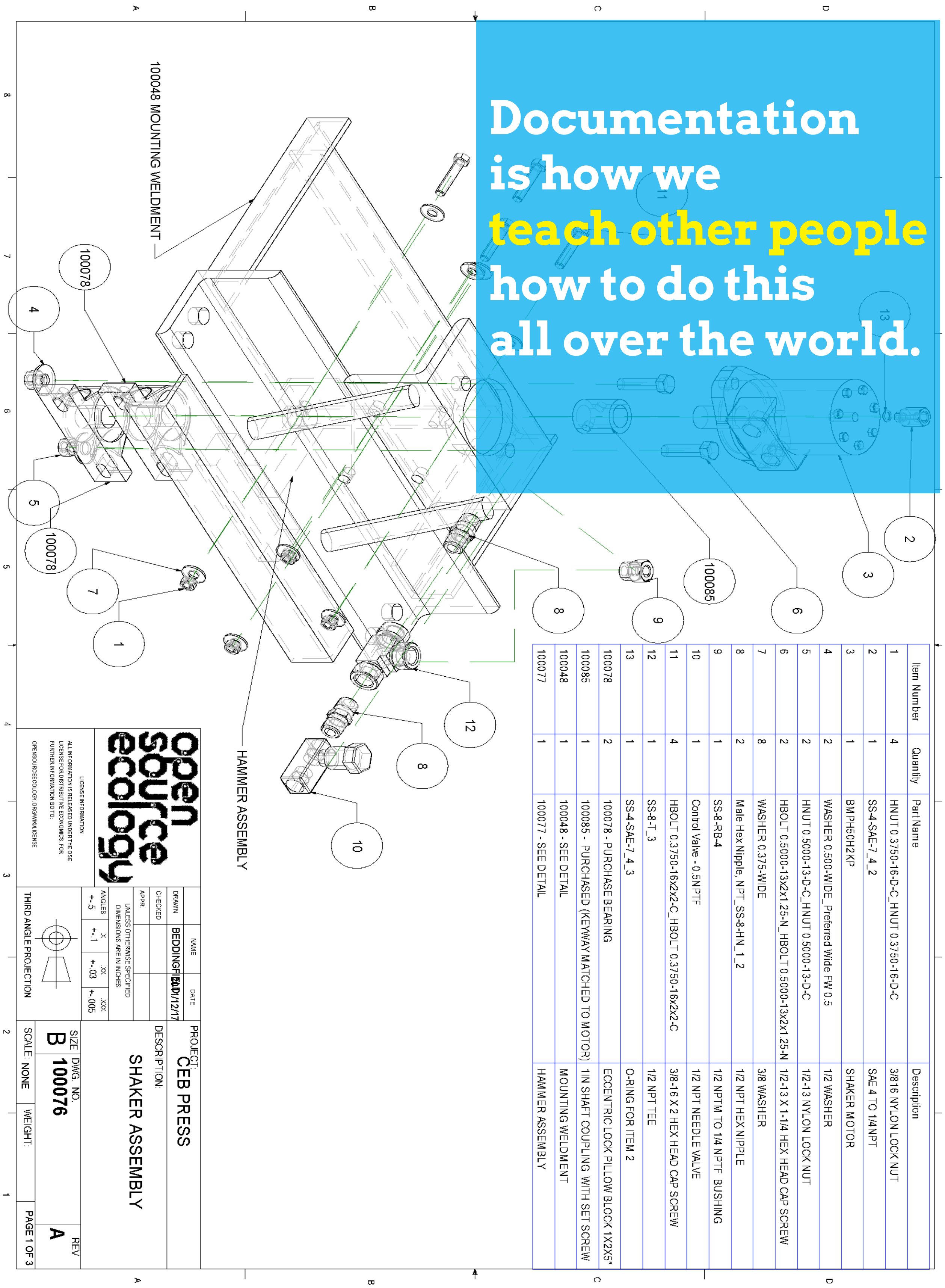
Global Village Construction Set

Civilization Starter Kit

.01

Documentation is how we **teach other people** how to do this all over the world.



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Foreword

The Open Source Ecology Paradigm

Marcin Jakubowski, Ph.D., 12.24.2011

Introduction

The Open Source Ecology Paradigm is an idea that the open source economy is a route to human prosperity in harmony with natural life support systems.

Open Source Ecology (OSE) is a movement to create the open source economy. The movement consists of hundreds of entrepreneurs, producers, engineers, makers, and supporters around the world – who believe in the power of open – who share the open ethic. The 'Ecology' in the name refers to the interaction of natural and human ecosystems – the environmental, societal, and technological systems – as they interact along open principles. Read a further description of the OSE concept as it was formulated initially in 2003 (see Appendix below). Since then, the concept has evolved to a platform for creating distributive enterprise, as a solid foundation for a sound economy - a third economic option beyond capitalism or socialism. The distributive economy paradigm centers around open access to efficient production as a means to transcend artificial material scarcity. The paradigm uses open source tools and techniques to produce advanced civilization – by unleashing the power of the responsible use of technology.

The main current project of OSE is the Global Village Construction Set – a set of 50 Industrial Machines that allow for the creation of a small scale civilization with modern comforts.

OSE Mission

The mission of Open Source Ecology is to create an open source economy - an economy that optimizes both production and distribution, while providing environmental regeneration and social justice.

Overview of the OSE Paradigm

The backbone of Open Source Ecology is open access to economically-significant information – product designs, techniques, and rapid learning materials for achieving this. Collaborative development, 24/7 around the globe, leads to best practice designs - accessible openly via the internet. When economic productivity is unleashed as such, there is a direct effect on community prosperity. As a result of lowered barriers to entry, each community can increase the range of products and services that it can provide. Global collaboration in open product and process design leads to best practices being commonly available. This is opposed to the dominant paradigm of today – where a few companies having the best products or monopoly control, and by definition, the rest is mediocre. Open economic development has the potential to raise the bar on the quality of products in the productive economy – as opposed to the enforcement of mediocrity through protectionism and monopoly.

All wealth comes from nature – rocks, plants, sunlight, and water. These are found ubiquitously.

Yet the presence of strategic resources results in conflicts over their appropriation. "Hey, that's my oil under your land." Open source technology can address this problem – via principles of substitutability. There are many routes to producing any economically significant product or service. Resilience of communities depends on having a diversity of options. As open access to technology becomes commonplace, every community can increase its level of productivity and appropriate technology – to the point that it can substitute any strategic material with local options – without any reduction in the standard of living – while contributing positively to global peace.

Transparency of the connection between technology and nature means that people begin to respect nature. This happens when people begin to respect that their well-being comes from nature. This transparency is facilitated when economically productive activities happen as close to the community as possible – not out of sight, out of mind in remote locations. This is true environmental accountability – as one tends to not destroy their own environment. Thus, there is a direct connection between transparency of production to natural regeneration – as people begin to make more sound production choices – by understanding the connection of production to the land. This means that industry no longer needs to occur in the form of toxic wastelands – but instead – eco-industry, on a human scale – serving the needs of people, not centralized industries competing for world domination.

Thus, technology and technological literacy are a way to reconnect to nature – not to destroy it.

The above depends on increasing the density of knowhow and technology in every community – which comes from the open paradigm – open information, open communication, and open everything. The limit of optimal density of productive knowhow is the point that any community is capable of producing the full range of essential resources necessary for it to exist, grow, and prosper. This is not to say that trade should not happen – but for community stability – trade should be avoided on essential products that the community needs. As much as a community would want otherwise – when placed in a scarcity condition – rationality goes out the window and people start to kill each other.

For the first time in history – we have a chance to do otherwise. Unleashed access to information and technology – as availed by the computer age – means that any conflicts related to material scarcity can become a thing of the past. This includes resource conflicts, poverty, overpopulation, and even bureaucracy – as bureaucracy is not much more than a mechanism to manage scarce resources. Further, regulatory costs are minimized via technological transparency - as a technologically-literate populace of the open source age becomes increasingly responsible for its own actions.

This is not a case for conflict between the rich and poor, the city or the country, the first or third worlds – it is a case where open access to information helps everyone. As barriers to entry are lowered, social upheaval is minimized. As production remains high – and increases due to the elimination of competitive waste – prosperity can only increase.

This is a paradigm shift. That is the core of Open Source Ecology.

This does not address evolving as humans – in cultural and scientific advancement - or in wisdom that prevents us from reverting to insanity. Open Source Ecology only lays a starting point and foundation - from which evolution becomes possible.

Open

We support everything open. See the notions of open at the Shuttleworth Foundation - *http://www.shuttleworthfoundation.org/about-us/our-philosophy/communication/*

Economy and Ecology

Distributive Enterprise - The distinguishing feature of this paradigm is a focus on distributive enterprise – open publishing of not only product designs, but also of open enterprise models so that others can replicate best practices. There is a direct relationship between open design and lowering of barriers to entry. Productive enterprise forms the backbone for communities' infrastructures and their prosperity. Open access to unprecedented high densities of productive information means economic prosperity – and everybody wins.

The open source economy is an economic system marked by open access to best-practice designs and techniques for producing economically-significant products and services. One feature of the open source economy is Industry 2.0 – or distributed, flexible production – where access to a down-loadable repository of open source design feeds local, multipurpose digital fabrication facilities. Such facilities - or powerful Microfactories - can produce just about anything that a community will need - local food, energy, housing, or cars. This is distinct from centralized production facilities that exist today.

An open source economy produces designs by global collaboration, with development cycles 24/7 around the globe. When a sufficient number of stakeholders join a development process, it is a matter of time before the development cycle yields the best designs – and these designs evolve continuously.

Integrated Economy – open fosters rapid learning (open IP) and low capitalization (open source products) – i.e., lower barriers to entry. Lower barriers to entry indicate that a single economic agent can have a broader range of productivity, therefore more resilience from economic shocks. In the limit of extreme diversity on the part of the producers, every community can attain a complete economy. If product evolution involves advanced techniques for material substitution, then every community can attain a complete economy based on local resources. This is the solution to resource conflicts. This is stability in the face of global economic upheaval.

