAL


January, 2008
Issue #2

bikecart@riseup.net
more plans at http://bikecart.pedalpeople.com

a 200 lb capacity bicycle trailer that's inexpensive and easy to build: $30 in parts, and 5 to 10 hours

a $1 donation supports free fabrication workshops and printing-
please support my work: bikecart.pedalpeople.com/support.html

## Material List

**Trailer Body ($19)**
(4 lengths) 1/2" thinwall EMT conduit (10')
(1) 1" X 1"X 1/8" angle stock, 8" per cart
(1) 3/8"-16 X 2" bolt
(3) 3/8" -16 nut
(1) 3/8"-16 wing nut
(6) 3/4" self taping screws or 1/2" EMT pipe straps

**Hitch ($10)**
1/4" rod (18" per cart)
rod end ball joint (zinc plated, oiled bronze 3/8"-24)
3/8" - 24 nylon nut
3/8" threaded female coupler, 1 1/2" long (2 hitches)
1" X 3/16" flat stock (3")

**Jig for Dropouts (use for future carts) ($4)**
(1) 3/8" -16 threaded rod, 3 feet long
(8) 3/8" -16 nuts
(8) 3/8" washers

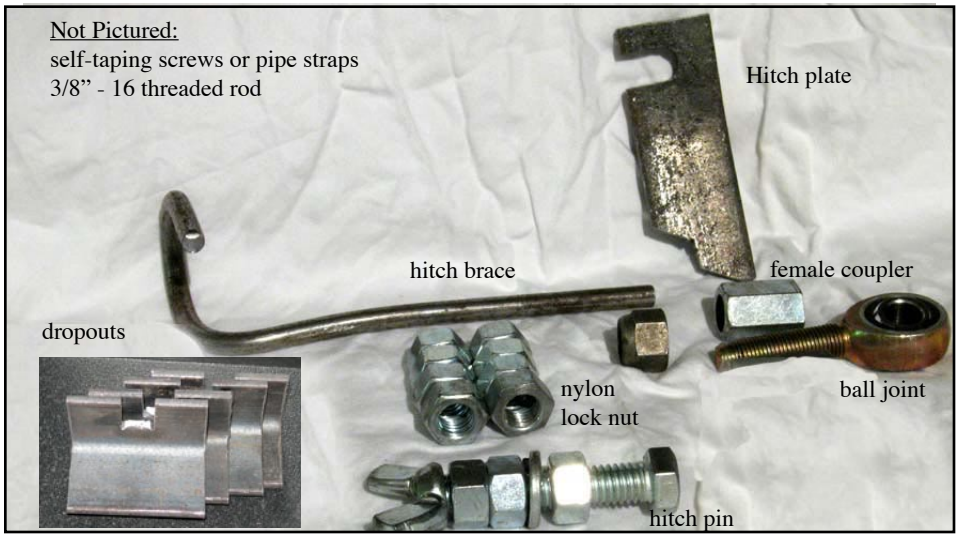
**Miscellaneous and can be found for free**
plywood for bed: 1/2" thick. 20" x 35"
exterior enamel paint for metal and wood
two 20" wheels, preferably front BMX wheels

## Tools

1/2" thinwall EMT conduit bender
hack saw
tape measure
marker
punch (or nail)
hammer
vice
1/8" bit and 3/8" bit
drill
8" half round file
bricks or flat metal surface

*Brazing:*
oxy-acetylene torch
brass brazing rod, brazing flux
shade 5 goggles, and gloves

*Arc Welding:*
MIG, TIG, or stick welder
welding rods and shielding
Shade 10 mask and gloves




## Obtaining Parts

The best wheels for this trailer are front BMX wheels with aluminum hubs and rims and at least 32 spokes. Next best are rear single speed wheels, without a coaster brake. Get 2 tires of similar size.

Hardware stores carry the EMT conduit and hardware. You can order the ball joint from mcmaster.com. It is part 6072K64 for the oil-impregnated bronze race with a chrome plated steel ball and right hand threads. It costs $5.92 without shipping. I think shipping is $3 or $4. You might consider getting a welding respirator ($12) from McMaster-Carr at the same time.



## Links

*commercial bike carts:*
http://www.bikesatwork.com/bike-trailers/
http://blueskycyclecarts.com/
http://www.burley.com/
http://www.bobgear.com/
http://www.bykaboose.com/
http://www.efn.org/~equinox
http://www.bikerev.com/
http://koolstop.com/trailers/beast.html
http://www.xtracycle.com/html/home.php
http://www.cycletote.com/
http://www.karstilo.net/bike/trailer/index.php
http://www.radicaldesign.nl/
http://www.efn.org/~cat/hpm/

Whirlwind Wheelchair International's "Rough Rider"
http://whirlwindwheelchair.org

*home made bike carts:*
http://carryfreedom.com/bamboo.html
http://www.re-cycle.org/trailer/
http://www.ibike.org/economics/trailer.htm
http://www.cyclecircus.org/cyclecircus/diy.html
http://drumbent.com/trailer.html
http://home.clear.net.nz/pages/joecolquitt/0trailer.html
http://www.motherearthnews.com/arc/6645/

*actions, social theory, economics*
http://benbikes.org.za/namibia
http://bikesnotbombs.org/
http://www.carbusters.org/
http://www.carsrcoffins.com/
http://www.bikesatwork.com/carfree/
http://www.guerillastickers.com/
http://www.critical-mass.org/
http://bikeforpeace.org/
http://www.carfree.com/
http://www.communitybike.org/
http://www.workbike.org/
http://www.worldcarfree.net/
http://www.carsharing.net/
http://www.kenkifer.com/bikepages/
http://www.catoregon.org/
http://www.journeytoforever.org/biofuel.html
http://whirlwindwheelchair.org

*metal-working and supplies*
http://www.handyharmancanada.com/TheBrazingBook/bbook.htm
http://www.mcmaster.com

BicycleR Evolution Shopper

Bikes At Work

CycleTote

Bob Yak

drumbent.com conduit trailer

my first prototype

Joe Biel's trailer,
used at Microcosm Publishing

Burley Flatbed

Koolstop Kool Mule

Burley Nomad

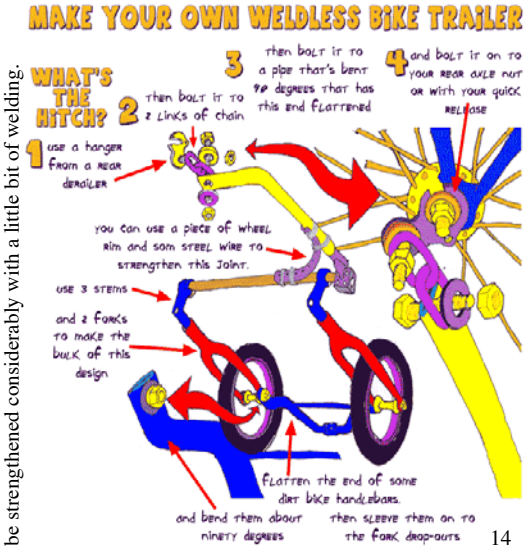
Extracycle

Koolstop Wilderbeast

Radicaldesign Cyclone

Cancart by Bikecartage

from cyclecircus.org ... another design for a weldless bike trailer. the chain in the hitch is a free version of a universal joint, but it allows the cart to tug on the bike. the design could be strengthened considerably with a little bit of welding.






## Dropouts

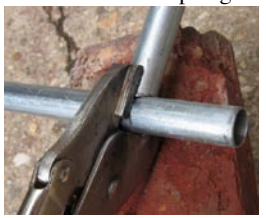
*Note: if you don't have a drill press and bench vice, drill all holes, and make the slots before cutting off each piece.*

Cut four pieces from the 1" X 1" X 1/8" angle iron, 1 1/2" long. (Some photos here have 1" flat stock, but please use angle, or strengthen the joint for the flat stock with reinforcemet rings.

Make a small dent in the middle of the material (1" from the ends and 1/2" from the edges) with a nail or a punch and hammer.

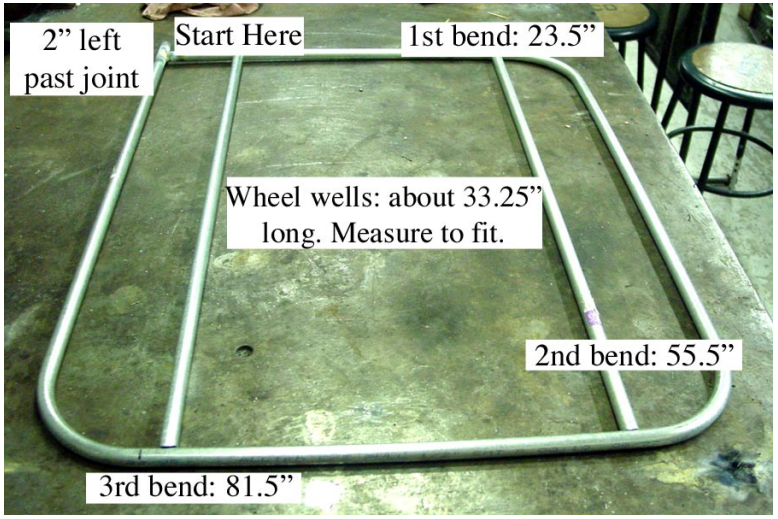
With the dropout in a vice, drill a 1/8" pilot hole, and then enlarge to 3/8" or 10mm. Cut in from the end to meet the hole with a hacksaw. The slot should be 3/8" wide. Make sure your wheel axles fit in the slots. Finish the slot with a file. File off the sharp edges. Angle grinders work too.