The end of artificial material scarcity – Artificial material scarcity may be defined as the condition where – in the absolute abundance of resources – namely rocks, plants, water, and sunlight – the distribution to humans is drastically uneven. Lowering barriers to entry helps to distribute production more widely. Product optimization from open development includes optimization for lifetime of use. Lifetime design (i.e., lower maintenance costs), combined with high productivity and low barriers to entry - indicates that material abundance can be the general human condition. This is a solution to poverty.

Transparency of Resource Use and Feedback – Rapid learning in the open source economy helps people gain numeracy and technological literacy. Technological literacy promotes the understanding of production – and specifically, the relationship between natural resources and human population. Local resource use fosters a high level of resource feedback loops – as the state of the local environment is easily observable. Such transparency of resource use is the solution to overpopulation in a rational (materially abundant) society.

Lower Cost – by eliminating competitive waste, the cost of buying or making open source products is reduced significantly.

Competitiveness with Globalization - When IP access barriers are eliminated in the open source economy, cost of production is reduced to production capitalization and labor. The cost of production capitalization, under the assumption of flexible fabrication assisted by automation - goes to zero in the scenario of community-supported manufacturing (think Open Source Fab Lab in every community). In the open economy of DIY ethics and local capacity and transparency - the cost of labor goes down – as the user can also learn to be the producer. In the limit of DIY ethic, this cost, defined as cost of external labor - goes to zero – and is replaced by one's time. Further, in the limit of lifetime-design products, the time required for production is minimized, as production has to happen only once. Thus, competitiveness with globalization is achieved by zero access barriers and local skill, and local social capital – a different paradigm.

Ecology

Closing the Nature-Technology Divide – Truly sound technology is not at odds with nature. We have a choice to produce technology in an environmentally sound way. For just about every harmful and polluting industrial process, a clean alternative may be found. Biomimicry shows us the way to do this in many cases. Moreover, truly sound technology should bring us closer to nature - i.e., if we appreciate that nature provides all material wealth, we are inclined to take care of nature. This is a case for educating generalists – not technologists or environmentalists – people who understand technology deeply to the point that they respect nature – and people who understand the environment deeply to the point that they respect technology. Technological literacy is facilitated by introduction of true technical education, as opposed to industry standard marketing forces.

Product Development Ecology – In the mainstream, the designer is not the draftsman, the draftsman is not the engineer, the engineer is not the fabricator, the fabricator is not the user, and the user is not the repairman. While is touted as the pinnacle of specialization, this introduces a lack of accountability between all these steps, and therefore, inferior product design when considered from the human ergonomic factors, product service, environmental issues, or wealth distribution issues. Open source design addresses this, as it is design by the people, for the people – and it is infinitely customizable.

Environmental Regeneration – There is a direct link between open source technology and environmental integrity. Open technology implies optimal technology – and one part of optimization is optimization for environmental friendliness. Thus, the trend of environmental degradation can be reversed to regeneration.

Appendix

Archived on February 10, 2005, see Mission at -
http://web.archive.org/web/20050210084651/http://sourceopen.org/Ca

Our Mission

By Marcin Jakubowski, 11.30.03

I. What is Open Source?

Open Source refers to the model of providing goods and services which includes the possibility of the end-user's participation in the production of these goods and services. This concept has already been demonstrated in Linux, the open source computing system. With Linux, a large number of software developers have contributed to creating a viable alternative to the proprietary Windows computer operating system. Many people can readily see the advantages- all Linux software is free. Please read these articles on the concept of Open Source software and its implications for changing business.

II. What is Open Source Economics?

Our mission is to extend the Open Source model to the provision any goods and services- Open Source Economics. This means opening access to the information and technology which enables a different economic system to be realized, one based on the integration of natural ecology, social ecology, and industrial ecology. This economic system is based on open access- based on widely accessible information and associated access to productive capital- distributed into the hands of an increased number of people. Read about an inspiring example of such an economic model being currently put into practice with respect to manufacturing vehicles.

We believe that a highly distributed, increasingly participatory model of production is the core of a democratic society, where stability is established naturally by the balance of human activity with sustainable extraction of natural resources. This is the opposite of the current mainstream of centralized economies, which have a structurally built-in tendency towards of overproduction.

III. What is Open Source Ecology?

We derive our organization's name from a concept which refers to the integration of the natural, societal, and industrial ecologies- Open Source Ecology- aiming at sustainable and regenerative economics. We are convinced that a possibility of a quality life exists, where human needs are guaranteed to the world's entire population- as long as we ask ourselves basic questions on what societal structures and productive activities are truly appropriate to meeting human needs for all. At the end of the day, the goal is to liberate our time to engage in exactly that which each of us wants to be doing- instead of what we need to do to survive. All have the potential to thrive. Today, an increasingly smaller percentage of the world's population is in this position.

Tactical Approach

To create an open source economy, we are starting with a small but sufficient subset, the GVCS 50. By developing the GVCS technology kernel, we enable the community-based solution of relocalized production. Because the GVCS tools are selected based on their large economic significance, this has widespread applications – such as enterprise startup, regeneration of urban decay, and building of communities – both in the developed and developing world. Because the GVCS is comprehensive, it is designed to provide a robust solution for rebuilding communities from the ground up.

We currently have $1/2M of funding to begin rapid parallel development of the GVCS, with development of 14 further tools starting January 1, 2012. We aim to produce beta product releases of most of these tools by April 1, 2012. From then, we will deploy the remaining 32 technologies, while documenting all results with global CAD and instructionals support. Our goal is to secure a total of $5.5M for 2012 by January 31, 2012. We are including $2.5M for prototyping, $2.5M for documentation and field testing, and $1/2M for deploying the fully-featured, open source CAD/CAM solution. See OSE Enterprise Plan video.

We have grown from about $20k/year for the past 4 years to $500k in the last 2 months, and we have the ambitious goal of $5M more secured within one month. We pride ourselves in efficiency of resource allocations. We spend about 98% of our resources directly on prototypes built, and our overhead for the nonprofit sector donations is 2% via a fiscal sponsor. We encourage you to donate and to put your energy into this work. We are doing a lot of the development with volunteers, and Factor e Farm is the main development facility. We are also outsourcing as much of the design, prototyping, and documentation work as possible – as funding allows. Increased resources mean increased burn-down rate for the GVCS 50 technologies.

The next 14 tools are:

CNC Multimachine – we are currently considering Dan Granett, a precision machining expert – to build out the CNC Multimachine, while utilizing any relevant techniques from a collaborating group - the Open Source Multimchine project

CNC Circuit Mill – Yoonseo Kang is the project lead on this at Factor e Farm, and we are considering the Snap Lock CNC as our platform of choice, evaluating it at present before starting deployment in January. Proposal Brief is forthcoming.

Ironworker Machine – Brianna Kufa is project lead, with initial design work completed, and Proposal Brief forthcoming. We currently have a design challenge up on GrabCAD to develop an open source cutting blade design.

CNC Torch Table – prototype I has been tested in producing tractor parts with success, and optimization is needed for the software tool-chain. We are currently considering an upgraded gantry shown under Prototype II on the wiki, a simple DIY design which has seen many hundreds of hours of production time and is a stable design. Z height control needs to be developed.

Induction Furnace – conceptual design done. Considering recruiting consulting assistance from Superior Induction. Looking for subject matter experts to join this project, Dedicated Project Visit or remote collaboration.

Sawmill – Prototype I 75% complete, ready for motor and blade attachment; looking for Dedicated Project Visitor for field testing.

Backhoe – Enniss Inc. is being considered for prototyping.

Bulldozer – considering modified LifeTrac frame and weights, jack shaft wheel drive and steel wheels like in old agricultural traction engines from 100 years ago; 10,000 lb. weight for first prototype.

Well-drilling rig – considering design consulting from Enniss, Inc. Looking for subject matter experts.

Modern Steam Engine – current plan is to use the Wally Munster scalable modern design. Collaboration with Tom Kimmel of Steam Auto Club of America to develop a plant for the next generation of modern steam Power Cubes, about 4x3x3 feet in size for s 25 hp Prototype 1. Plant includes Gasifier Burner, Heat Exchanger, oil pump, water pump. Plan for Heat Exchanger is to work with Tom using his open source coil winder.

Gasifier Burner – Larry Dobson is completing plans for an advanced gasifier burner with heat exchanger for heating water. Plans will be completed on January 31, 2011.
Pelletizer – Need design and fabrication drawings. Can be fabricated by Sweiger Shop readily. See pelletizer dies on research and development page - and design around those.

Power Inverter – following the development of the CNC circuit mill, we will prototype the inverter. Need power electronics subject matter experts to join the team.

Solar Concentrator – the current plan is to build on documentation available from the SolarFire project. Collaborating with Dr. Peter Schwartz of Cal Poly on design evaluation.

Getting Involved

We aim to make this one of the most collaborative projects in the world, and we aim to train movement entrepreneurs dedicated to developing distributive enterprise.

So, You Want to Build a New Civilization?

All right. Please go to the OSE Wiki and sign in. You will see a list of the 50 GVCS technologies, There is plenty of work left on the GVCS 50. Pick one, and start contributing information. There is research and development, where you can contribute conceptual design, analysis of industry standards, diagrams, prior art, background research, and other supporting information. Then comes the design stage – CAD, calculations, simulations, CAE analysis, fabrication drawings, etc. Peer review is useful. Then comes the build – which requires a bill of materials. sourcing, and a facility to build. We encourage you to work remotely and contribute test data. We invite you to write a Proposal Brief, and we can fund your work upon technical merit. Or you can come for a Dedicated Project Visit to Factor e Farm.