1" X 1" X 1/8" angle, with a 10mm wide slot in one side, 15mm deep



Hold the main frame together for brazing

The underside of the original "Flatsy" trailer




Bending diagram and sequence for the mainframe. Add the wheelwells after the mainframe is made, cut to fit each side.

## Frame

Miter one end of the main frame tube.

Bend main frame following the diagram, so that the miter is in the parallel to the frame tubing where it intersects 2" before the end of the tube. Tweak the main frame by hand to make sure it's in one plane.

Braze the miter on the main frame 2" before the end of the tube, holding it in place with locking pliers, as shown above.

Cut the inside wheel wells to fit inside the frame, after mitering, so that the wheel well tubes are spaced 4 1/2"center to center with main frame.

## Dropout placement

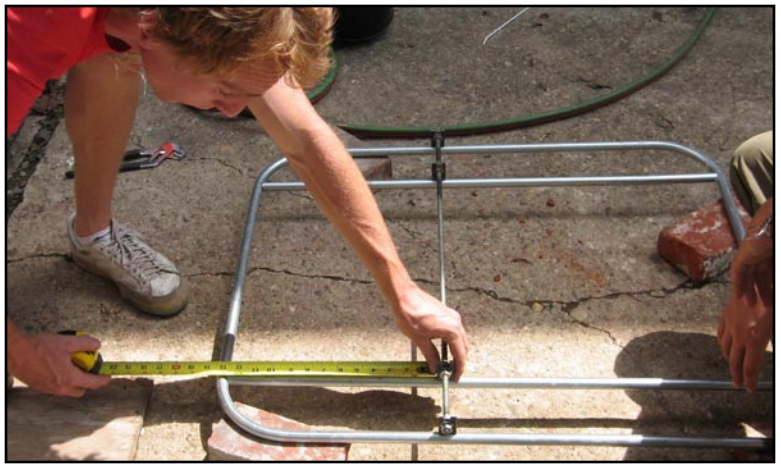
Measure the hub spacing on your wheels between the locknuts on the axle. If you're using front 20" wheels, set the pacing at 100mm. If you're using rear BMX wheels, set the spacing at 110mm.

Braze the wheel wells in place at 4 1/2" on center for 100mm hubs, or 5" on center for 110mm hubs. Make a dropout jig by threading a series four series of nut-washer-washer-nut groups onto a threaded rod. The two inside dropouts should be held by the jig so that they are centered on the wheel wells. The flat part of the angle iron should face the wheel. Tighten the dropouts between the washers by the nuts. The two outside dropouts should be held the distance of the hub spacing plus 1/8" from the inside dropout.

Place the cart upside-down on a flat surface, with the dropouts on top, slots facing up. The dropouts should be 13" on center from the back of the cart, to leave room for the 20" wheels. Make sure that the 2" extention of conduit will be on the left side of the bike when the cart is rightside up.

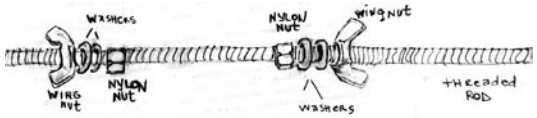
Tack-braze all the dropouts in place on the edges. You'll need to focus the flame on the thick dropouts to achieve even heating and strong joints. Finish brazing the dropouts. The strength of the brazes is very important here. You shouldn't see any convex bumps, which indicates too little heat. Make a large fillet braze.

***I don't recommend flat stock for dropouts, but if you do use it, bend a piece of 1/4" rod into four circles of 3/4" ID, each with a 3/16" gap. Braze these rings around the frame tubes where they hold the dropouts for added strength and resistence to dropout failure. (No photos here; check bikecart.pedalpeople.com/gallery.html for photos and updates)***



Jake places the dropout jig 13" forward from the back of the mainframe.