The first step you should take when you get involved is to fill out the Team Culturing Survey. This helps to provide transparency and to introduce you to the rest of the global team. The beauty of the project is that collaborative development is beginning to take place 24/7 around the world. We should also develop a better human resources platform – where people are listed by their skills and contributions, promises and delivered products – so it becomes transparent who is doing work and fulfilling on their promises. This applies to volunteers and paid people.

How do you know what are the current priorities? First, see the Wiki, and the basic approach is - “If it is not on the wiki, it doesn’t exist.” From this point, you have to analyze the state of development critically. If it is not clearly documented on the wiki, it is probably in development or untested. Click on any device at the 50 GVCS technologies page. Ask yourself: Is there a project leader? What preliminary research has been done? Does full CAD exist? Are full fabrication procedures documented? Does a complete PDF of plans exist that you can take to your local fabricator? Does economic analysis exist so you can start your own enterprise? If not, those are to be completed – and it is a chance for you to get involved.

Current project leaders as of 12/25/11 include:

Yoonseo Kang – CNC Circuit Mill, Inverter component of the Universal Power Supply
Brianna Kufa – Ironworker Machine
Mark Norton – Modern Steam Engine
Larry Dobson – Gasifier Burner and Heat Exchanger
James Slade, Mike Apostol – CEB Press, LifeTrac
Tom Griffing – Power Cube
Marcin Jakubowski – CNC Torch Table, Induction Furnace
Aaron Makaruk – Resource Development
Mike Apostol – OS CAD/CAM solution

Contact these leaders on the latest progress.

The wiki is a huge sandbox, and the magic of it is that over time, even with many random contributions, editors organize content into a more cohesive form. The basic product template for each of the technologies at the GVCS 50 page contains general headings. You can search for information on the wiki, and if you find something relevant to one of the headings, you can edit to put the content at the right place.

Is a technology of your choice not part of the official 50 GVCS list? Then start new pages on the wiki for non-GVCS tools. The wiki is infinitely expandable. The GVCS is only a limited but sufficient set – limited so it remains a tractable project with a clear deliverable. We don't really know if the choices made are the best – but we will reevaluate after the set is done by year-end 2012. We can't tell until we see all the devices work together as a complete set. We just selected the 50 best ones according to OSE Specifications and the Product Selection Metric almost 4 years ago.

If you are a subject matter expert, designer, video editor, CAD draftsman, or other technical contributor in any of the 50 technologies – you are welcome to bid on work. We suggest you submit a Proposal Brief. The key to the project is finding qualified people – and we found that word of mouth and references from trusted sources tend to provide best results. Help us find these people.

We are also looking for full time people to join Factor e Farm – master builder, farmer, fabrication manager, CEO, CTO, and co-founder. With the farmer - we need to continue field testing the equipment while feeding our team. With the builder, we want to continue building out infrastructure, building out our electrical grid. With the fabrication manager, we want to continue production runs as a first-hand test of our economic significance, and to continue building the tools that we use on site. We are looking for startup instigators, not employees – as this type of risk-sharing is part of the responsibility that we seek in our partners.

There are other support roles. We also welcome you to join us in resource development – the OSE Enterprise is an open business plan that you can use. We are working on developing remote video editing capacity, where you can edit remotely after downloading footage from our repository – such as YouTube. Our current plant is to use smartphones for constant uploads of content – indexed by topic. Then, remote editors can take the content to make quality videos from the raw footage. We are also looking for ongoing CAD, fabrication drawing, simulation, and analysis support for prototyping.

At best, as the team grows at Factor e Farm, remote support functions would include:

- ***Video Editing Support*** – ongoing instructionals
- ***CAD Support*** – converting videos with measurements into CAD files;
- ***Fabrication Drawing Support*** – converting CAD files into fabrication drawings that one can take to a local fabricator
- ***CAE Support*** – converting CAD files into CAE analysis for structural, thermal and other

properties;

- ***Modeling Support*** – animations modeling the function of machines, as part of explanatory
- ***Material Blogging Support*** – keeping track of a project with the project lead to provide regular
- ***Blog Updates on a Given Project*** – such as checking in ½ hour each week by phone and writing a blog post. Strong journalism/reporting/creative writing skills are required to provide context and to pique the reader's interest. This is critical as we have a regular backlog of reporting from Factor e Farm and other locations.
- ***Collaboration Support*** – dedicated searching for allied efforts, collaborators, peer reviewers, funding support, bidders, subject matter experts, and any other support that media and music repository support – keeping a repository of high resolution media, graphics, diagrams, and other materials for use in press releases, reports, and other publications; open source soundtrack repository for videos
- ***Nonprofit Fundraising*** – join Aaron Makaruk in raising funds for OSE. See his sample contract *http://opensourceecology.org/wiki/Contract_Aaron*

OSE Branches and Allied Efforts

There are 3 main forms of OSE-related operations: independent OSE efforts, chartered OSE organizations, and certified OSE/GVCS Producers

Independent OSE Efforts

OSE is a movement to create an open source economy by developing and using economically significant, open source information (open product and process design and techniques of production). OSE refers to more than just an open source economy. The distinction is that OSE produces not only open design, but also produces distributive enterprise as the means to affect the economic process. On top of this, it connects to environmental regeneration and social justice as discussed at the OSE Paradigm section.

We encourage that the OSE message be spread far and wide as the third economic paradigm. To this end, we do not restrict anybody from using the OSE name as long as they are following the OSE Paradigm. Others are welcome to use the official OSE name or official logo in branding their work or group as an independent OSE effort, without explicit permission, if they are an individual, group, or organization. Independent OSE Efforts are intended to promote that work of OSE, while not demanding that any resources on the part of OSE International.

To be an independent OSE effort in good standing – the effort may be one or more of the following:

- A user of GVCS technologies
- Doing outreach about the OSE Paradigm
- Developer or prototyper of GVCS technologies
- Engaging in the development of any other, non-GVCS technologies while publishing designs and open business models. We believe in open everything, and the wiki is infinitely expandable. We recommend that you publish on the OSE Wiki for recognition.
- An effort for raising money (nonprofit sector or otherwise) by using the OSE brand. In the case

that you are raising money, we request that if you use the OSE brand, that you contribute 25% of your net funding raised to promote the work of OSE International. This money will be used directly for GVCS prototyping in 2012, so your funding will help the entire movement to achieve its goals faster.

While others are allowed to use the GVCS designs for profit - they are not allowed to use the official OSE logo to brand their products. They are welcome to sell products under their own label. If one wants to sell products under the official OSE/GVCS label, then one is required to become a certified OSE/GVCS producer, as discussed below.

If you are using the OSE identity to run some form of operation or effort, please let the greater community know as a matter of courtesy, by posting your organization's name, date formed, contact details, and activities at Independent OSE Groups on the wiki.
Chartered OSE Organizations – OSE Development Facilities

OSE has a good chance to change the world. To maintain and enhance a strong identity as a world-changing organization that produces transformation of economies, we are setting high standards for new facilities. New facilities, if chartered as an official part of the core development work of OSE, must comply with the distributive economic goals of the OSE Paradigm. Moreover, if the OSE Paradigm is indeed effective – then the new organization should have a significant and visible effect on the economy – not only in terms of achieving a post-scarcity economy on its own soil – but also in instigating the same in surrounding communities. Visible economic and political transformation should occur on sub-decade timescales in these communities. A network of thousands of communities as such is expected to arise within about 3 years of GVCS completion of year-end 2012. This is a seed for thorough global transition to the open source economy, and to Open Source Ecology.

To achieve this, a Chartered OSE Organization must be:

- A land-based facility, where the land is placed in a trust as a site of permanent human heritage. This is intended to guarantee continuity and significance to any new effort of this nature.
- A beacon of light for its local community, which demonstrates in itself a functional community operating under the conditions of material post-scarcity.
- A development and education center and a place of lifelong learning, with the ideal of creating the next generation of responsible stewards of their communities and of the greater world in the context of the open source economy.
- A productive facility and a product development center capable of producing all of its essential needs from local resources.
- A change agent for surrounding communities, the success of which is measured by the adoption of open source economic and OSE practices in the surrounding communities
- Populated by full-time individuals who live a post-scarcity economy lifestyle – where a high standard of living is achieved from local productivity.

The enabling technology base for such a community is the complete set of 50 GVCS tools, or a related infrastructure package that provides for all of the community's material and energy resources.

The above is not an easy task, and we are looking for initial discussions with small core groups of movement entrepreneurs interested in starting such new facilities. These core groups must have demonstrated the practical, tactical, and people skills to organize rapid learning and development efforts required for the successful startup of such communities.

The benefit of OSE-chartered status is the publicity, funding, and access that comes from that relationship. We are willing to consider other types of chartered organizations under specific terms. Otherwise, another route is operating as an independent OSE effort as in the previous section.

Certified OSE Producers

OSE International is currently developing training programs and infrastructures for producer training. Typically, a producer is a skilled craftsman who picks up additional skills during a build of one or more complete machines as part of their training. Another route to producer training is for independent producers to submit finished copies of devices for quality control approval by members of the OSE International certification committee.

Certified producers may sell under the OSE brand. OSE can provide marketing assistance. In return for certification, OSE Certified Producers are required to pay 5% of their net. This funding goes to support the development of the GVCS and the replication of OSE Development Facilities. Non-certified producers do not have to pay a license fee if they sell under their own label.

Chartered OSE Organizations

Becoming a chartered OSE Organization is not a task to be taken lightly, as the goal of OSE as a movement is to produce disruptive change. Starting a branch means creating the substance of the next economy. Our goal is to create a strong identity for OSE as a clear and positive change agent who delivers tangible results. Anything short of this is diluting the message, and does not help the movement as a whole.

If you would like to be endorsed as an official OSE facility, the first thing is a charter – defining your goals clearly. This includes the resources you aim to secure, distributive enterprises that you aim to develop – and the team that will help you get there.

We are interested in assisting startup facilities in the full capitalization and infrastructure to create powerful development and productive facilities – starting with land. To facilitate this – we suggest that the timing for this would occur after the 50 GVCS tools are developed, or after Dec. 21, 2012. The reason for this is that once the 50 tools are available, startup costs will be decreased significantly – perhaps from $1M for a new facility to $100k.

We aim to provide startup assistance in the form of immersion training and capitalization assistance. We suggest that a core team of 2-4 people come to Factor e Farm for 6 months of immersion training. The core team would pick up a wide range of practical village construction skills – from digital fabrication, integrated agriculture, renewable energy, housing construction, and others. This training may be funded by grants or production earnings.

Capitalization Assistance Model

During the immersion training, trainees will have a chance to build real products that can be sold. With the economic power of the GVCS and social capital of OSE, marketing is not expected to be a barrier to successful fundraising by production. We expect that a single trainee should be able to generate $5k of value per month, assuming ½ time participation in production at 50% capacity compared to a professional fabricator. We have initial evidence that with proper guidance and sound ergonomic design of the workshop – this is a realistic proposition. For a 6 month duration, that is $30k value generated per person. This is sufficient to generate significant capital for startup. If the cost of training is $10k per person, then a core team of 4 trainees can leave their 6 month immersion training with: (1), a highly integrated, practical skill set covering all sectors of the productive economy (agriculture, construction, energy, technology); (2), connection to a network of change agents around the globe; and (3), $80k of startup capital for their own facility.

This is the type of commitment that we expect from startup instigators in other locations around the world – if the expectation is full endorsement and support from OSE headquarters.

Note On Strategy

In 2013, we will be expanding to other goods and services, but for now, we are focusing on the GVCS 50 as the strategic core. Once developed, this will provide the track record, process, and economic power to diversify into other products and to facilitate the creation of communities, enterprises, and new countries. Remember that this is an Apollo Program for the GVCS – and we expect to finish the 50 beta product releases by December 21, 2012. If things continue as they are now, we may be done ahead of schedule. Completion of the GVCS provides everyone with a much larger index of possibilities for 2013.

Strategically, OSE International is putting all its effort into securing and allocating the $5.5M that it will take to develop the GVCS 50 by year-end 2012. This is a monumental organizational task, and it requires our full attention. Anything not related to this plan is a distraction to the core effort. We ask the rest of the community to help out in the GVCS 50, and in particular, in the Factor e Farm experiment. This focus has to happen for only 1 year. Access to all the 50 technologies will mean about a 10x reduction in startup cost of any new OSE-related effort. The GVCS 50 is the key to viral replication. Therefore, it is better for the whole movement that all effort is spent on the GVCS 50 – and get it done even ahead of schedule. Then, the possibility of viral replication will be real.

If you are considering replication right now – you have to consider that we have only 4 beta product releases – which does not address fuel, power, or fabrication aspects of a robust community. Yes, new facilities can be built right now – but at high startup costs. My personal frustration is that everyone thinks that we have all the technology already. We don't – we are in development –

and moreover, these products need to go through the thousands of hours necessary for general adoption by the rest of the world. As such I ask this Christmas day that we all work together to get there, and magic will follow.

I know that many people are itching to get involved – this was exactly my state about 6 years ago. I found out that access to the enabling tools crushed my whole initial plan. That is a condition that anyone will still face today – until many more of the GVCS 50 tools are done. We have too few of the tools developed as of yet to make replication a painless process. Even with all the tools available – there are enough things that can go wrong – that my best advice to anyone is not to do this until all the tools are available. It will simply be easier for everybody involved.

We would like to continue making this one of the most collaborative projects in the world: open engineering, open economic development, and distributive enterprise for the common good. Let's work together to make this happen.

From the Founder: My Story
Marcin Jakubowski, 12.24.2011

I have been asked a number of times – what experiences led me to start OSE? I am sharing my story here to shed some light on the formative experiences influencing this work, with the hope that they may help to clarify the approach.

Ever since I was a little child I wanted to apply science to creating human prosperity. Wow – with all the Amazing technology around us – life should be good. My father is a molecular biologist, and ushered me to go high in academia. But the further I went the more useless I felt, while noticing that there were pressing global ills to solve. It was during my Ph.D. Program in Madison, WI, that I got radicalized. I discovered firsthand the myth of technology – with ever improving technology; people are still working harder and harder, missing out on the finer things in life. This troubled me greatly.

In Madison, there was a string of events that led me to formulate the Open Source Ecology concept. It actually started at Princeton U, where I went for my undergraduate studies. I found Princeton to be a shocking wake-up call – more a breeding place for the power structure of the world – less a playground for ideologues improving the human condition. I vowed after this never to go to another Ivy League, and found myself at U. Wisconsin, Madison, for grad school - a progressive, rabble-rousing environment. Soon enough, I became totally disillusioned with my studies – I was becoming more specialized and useless every day – and I was learning theory about things that didn't exist. I felt that was a great abnegation of human responsibility – given that there are pressing issues in the world to solve.

So I started getting involved in the student community to remain sane. I started the Polish Club to bring the Polish crowds together, then Global Connections, to get all the internationals together. Then I moved on to organize interdepartmental grad student socials – since we never had a chance to interact with anyone outside of our department. Since I was interested in energy, I started a Global Energy Forum, and then Sustainability Forum to immerse intellectually in sustainability issues, then Gandhi Network to get some hands-on experience beyond the mind, such as building a solar dehydrator.

Through all of these events, I learned 2 things. First, people rarely collaborate or cross disciplines in their work. Second – people did not have time to do cool things any more. Lectures and workshops were all fun and games – but they were really brief sessions of escapism - as nobody really had the time to pursue any of the topics discussed more deeply. People go to the talks and workshops - then they go back to work for the man on Monday. What was needed was a different lifestyle, a new economy – where people were not so alienated from their work, where they could pursue the things that they really care about. It is then that I thought that civilization needed a thorough reboot in terms of right livelihood and meaning in peoples' lives. The economy and environment and social justice were all in havoc all over the world – yet everybody was going about business as usual.

Then it became crystal clear to me – only if we collaborate truly openly – as in creating an open source economy where people actually build freely on each other's progress – only then can we achieve a sound economy – and spare time. This became clear to me when I could not discuss my PhD research openly with other university groups – because we had hot stuff and competitive advantage for funding. Thus, my learning process was hampered. That frustrated me to the point that I decided I would work wholeheartedly to change this aspect of modern civilization.

In my last year of the Ph.D. Program, I coined the Open Source Ecology concept. It was about creating an open source economy – based on the principles of collaboration that came from the open source software movement. I claimed that if we operate openly, we learn more, we become more responsible, which includes responsibility for taking care of nature – as it is the source of all of our material well-being. Therefore, open source ecology refers to the integration of human and natural ecosystem into a harmonious system of interactions, based on open source principles of cooperation.

Any civilization starts with access to land – so in my own civilization reboot experiment, land was the first thing I secured after my PhD. In the initial phases, with little money and big dreams, voluntary simplicity was my only option, and I explored the limits of how little one could do with. But that got old after some time. I was living like a hippie in the woods with a pocket knife, and it occurred to me quickly that a firm economic foundation and powerful tools were necessary if one is to face nature and ask her to provide directly for one's needs. I also learned quickly that use of nature does not have to mean abuse of nature. I also learned that we have the technology to do things right – in harmony with nature – and it is only greed and myths that dictate that human prosperity should be at odds with nature. I learned firsthand from the land - that nature is abundant – and that general human prosperity is a matter of distribution – not production.

So with this, my tractor broke, and the rest is history as you see in my GVCS TED Talk of 2011. Point is: we can create open source equivalents to industry standards – AND take care of the environment, AND in fact, we can do much better all together by eliminating the inefficiencies of competitive waste in all its forms. Globalization is a simple manifestation of competitive waste – competing for strategic resources because we refuse to learn how to use local resources more cunningly to achieve the same ends.

I also come from Poland, with its long history of war, surrounded by powerful neighbors. My grandfather was in the Polish underground engaging sabotage actions against Nazis during WWII, and he was a horseback soldier in WWI. My grandmother was in a concentration camp. I read all types of books on these troubling topics, as they are fascinating – regarding the nature of the human spirit under extremes of conditions – playing out the good old fight of good versus evil.

I pictured myself living in those times, and still have bad dreams from time to time - and put myself in the place of the people in these books - and consider how I would act myself. And today, I grasp to understand why we are still so un-evolved as humans, still killing one another.

The most fascinating explanation I have yet read on the topic – and interestingly – from a survivor of turbulent political times of post-WWII Poland himself – is Political Ponerology: a Science on the Nature of Evil Adjusted for Political Purposes. That is the most important book on the topic of achieving general human prosperity that I have read. It is a psychological study that explains why psychopaths tend to move up in corporate boardrooms and in positions of power – and how all of us support them - in getting there.

Today I do my part in the open source 'underground' – a fringe movement still, waiting to be the next trillion dollar industry. Except this time, it will not be a centralist phenomenon – but a movement created by many independent players. If we open source a few critical yet sufficient technologies for survival as a species – then a shining example can be set, and a solid economic foundation can be laid – for human progress. My role is to seed a kernel, in the form of the GVCS 50 tools – and the economic power created will take care of the rest.

What is the rest? When people address basic material scarcity – a new economy, and new politics, will follow. It will be a new paradigm. What do I see myself doing then? I will be spending my full attention on how to become a better human, and helping others to do the same. This depends on material scarcity being removed as one of the stresses affecting humanity, as mastering material security is a prerequisite if we want to have a fair chance – of evolving to freedom.

New education, new communities, and new politics – they are all around the corner. Even when the world is cracking at the seams, the human spirit will never die.

How are you doing your part to play this out?

Compressed Earth Brick Press

The Liberator

Design Rationale

The OSE CEB press is a vertical press, where soil falls by gravity directly from the hopper into the compression chamber. The main cylinder compresses soil, and the soil loading drawer closes/ opens the compression chamber and ejects bricks from the machine.