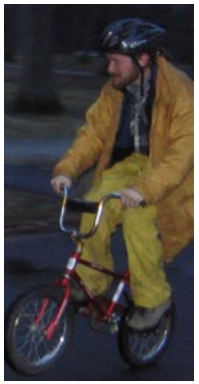
Two brazed dropouts, held by dropout jig




One side of the dropout jig: 8 nuts and 8 washers. This one uses wing nuts, but regular nuts work better.







summer, rebecca, dan, lillian, and aaron

Ingrid fitting a modified bicycle trailer to a wheelchair

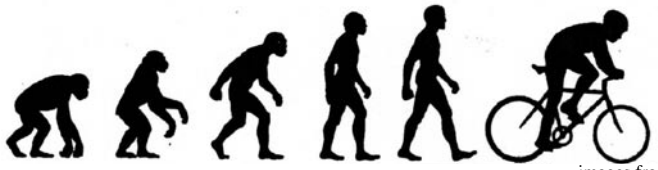
Carryfreedom's Y-frame

donna picking up hay bales in deep and long

I-bike trailer

Bikes at Work

Human Powered Machines: Hauler



images from microcosm publishing

## Philosophy and Social Theory: bike carts are political

I've been designing carts that people can build in their communities for a low cost, with fairly basic fabrication skills and access to common tools. Through making carts, people can build community, and extend that farther by sharing their skills or starting community cart programs, in which a lot of people can use a few carts/bikes.

Car Independence: In my opinion, cars are problematic because they support global industrial capitalism and the outsourcing of manufacturing to the people who are hurt the worst by industrialism. They also support militarization and environmental degredation of oil-rich areas of the world for access to cheap energy. Our use of cars releases greenhouse gases into the atmosphere, and burns dirty fuel in inefficient engines where the combustion byproducts poison humans, other organisms, and the land. Additionally, the automobile paradigm takes us out of small centralized communities where we could work, live, and play, and spreads us out to the far reaches of sprawling development where we use our cars to go everywhere and isolate ourselves from our neighbors, local small businesses, and family.

Why bike carts? Too often people complain that they would ride a bike except they can't carry what they need for work, that they can't bring their children, that they have to pick up a bag of potting soil that they couldn't possibly fit on their bike with the groceries...sound familiar? Bike carts are a great solution, but most are expensive (for a cart that can haul 200 pounds, $300 to $500 USD). This cart weighs 25 pounds, costs $30 to build, and will carry more weight more securely than many commercial bike carts. So this is a zine about making bike carts, but it's also about finding a way to gain independence from our cars and to build community by fabricating, playing, and biking together. Reclaim transportation technology and empower ourselves by taking technology choices and development back into our own hands.

Cars teach us that to get around, we need to spend lots of money to buy something which is environmentally damaging. They teach us that when something breaks, we need to take it into a shop, send away for parts, and pay lots of money, and eventually start all over again with a new car. You can't build them, fix them very easily, grow fuel for them (for the most part: read on vegetable oil, ethanol, and biodiesel), or reuse their parts efficiently.

If we question cars, we learn that we can lessen our impact by buying a less-bad car (small car, hybrid, grease, biodiesel), and that less-bad is a fine way to be. Make that choice for yourself.

One Less Car

make it two?

azuki bean: my 2-speed break-away bike frame for travel. the coupling plates are 1/4" flat stock with two 1/4" bolts.



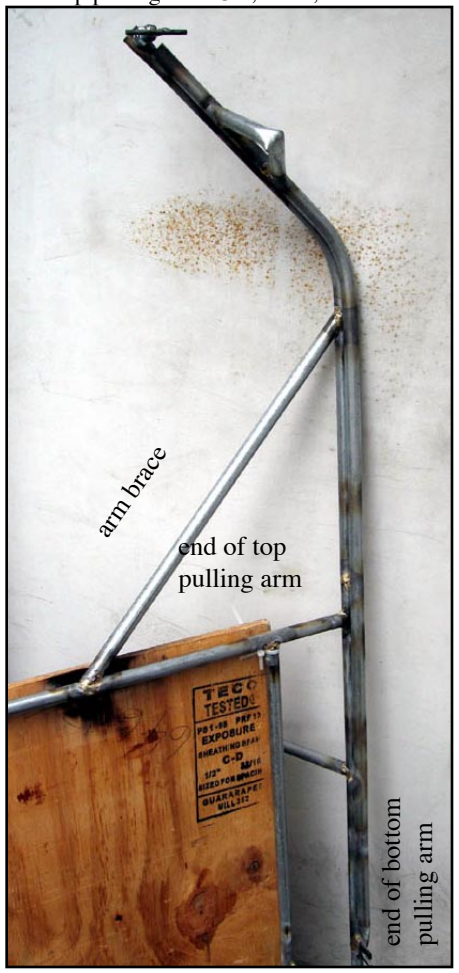

## Pulling Arm

Cut a new piece of piece of conduit to 29" and bend a 45 degree angle 11" back from one end. Butt-weld the top pulling arm (with the 11" mark) to the main frame tube, making sure that they are in the same plane and aligned. Reinforce that joint with a 2" long piece of the 1" X 1" X 1/8" angle, covering the top and outside of the joint.

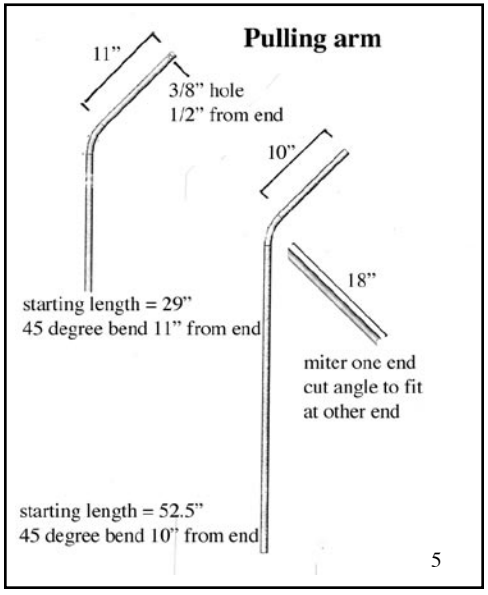
Cut the bottom arm so that it extend all the way to the dropout. This piece should be 23.5" longer than the top pulling arm. It will be about 52.5". Bend at the same 45 degree angle, at 10" from one end. Achieve the same angle by under-bending slightly and stacking the two pulling arm pieces to sight the angle. Continue to bend the tubes until they are the same angle.

Squash the end of the bottom pulling arm tube flat in a vice, so that the end can butt against the dropout. See the diagram below. Cut off the bit that protrudes on the top, preventing good arm contact. Cut again if necessary to line up the pulling arm bends. The front of the top pulling arm should extend 1" beyond the bottom arm. Braze the two pulling arms together every 8" or so, and braze the end of the bottom arm to the dropout.

Use a 18" scrap of conduit to make a brace between the center front of the main frame and the bend in the top pulling arm. Cut, miter, and braze as needed to attach the arm brace to the cart.




Connection of bottom pulling arm to left-side dropout



## Hitch

The hitch clamps onto the left side of the rear axle. There is a slot cut for the wheel's axle, a tube to allow the ball joint to pivot, and a rod that is braced against the chainstay to keep the hitch from twisting around the axle.

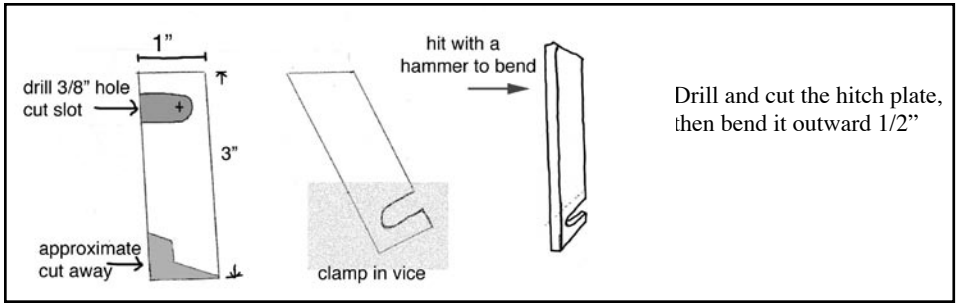
The hitch plate is a 3" piece of the 1" X 3/16" flat stock that you used for the dropouts. Drill a 3/8" hole for the axle 1/2" from the end and 1/2" from each side. Cut towards the hole from the sides to make a 3/8" wide slot. Cut the other end at a 30-degree angle as shown below and cut a notch for the nut.

Clamp the slotted end of the piece in a vice at a 30-degree angle from vertical. Clamp it so that the slot is hidden in the vice by 1/2" and so that the end of the piece is parallel to the ground. Hit the plate with a hammerso that the hitch moves the ball joint about 1/2" away from the side where the bike will be located. See the diagram below.

Holding the 3/8" female coupling firmly in a vice, drill out the threads with a 3/8" drill bit. Use caution because the bit can grab the metal and twist the drill forcefully. Cut its length in half with a hacksaw and file the edges smooth. This tube will hold the ball joint loosely so it can turn freely. Alternative: cut a 3/8" ID tube to 7/8" long. Line up the tube along the angle of the hitch plate, so that the ball joint sticking out of the end could rotate freely. Make sure that there is enough room for a 3/8" nut to spin freely at the end of the tube. This needs to be very strong.