Results and Improvements Made

Note on the brick pressing rate: maximum of 16 thin bricks per minute with 54 hp, without using grate shaker.

The main addition to the CEB machine design since last year is the increase of machine height from an 8" to a 12" main pressing cylinder, so that the resulting bricks are (2"-6")x(6"x12") as opposed to the (2"-4") bricks.

This means the pressing rate is reduced but larger bricks are made.

Because it was late in the season and the soil was typically too wet, we had bridging problems and we could run the machine only at half its rated power, or 27 hp.

Brick pressing rate was 4 bricks per minute with 27 hp for full-size (6"x6"x12") bricks.

The compression chamber front and back u-channel was reinforced with a 1/2"x2" bar along its length to prevent it from bulging out; this failure was not observed in Prototype I and II because the width of the main chamber was 4" and 3" smaller.

Improvements Needed

The machine is currently moved into place by forks, but a trailer will be added to improve mobility.
Sides will be added to the grate to prevent soil from falling off the grate.
Flat bar will be used instead of rebar as the grate to facilitate soil falling through the grate.

Physics of Why the CEB Press Works

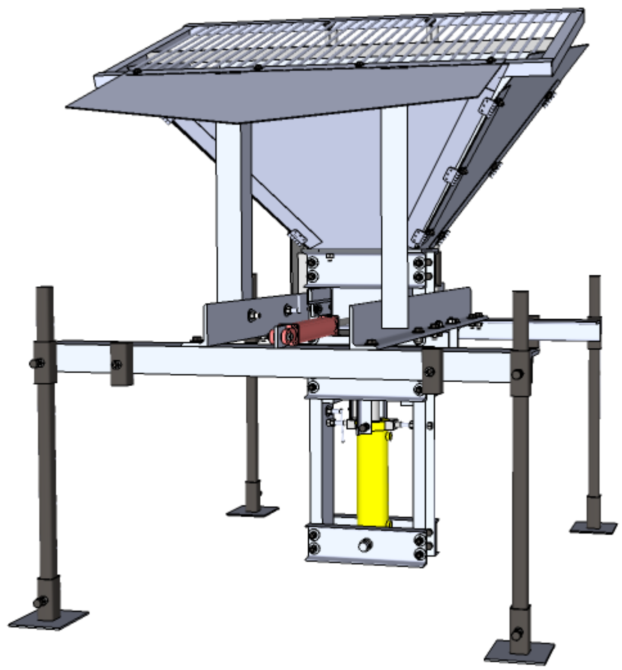
Bricks are made of 20%-30% clay, the rest being sand and silt. A combination of mechanical and electrostatic forces is responsible for the high strength of compressed earth blocks.

Compression physically removes voids from the earth. As particles come closer, mechanical forces of rough particles touching each other lock particles into place. For microscopic particles of clay, which are less than 4 microns in size - electrostatic forces of intermolecular attraction begin to play a role.

For stabilized bricks, chemical binding forces of the binder - such as cement - are responsible for the strength. Cement binders tend to bind larger particles of sand and aggregate, and lime binders tend to bind the finer particles of clay.

It appears that the exact nature of the large compressive strength of pressed earth is not well understood.

CEB



Complete Fabrication Instructions, 2011

Open Source Ecology

Compiled by Brianna Kufa

CEB Introduction

The purpose of this guide is to provide all information to make the 2011 version CEB Press from stock steel and parts. More information, and a constantly updated procedure can be found on the OSE wiki CEB Manufacturing page.

This guide is broken into 3 main fabrication steps: Mechanical Fabrication, Electronic Components, and Machine Integration. The steps in Mechanical Fabrication and Electronic Components are independent of each other, but within each category, the suggested order should be followed. Once both are finished, you the machine's mechanical and electronic components can be integrated. At that point, your machine can be used.

Mechanical Fabrication begins with the cutting of all stock steel. After that, it is broken into two sections: Parts Fabrication, and Parts Assembly. Parts fabrication focuses on cutting, drilling, punching, bolting and welding the steel into individual parts, and is organized by machine systems. Parts assembly joins all of the sub-parts into the whole machine. To complete mechanical fabrication, the machine must be painted.

This video offers good insight on how to do many of the steps in assembly. Some steps will vary though. The written instructions are correct.

The Electronic Components section covers preparing all of the components which automate the machine. It requires the preparation of the machine sensors, and all of the components which reside in the controller box.

Machine Integration links the hydraulic, mechanical, and electrical components into a functioning CEB.

CEB Bill of Materials

Steel

Type	Size	Total (inches)	Total (feet)
Angle	.25x2x2	291	24.25
Angle	.5x4x4	105	8.75
Angle	.5x4x6	288	24
Angle	.5x4x7	12	1
C-Channel	3	3	0.25
C-Channel	6 heavy	274	22.83333333
DOM Round	1.5	14.5	1.208333333
Dom tubing	1.5 ID 2.0OD	3	0.25
Flat	.25x1	14	1.166666667
Flat	.25x2	71.5	5.958333333
Flat	.1875x2.5	72	6
Flat	.25x3	6	0.5
Flat	.25x6	27	2.25
Flat	.25x7	27	2.25
Flat	.25x8	44.5	3.708333333
Flat	.375x 3	51	4.25
Flat	.5x2	72	6
Flat	.5x3	93.5	7.791666667
Flat	.5x6	12	1
Flat	1/8x3	288	24
Flat	1x1	5	0.416666667
Flat	1x2	11	0.916666667
Flat	1x4	10	0.833333333
Flat	1x6	12	1
Flat	1x7	12	1
Pipe	.75ID 1OD	2	0.166666667
Rebar	0.375	9	0.75
Rebar	0.5	1122	93.5
Rebar	1	14	1.166666667
Round	1	7.25	0.604166667
Threaded Rod	0.75	40.75	3.395833333
Tubing	.1875x2.5x2.5	84	7
Tubing	.25x2x2	288	24
Tubing	.5x6x6	12	1
Sheet	1/8"x5'x10'	1 full sheet	
	1/8"x5'x23.5"	Part of a sheet.	

Fasteners

Description	Quantity
Bolt, HHCS, 0.313"-18x0.625"x0.625"	8
Bolt, HHCS, 0.375"-16x2"x2"	4
Bolt, HHCS, 0.5"-13x1"x1"	16
Bolt, HHCS, 0.5"-13x2"x1.25"	5
Bolt, HHCS, 0.5"-13x4"x4"	2
Bolt, HHCS, 0.75"-10x1.5"x1.5"	9
Bolt, HHCS, 0.75"-10x2"x2"	34
Bolt, HHCS, 0.75"-10x2"x2"	19
Bolt, HHCS, 0.75"-10x2.5"x2.5"	6
Bolt, HHCS,0.75"-10x3"x3"	6
M12 Bolt, Modified- 55mm	4
Bolt, HHCS, 0.25"x2"	1
B18.2.4.1M - Hex nut, Style 1, M12 x 1.75-D-C	4
Nut, Hex, 0.375"-16	4
Nut, Hex, 0.5"-13	24
Nut, Hex, 0.75"-10	77
Nut, Hex, Steel, 0.75"x10	12
Nut, Hex, .25"-16, Lock	1
Washer, Plain, Narrow, B18.22.M, 12mm	4
Washer, Wide, 0.375"	8
Washer, Wide, 0.5"	28
Washer, Wide, 0.75"	74
Washer, Lock, 0.25"	1

Hydraulics

Type	Item	Qty.	Source
Cylinder	5x12x2.5 Crosstube	1	https://www.surpluscenter.com/item.asp?item=9-1143-12&catname=hydraulic
	2.5x14x1.125 Clevis	1	https://www.surpluscenter.com/item.asp?catname=hydraulic&qty=1&item=9-7619-14
Motor	Dynamic Hydraulic Motor	1	https://www.surpluscenter.com/item.asp?item=9-7077-50&catname=hydraulic
Hoses	1/4"x12" NPTM	1	https://www.surpluscenter.com/item.asp?item=916-1412&catname=hydraulic
	1/2"x36" NPTM	3	https://www.surpluscenter.com/item.asp?item=905-1236&catname=hydraulic
	1/2"x56" NPTM	2	https://www.surpluscenter.com/item.asp?item=905-1260&catname=hydraulic

Type	Item	Qty.	Source
Valves	1/2" NPT Needle Valve	1	http://www.surpluscenter.com/item.asp?item=9-7960-8&catname=hydraulic
	1/2" Flow Control and Relief Valve	1	https://www.surpluscenter.com/item.asp?item=9-064-50&catname=hydraulic
	1/2" NPTF Check Valve	1	https://www.surpluscenter.com/item.asp?item=9-7933-8-5&catname=hydraulic
Fittings	SAE 4M to 1/4" NPTF Swivel	1	https://www.surpluscenter.com/item.asp?item=9-6900-4-4-S&catname=hydraulic
	SAE 6M to 1/2" Swivel	6	https://www.surpluscenter.com/item.asp?item=9-6900-6-8&catname=hydraulic
	SAE 12M to 3/4" Swivel	2	https://www.surpluscenter.com/item.asp?catname=&qty=1&item=9-6900-12-12
	3/8" NPT Hex Nipple	2	http://www.surpluscenter.com/item.asp?item=9-7184&catname=hydraulic
	1/2" NPT Hex Nipple	6	https://www.surpluscenter.com/item.asp?item=9-5404-8-8&catname=hydraulic
	1/2" NPTM to 1/4" NPTF bushing	1	https://www.surpluscenter.com/item.asp?item=9-5406-8-4&catname=hydraulic
	1/2" NPT to 3/8" NPT bushing	2	http://www.surpluscenter.com/item.asp?item=9-5406-8-6&catname=hydraulic
	3/4" to 1/2" NPT Bushing	2	https://www.surpluscenter.com/item.asp?item=9-5406-12-8&catname=hydraulic
	1/2" NPTM to 1/2" NPTF 90 Elbow	3	https://www.surpluscenter.com/item.asp?item=9-5502-8-8&catname=hydraulic
	1/2" NPTM Elbow	2	https://www.surpluscenter.com/item.asp?item=9-5500-8-8&catname=hydraulic
	1/2" NPTF Tee	2	https://www.surpluscenter.com/item.asp?item=9-5605-8-8-8&catname=hydraulic
	1/2" Quick Coupler Pair	5	https://www.surpluscenter.com/item.asp?item=928&catname=hydraulic
	3/4" Quick Coupler pair	1	https://www.surpluscenter.com/item.asp?item=928-C&catname=hydraulic
Solenoid	Daman Manifold AD05S033S or Dalton part# 240-712	1	Call Dalton to order http://stores.daltonhydraulic.com/StoreFront.bok