Cut a piece of 1/4" rod 8 inches long. Bend the end in the shape shown in the diagrams (a hook to go around the chainstay). Use a hammer and vice to make the bends. Braze the rod onto the opposite side of the hitch plate, at the same angle as the cut, making sure that it does not hang over the edge of the cut. Bend the rod with a vice, hammer, pliers, or your hands until the hitch fits well on the chainstay. The 3/8" ID tube needs to be parallel to the ground and the hooked arm should rest on the chainstay without interfering with the spokes of the wheel.

File everything smooth. Paint the hitch. Once dry, attach the rod end ball joint through the tube, and secure it with a nylon nut. Make sure the ball joint can spin freely, but without play.




Drill and cut the hitch plate, then bend it outward 1/2"

The hitch attaches to the left side of the rear axle. The trailer's hitch pin drops through the ball joint and is attached with a wing nut.



## Using the Tools

To use a conduit bender, line up your bend mark with the arrow on the bender. Step on the foot plate, while pushing down and pulling back on the bender handle. Bend until the bubble level reads level with no force on the handle.

To cut with a hacksaw, clamped the piece well and cut close to the clamp. Use two hands and the full length of the blade with even, forward force. Cutting happens on the forward stroke of files. Pulling back with downward pressure on the file will only dull the file. File close to your clamp. You can also miter with two cuts with a hacksaw.

To drill into metal, make a starting dent with a nail, and drill a small hole at high speed with a sharp metal bit. To enlarge it, use a lower speed and watch out for the bit catching as it breaks through the material. Always drill into material secured in a vice or by clamps.

General safety: Wear gloves when things are hot, don't wear gloves with spinning tools. Wear safety glasses when there are chips flying (drilling, cutting). Wear shoes or boots and long non-flammable clothes when working with the torch. Don't breathe fumes from cutting, heating, or painting. Have fun and take care of yourself so you can ride your bike and pull your bike cart and tell your friends how great it is to not use a car.

Oxy-acetylene Torch Setup

Conduit Bender


## Brazing Basics

*This description is not meant to replace instruction by someone with experience with torches.* Brazing is the welding process of bonding surfaces by heating them to a temperature above the melting point of the filler material, but below the melting point of the base material; the filler material is drawn into the joint through capillary action. To braze a joint, heat up both metal surfaces to a temperature hot enough to melt the filler material (usually brass). Brazing is more effective than welding for galvanized steel because is compatible with the zinc coating.

**How to braze:**

Put on gloves and number 5 shade goggles. Ensure adequate ventilation and use a respirator. Turn on your oxy-acetylene torch setup. First close the torch valves and make sure the regulators are disengaged (counter clockwise). Open the fuel (acetylene) tank valve 1 turn, while looking away. Usually, you will set the regulator to 10 psig. Open the oxygen valve all the way, and set the regulator to 10 psig. Bleed the gasses out of the torch handle by opening and closing the acetylene, then the oxygen valves. Open the fuel valve on the torch handle, and light it with a flint striker. Adjust the flame so that it almost creates a gap (without a flame) right at the tip of the torch. It is too low if it produces a lot of smoke. Add oxygen until the two visible flame cones come close together. For fine work, you will want the cones to merge. For general heating, keep them separate.

Coat the surface to be brazed with a brazing flux paste. Heat the two base materials with the flame, just beyond the inner cone. When the metal starts to shimmer a little, touch the brazing rod to the hot metal. The filler rod will flow into the joint. If the metal is too hot it will spark. If it is not hot enough the rod won't melt. Go all the way around the tube, creating a good fillet. The strength of the joint comes from the surfaces joined in close contact with brass and from the fillet (smoothed-out corner) between the base materials. DO NOT BREATHE THE FUMES FROM BRAZING GALVANIZED METAL (EMT conduit). Use good ventilation and a welding respirator.

Turn off the torch by first closing the fuel valve on the torch handle. Then close the oxygen valve on the torch handle. Close the valves on the tanks, and open the torch valves to bleed the lines. Unscrew the regulators until they are loose. Close the valves on the torch handle.

**Safety Considerations:**
You are heating galvanized metal, which is coated in zinc. The zinc will burn off and oxidize in the air, creating zinc oxide. Breathing zinc oxide can cause Metal Fume Fever. See below.

Ventilation and Respiratory Protection:
Braze outside, and keep air moving across the work sideways with a fan or the wind. Don't breathe the smoke plume, and keep your head back from and never above the area that you are brazing. Even with good ventilation, wear an N95 (or higher) type respirator. You can buy a N99 filter respirator from McMaster-Carr for $11.34 (Part #53565T2).

Eye protection:
Use #5 shade eye protection for brazing (and clear glasses for drilling). If you look at the flame for a second, you're not going to lose your sight, but it's bright and bad for your eyes. I've heard that your eyes are safe 10 feet back from the flame. Use shade 10 for arc welding.

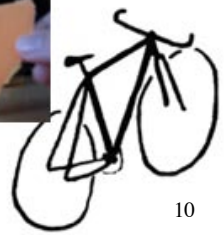

Heat Protection:
Use gloves when you might come in contact with hot metal or a flame, but never for a grinder, drill press, or other spinning tools.

**Metal Fume Fever Information**
According to the American Welding Society, Metal Fume Fever is an illness caused by exposure to zinc oxide, a chemical present in fumes from welding and brazing galvanized metal. The symptoms of metal fume fever are flu-like, including headache, nausea, fever, fatigue, and chills. Symptoms start several hours after exposure and last 6 to 24 hours, although total recovery might not be for 48 hours. High levels of exposure may cause metallic taste in mouth, dry and irritated throat, and coughing. Several hours after exposure, you may have a fever (lower than 102 degrees F, then chills before returning to normal). The OSHA standard for zinc oxide exposure is 5 miligrams per cubic meter of air averaged over an 8 hour work shift. NIOSH uses the same 5 mg per m^3 (cubic meter), but suggests that it is permissible for 10 hours per day, or 40 hours per week. They further permit a STEL (short term exposure limit) of 10 mg/m^3 averaged over a 15 minute period. There is no published information about long term effects of zinc oxide exposure. (American Welding Society. Safety and Health Fact Sheet No. 25)

Even though there are no known long term effects, it doesn't make sense to expose yourself to zinc oxide and potentially suffer from Metal Fume Fever, because it's easy to prevent exposure. In the process of designing and learning to build bike trailers with galvanized conduit, I got metal fume fever twice, through carelessness. It's quite possible to braze EMT conduit safely, however. The sickness felt like the head and body ache that are symptoms of influenza. I felt dehydrated and tired, but was fine the next morning. It's still not worth it though.

Protect yourself from exposure.


paying my respects...





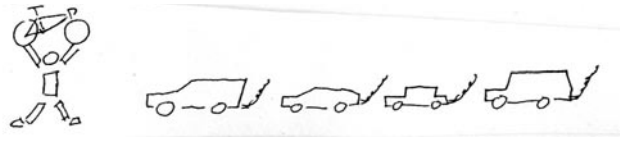
**Wheel Guards**
One way to make wheel guards is with two 35" pieces of conduit, bent at right angles 5" from each end, mitered, and brazed onto the main frame tubes. This will guard the wheels, and with some plastic, wood, or sheet metal you can protect the inside of the cart from the spokes and make a fender as well.

Make another guard that will hold the cargo to the front of the trailer. As with the wheel guards, bend and miter from both ends. Bend at 6.5" from each end on a piece 37" long. Braze it to the frame at a forward-slant, so that the top of the guard is at the same height as the tops of the wheel guards. Alternatively, you can make this guard like another wheel guard, and weld it aligned vertically at the back of the trailer to allow for use as a hand cart (which will tilt the cargo back into that guard).

Add a plywood bed, 20" by 35", with small notches for the wheel guards. Use 1/2" thick painted plywood, and attach it with six conduit clamps or self taping screws. I recommend sliding strips of bike tubes between the conduit and the plywood to prevent rattling.

The two wheel wells protect cargo from the spokes, and the front guard further secures cargo and encourages loading the cart in front of the axles. This cart can now receive fabric, plastic, or sheet metal within the wheelwells to further potect the cargo.

Use 6 pipe straps or self tapping screws (recommended) to secure the plywood to the frame. The plywood will rattle if it's not secured well.



## Finishing the Trailer

Hitch pin: Drill a vertical 1/8” starter hole 1/2” from the end of the pulling arm, and enlarge to 3/8”. Crush the end of the pulling arm slightly around the bolt hole so a 3/8” nut just slides inside. Slide a 2” long 3/8” bolt through the arm, from the top to the bottom, threaded through the nut inside the arm. Slip a 3/8” split-ring lock washer on, and then thread another 3/8” nut onto the end of the bolt and tighten it until the tube is crushed around the interior nut. Thread one more 3/8” nut onto the bolt. Make it tight. Option: Braze the nuts and bolt together, and to the arm.