Solenoid Valve for motor Type H, Dalton Part #: 240-241	1	http://stores.daltonhydraulic.com/-strse-675/Solenoid-Directional-Control-Valve%2C/Detail.bok?category=Control+Valves+-+Solenoid%3AD05+40GPM+Directional+Valves+-+DC
Solenoid Valve for rams Type C, Dalton Part #: 240-244	2	http://stores.daltonhydraulic.com/-strse-674/Solenoid-Directional-Control-Valve%2C/Detail.bok?category=Control+Valves+-+Solenoid%3AD05+40GPM+Directional+Valves+-+DC

Other

Description	Quantity	Source
Generic Door Hinge	12	Home depot
1" Keyed Coupler	1	https://www.surpluscenter.com/item.asp?item=1-1563-E&catname=powerTrans
12mm x 3mm N42 Epoxy Coated Disc Magnet	6	http://www.gaussboys.com/ndfeb-magnets/D1203E-N42.html
Pillow Block Bearing - 1"	2	https://www.surpluscenter.com/item.asp?item=1-205-16-P-C&catname=powerTrans
V-Groove Bearing	4	http://www.vxb.com/page/bearings/PROD/Kit8406
Power Clamps, AKA Hose Clamps- 1" Max OD	4	Automotive Store, see http://opensourceecology.org/wiki/File:Hose_Clamps.jpg

Electronics

Item	Qty.	Source	Notes
50ft 16AWG Extension Cord	1	Electronics Store	http://opensourceecology.org/wiki/File:50ft3Wire16AWGExtensionCord.jpg
Pair of Large Alligator Clips (Black and Red)	1	Electronics Store	http://opensourceecology.org/wiki/File:AlligatorClips.jpg
Female Insulated Connector 16-22AWG	1	Electronics Store	http://opensourceecology.org/wiki/File:FemaleInsulated16to22AWGConnector.jpg
Outdoor Main Lug Box	1	Hardware Store	http://opensourceecology.org/wiki/File:LugBox.png
Wire Clamps	2	Hardware Store	http://opensourceecology.org/wiki/File:WireClamps.jpg
Toggle Switch	1	Hardware Store	http://opensourceecology.org/wiki/File:ToggleSwitch.jpg
Washer 1.25" OD .5" ID	2	Hardware Store	http://opensourceecology.org/wiki/File:Washer1-25OD0-5ID.jpg

Fuse Holder	1	Electronics Store	http://opensourceecology.org/wiki/File:FuseHolder.jpg
Male Insulated Connector 10-12AWG	1	Electronics Store	
Ring Insulated Connector Small Hole 10-12AWG	2	Electronics Store	
Buss Fuse 10Amp	1	Electronics Store	http://opensourceecology.org/wiki/File:10ABussFuse.jpg
Ring Insulated Connector 10-12AWG	20	Electronics Store	
12cm by 7.5cm by 0.4cm HDPE Plate (4.75"x3"x5/32")	2	Hardware Store	
M3 20mm Machine Screws	4	Hardware Store	
M3 Nylon-threaded Locknuts	4	Hardware Store	
8-32 machine screws of 3/8 inch length	7	Hardware Store	
8-32 machine screws of ¾ inch length	4	Hardware Store	
Arduino Uno Microcontroller	1	Digikey	http://www.digikey.com/1/parts/2412553-arduino-uno-board-a000046.html
Underground Telephone Wire (4-wire) 3m length	1		
Shrink Tubing 16-22AWG 18cm length	1	Electronics Store	
Hall Effect Sensor	2	Digikey	http://www.sparkfun.com/products/9312
PVC Pipe with 1" Outer Diameter, 9/16" Inner Diameter, 3.5" Length	2	Hardware Store	
Silicone 250ml	1	Hardware Store	Transparent Silicone Caulking
Ring Insulated Connector 14-16AWG	20		
Red Wire 18AWG 25ft	1	Electronics Store	
Black Wire 18AWG 25ft	1	Electronics Store	

Solenoid Driver –

Note: this is included separately from electronics in case you choose to make a different driver board.

Description	Qty.	Source
Power N MOSFET	5	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=RFD16N05LSM9ACT-ND
Green LED	7	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=160-1169-1-ND
Diode	5	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=641-1331-1-ND
499 Resistor	5	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=311-499FRCT-ND
49.9k Resistor	5	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=311-49.9KFRCT-ND
10k Resistor	2	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=311-10.0KFRCT-ND
2 Pos Terminal	9	http://search.digikey.com/scripts/DkSearch/dksus.dll?vendor=0&keywords=ED1514-ND
reset switch	1	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=SW262CT-ND
6 Pos Header	2	http://search.digikey.com/scripts/DkSearch/dksus.dll?vendor=0&keywords=a1913-nd
8 Pos Header	2	http://search.digikey.com/scripts/dksearch/dksus.dll?pname&site=us&lang=en&WT.z_cat_cid=Dxn_US_US2011_Catlink&name=A1914-ND
PCB	1	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=473-1002-ND
100 Resistor	2	http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=311-100FRCT-ND

CEB Cut List

Cut the steel into the following lengths. Label and separate cuts by "Step" number so you can easily find cuts for each step during the fabrication stage. The step number for each sub-guide is listed in parenthesis in the upper left corner in the header.

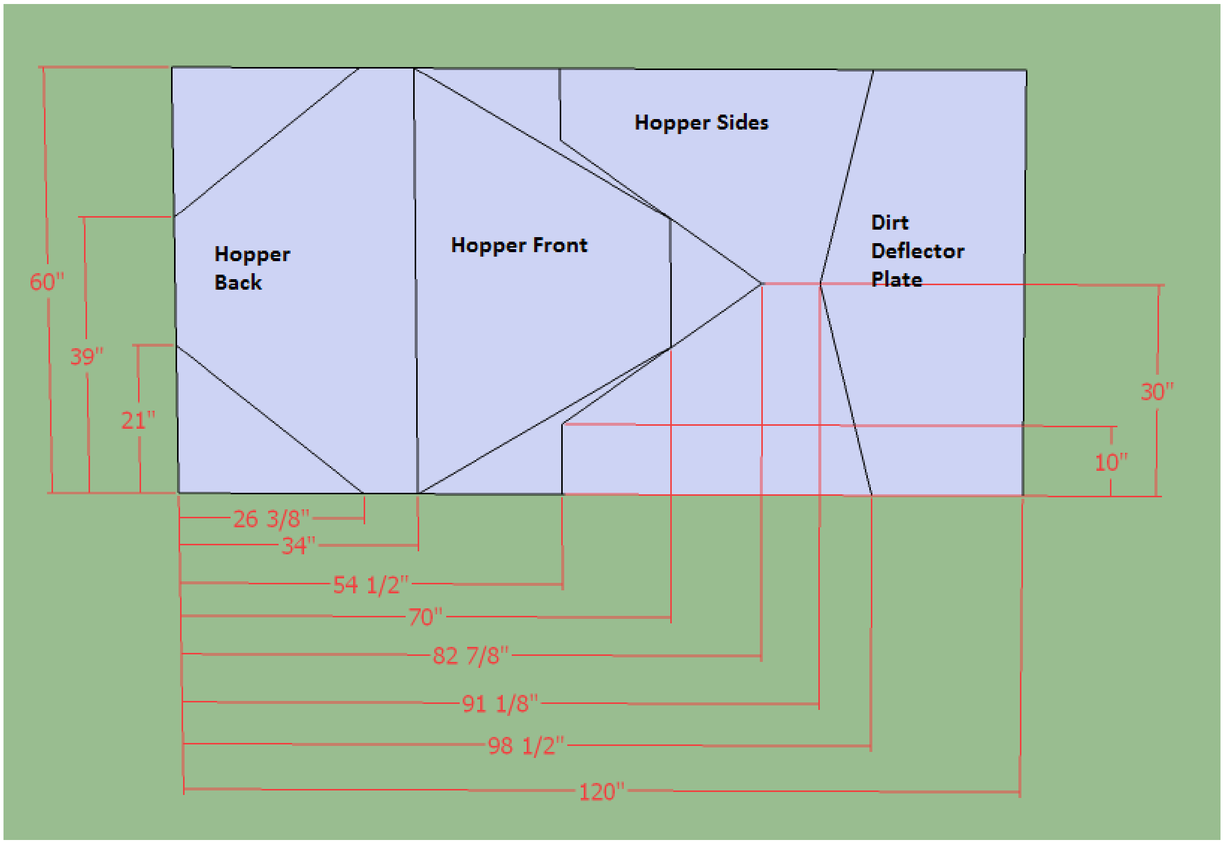
Type	Size (")	Length (")	Qty	Primary Part Name	Secondary Part Name	Step #
Angle	.25x2x2	6	2	Main Frame	Dirt Blockers	17
		6	2	Wide cylinder support		12
		10	2	Soil Shaker	Side of guard	3
		16	2	Soil Shaker	top and bottom of guard	3
		35.5	2	Soil Grate		9
		72	2	Soil Grate		9
Angle	.5x4x4	8	1	Soil Shaker		3
		21	1	Soil Shaker		3
		38	2	Grate supports		6
Angle	.5x4x6	72	2	Secondary Arms		2
		72	2	Primary Arms		2
Angle	.5x4x7	12	1	Soil Loading Drawer	Back	10
C-Channel	3	1.5	2	Main Frame Small Components	Thin Cylinder support	13
C-Channel	6 heavy	13	2	Main Frame	Spacers	17
		21	4	Main Frame	Horizontal Members	14
		29	2	Wide cylinder support		12
		53	2	Main Frame	Vertical Members	14
DOM Round	1.5	3.5	1	Main Cylinder	Fill in rod tubing	16
		11	1	Main Frame	Cylinder Pin	18
Dom tubing	1.5 ID 2.0OD	1.5	2	Main Frame	Horizontal Members, cylinder mounting	18
Flat	.1875x2.5	36	2	Soil Loading Drawer	Outer Rails	10
Flat	.25x1	14	1	Main Frame Small Components	Magnet Holder	13
Flat	.25x2	12	1	Controller Mount		1
		71.5	1	Soil Grate	Cross piece	9
Flat	.25x3	6	1	Controller Mount	Bottom piece	1
Flat	.25x6	12	1	Valve Mount		1
		15	1	Controller Mount		1
Flat	.25x7	13.5	2	Soil Loading Drawer	Sides	10
Flat	.25x8	8	4	Feet		2
Flat	.25x8	12.5	1	Soil Loading Drawer	Roof	10
Flat	.375x 3	24	2	Main Frame	Horizontal Members Reinforcement	17

		3	1	Roller Guides	Spacer Plate	11
Flat	.5x2	36	2	Soil Loading Drawer	Inner Rails	10
Flat	.5x3	3	1	Secondary arms	Eye for 2nd cyl	a5
		3	1	Soil Loading Drawer	Tongue	10
		11.25	2	Hopper Mounting Plate		8
		15	2	Hopper Mounting Plate		8
		16	2	Roller Guides	Main Plate	11
Flat	.5x6	12	1	Soil Loading Drawer	Vertical Supports	10
Flat	1/8x3	36	8	Hopper Sheet Metal	Hinge Plates	7
Flat	1x1	2.5	2	Preparing the Main Cylinder	Press foot supports	16
Flat	1x2	5	1	Soil Shaker	Hammer	4
		6	1	Soil Shaker	Hammer	4
Flat	1x4	10	1	Preparing the Main Cylinder	Lower Press Foot	15
Flat	1x6	12	1	Preparing the Main Cylinder	Upper Press foot	15
Flat	1x7	12	1	Soil Loading Drawer	Press Plate	10
Pipe	.75ID 1OD	1	2	Main Frame Small Components	Thin Cylinder support	13
Rebar	0.375	3	1	Main Frame Small Components	Sensor Holder	13
		6	1	Main Frame Small Components	Sensor Holder	13
Rebar	0.5	34	33	Soil Grate		9
Rebar	1	7	2	Soil Shaker		3
Round	1	7.25	1	Soil Shaker		4
Threaded Rod	0.75	1.25	1	Main Frame Small Components	Magnet Holder	13
		3.5	1	Main Frame Small Components	Sensor Holder	13
		3.5	1	Main Frame Small Components	Sensor Holder	13
		6.25	2	Main Frame Small Components	Thin Cylinder support	13
		3.75	4	Main Frame	Drawer member drawer adjuster bolts	14
		2.5	2	Main Cylinder	Upper Press foot	15
Tubing	.1875x2.5x 2.5	6	14	Leg Holders		2
Tubing	.25x2x2	48	4	Legs		2
			2	Hopper Supports		6
Tubing	.5x6x6	12	1	Soil Loading Drawer	Spacer	10
	6x12	50	1	Optional Jig for Main Frame Assembly		17

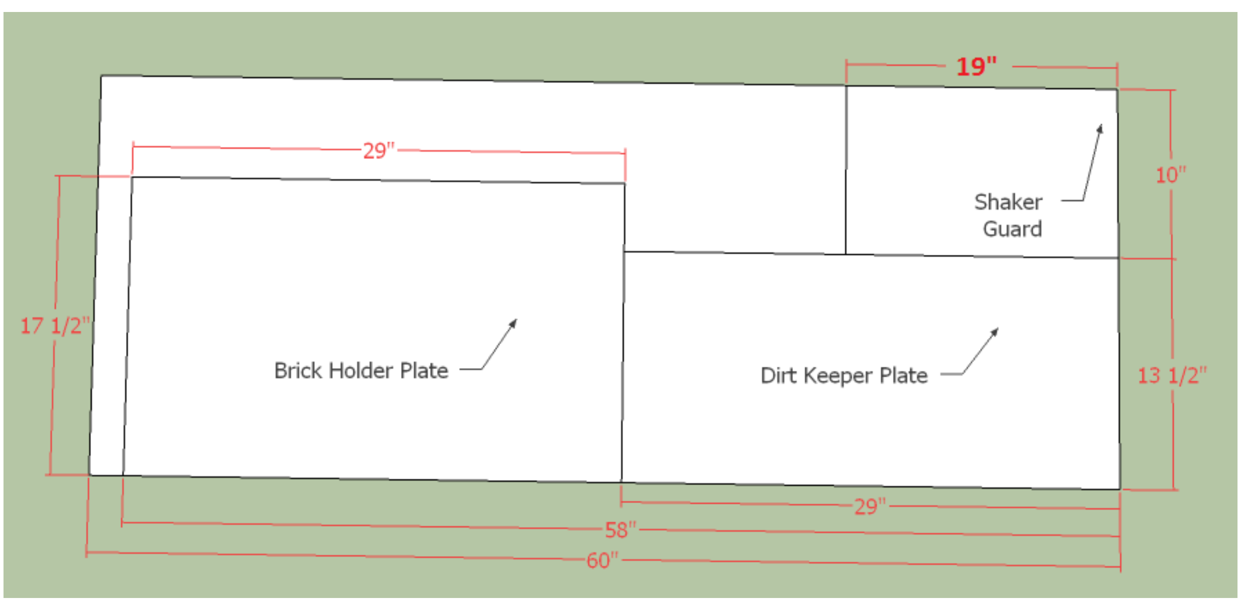
1/8" sheets, to be torched:

- After torching, grind the edges smooth.

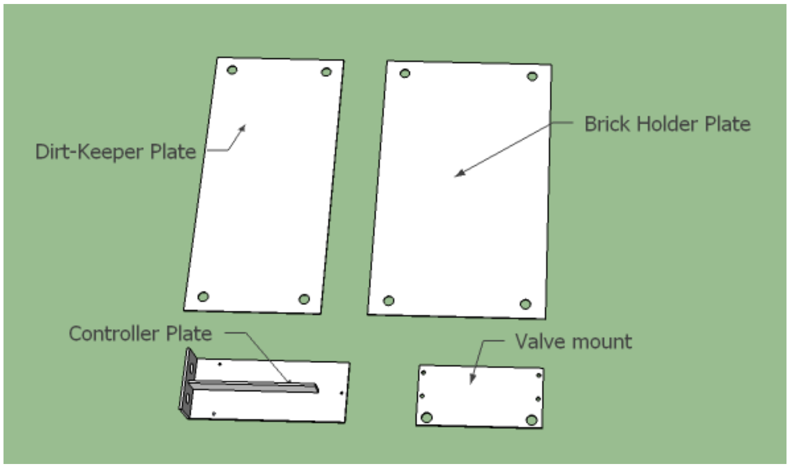
Full sheet:



Partial Sheet:



CEB Simple Plates



See the Sketchup Model.

Tools Needed:

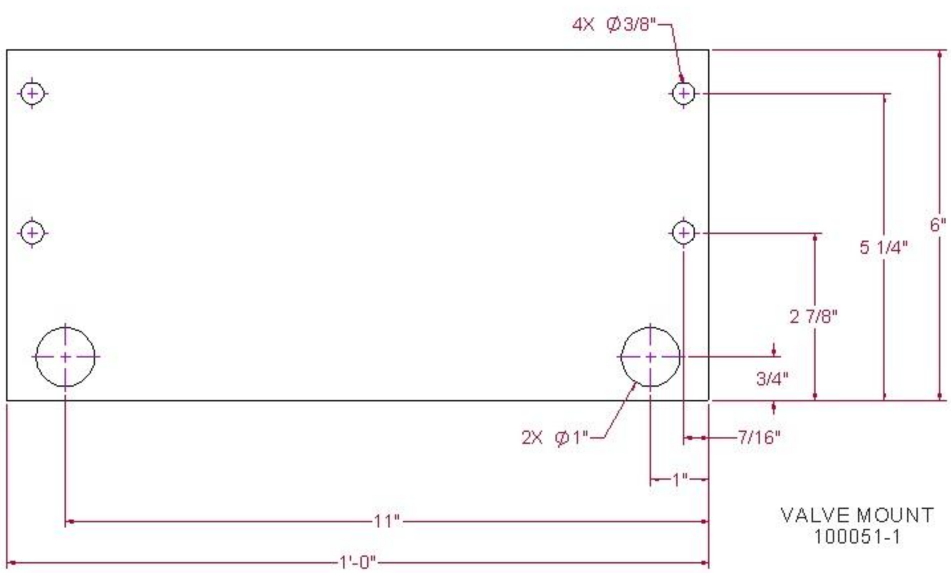
- Hole Puncher
- Drill Press
- Center Punch
- Hammer
- Welder