Braze a 2” long tube, 4” back from the hitch pin, facing down, as shown below. This will protect the hitch piu from the ground.

Take a 3/8” wing nut and braze a 2” long piece of rod onto the two wings. This will be the nut that attaches the cart to the bike, and the wing nut extension allows removal without tools. (Alternative: use a 3/8” nut with a wrench for theft-resistance.)

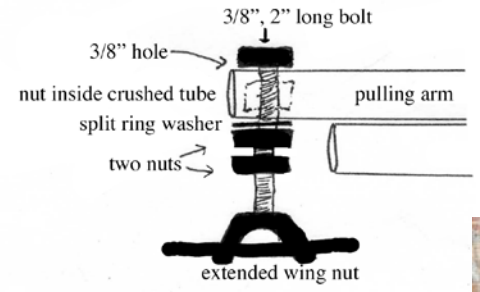
Clean it all up with a wire brush, sand with course sandpaper, wash it with water and soap, let dry, then paint the cart.

Attach the wheels to the cart. Use washers if there is space between the dropouts and hub. Make tie-down straps out of old bicycle tubes, with the valve cut off. Use bowline knots to attach them to the main frame, or reappropriate bungee cord ends.

A nice option: Add something unique and special to the cart. Try a pole with space for art and signs. “One less car” “Yes, I’m moving by bike” “One less car; make it two?”

Send me pictures and the measurements that you used, and consider supporting this project: www.bikecart.pedalpeople.com/support.html

Hitch pin assembly diagram




Add a 2” long tube to the bottom of the pulling arm to protect the hitch pin from the ground. Cap the end for user safety.

Ben and Jimmy test ride the first cart from the Washington DC workshop in July, 2006. This shows another kind of skid to protect the hitch pin.



### Using the Cart

*Community cart programs:*

I would like to see community bike cart programs with user accountability. Imagine this: a group of people get together, obtain some funding from the town for a community development project, and build a few bike carts. They advertise the program in the town/neighborhood, and offer the use of these carts to anyone. For a small deposit of money, barter equivalent, trust, etc, you get a key that unlocks the bike carts from wherever they are. You have designated locations where they live, where you might expect to find a cart. In this way, many people can use a few carts. The carts could either have designated bicycles, or you can attach the hitch to your bike when you get the cart. Carts from workshops are in Northampton, MA, San Francisco, and Washington, DC.

*Weight capacity*

I recommend a 200 pound weight limit. You will be able to load more weight if you don’t ride on steep sideslopes or corner quickly. Balance the load just in front of the wheel axles. Secure the load with straps, especially on bumpy roads. Don’t corner too fast when the cart is empty, because it could flip over., or when its heavily loaded, because the sideways force on the wheels could cause them to buckle. Don’t jack-knife the trailer when backing up or turning.

*Investing in an alternative to cars*

There is a significant amount of embodied energy and chemicals involved in the fabrication of these trailers. The steel industry has a long history of chemical pollution and labor exploitation. I don’t know what’s in brazing flux, or what the process of galvanization is like. Brazing conduit releases zinc oxide and other chemicals. The paint used to protect the joints is dangerous, and paint cans have a disposal problem. Recognizing all this, bicycle trailers can replace a technology that is much more chemical, energy, and exploited-labor intensive: the automobile. The health benefits from transporting oneself by bike are significant. I encourage you to treat this project as an investment in an alternative to cars, and as such its usefulness will outweigh its social, environmental, and financial costs.

**Glossary**

- ***EMT Conduit:*** The kind of tubing used for the cart frame. It is used to protect electrical wires. You want “Thinwall EMT conduit.” The outside dimension (OD) for 1/2” EMT is about 0.7”
- ***Jig:*** A device to align the dropouts and hold them at the correct spacing.
- ***Miter*** :A fitted connection between two pieces of metal.
- ***Dropout:*** The slotted piece that holds the wheel axles.
- ***Hitch:*** The connection between the bike and the pulling arm. It is a piece of flat metal with an arm that hooks around the chainstay. There is a ball joint on the hitch, to allow rotation for corners, bumps, and leaning.
- ***Rod-end Ball Joint:*** A universal joint that spins freely around two axes and about 19 degrees in the third.
- ***Oxy-Acetylene Welding/Cutting/Brazing torch:*** This setup burns oxygen and acetylene in a hot flame from a welding tip.

CarryFreedom’s bamboo trailer. Plans are available from Nick at carryfreedom.com/bamboo.html