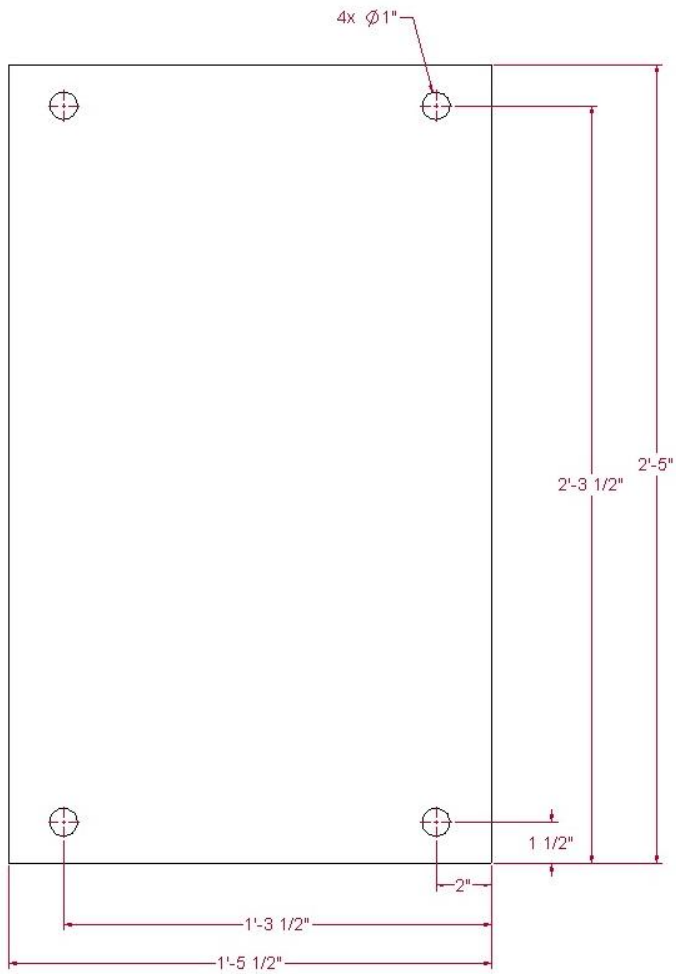
Materials Needed:

- 1/8" Sheet- 17.5"x29" Brickholder Plate
- 1/8" Sheet- 13.5"x29" Dirt-Keeper Plate
- ¼"x6" Flat- 12" Valve Mount
- ¼"x6" Flat- 15" Controller Mount
- ¼"x3" Flat- 6" Controller Mount
- ¼"x2" Flat- 12" Controller Mount

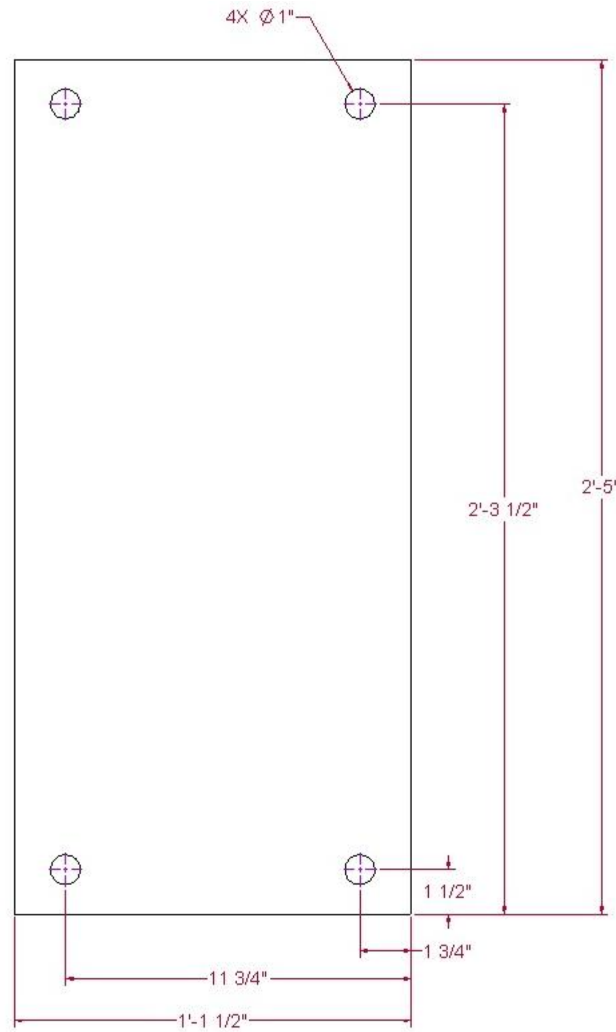
Brick holder Plate, Dirt Keeper Plate, Valve Mount

Punch or drill the holes as shown.





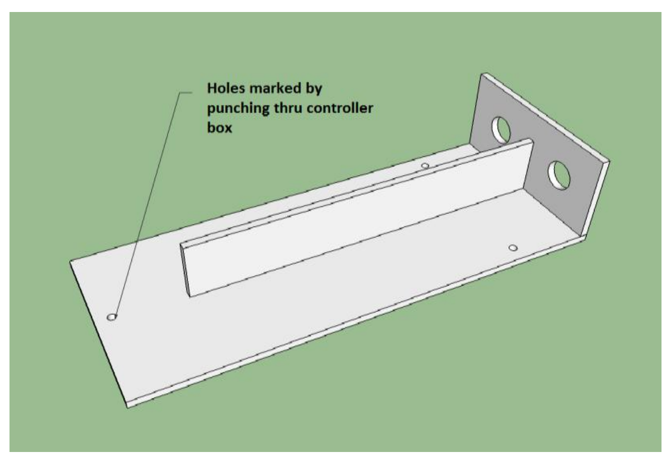
BRICK HOLDER PLATE
100079-1

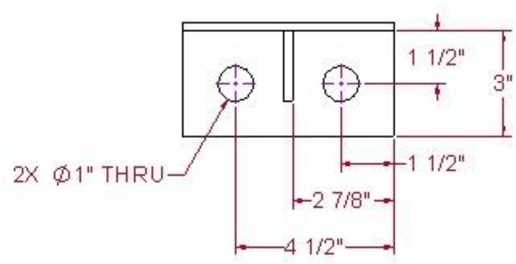


DIRT KEEPER PLATE
100080-1

Controller Plate

1. Find your controller box (also called outdoor main lug box) and locate its mounting holes on the back.
2. Place it on top of the 6x15 plate so it is square and the top hole is about ½" away from the top. Transfer punch the holes on the controller box to the plate.
3. Drill those as ¼" holes.
4. Punch the holes in the bottom piece.
5. Weld the bottom piece to the large plate. Make sure it is square.
6. Weld the 1/4"x2 to the back as well.





CEB Frame Structural Support Components

This section covers:

- Leg Holders-Model
- Feet- Model
- Legs- Model
- Secondary Arms- Model
- Primary Arms- Left Primary Arm Model,
    - Right Primary Arm Model

Tools Needed:

- Angle grinder
- Speed Square
- Welder
- Hole Puncher
- Torch

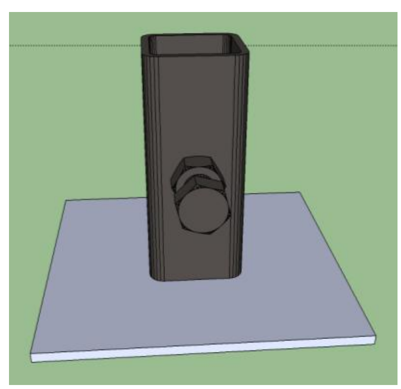
Leg Holders

- You will need 14 Leg Holders for the CEB. 12 will be used in this section. Save the remaining ones for later. Make all leg holders at once to save time.
- These require:
    - 3/16”x2.5”x2.5” square tubing- 6” (14)
    - ¾” Steel Nuts (14)
    - ¾”x1.5” Bolts (14)

1. Torch a 3/4” hole in the center of one of the faces of the tubing; make sure it's large enough for a 3/4” bolt.
    - It's not crucial that the hole be centered. It just needs to be somewhere close to the center.
2. Weld the nut over the hole, ensuring the nut is level, and the hole is clear.
3. Make sure no spatter goes into the threads by covering the top of the nut.
4. Thread the bolt onto the nut.

Feet

- You need to make 4 of these.
- These require:
    - Leg Holders (4)
    - ¼”x 8” Plate- 8” (4)

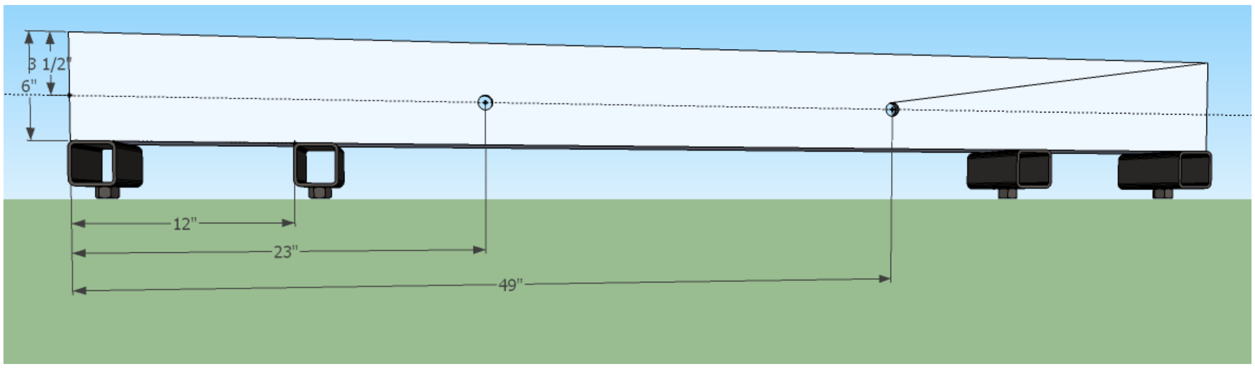


1. Center a leg holder on the ¼”x8”x8” plate, insuring it is square in all directions.
2. Weld it 100% to the plate.

Secondary Arms

- These require:
    - Leg Holders (4)
    - ½”x4”x6” Angle- 72” (2)

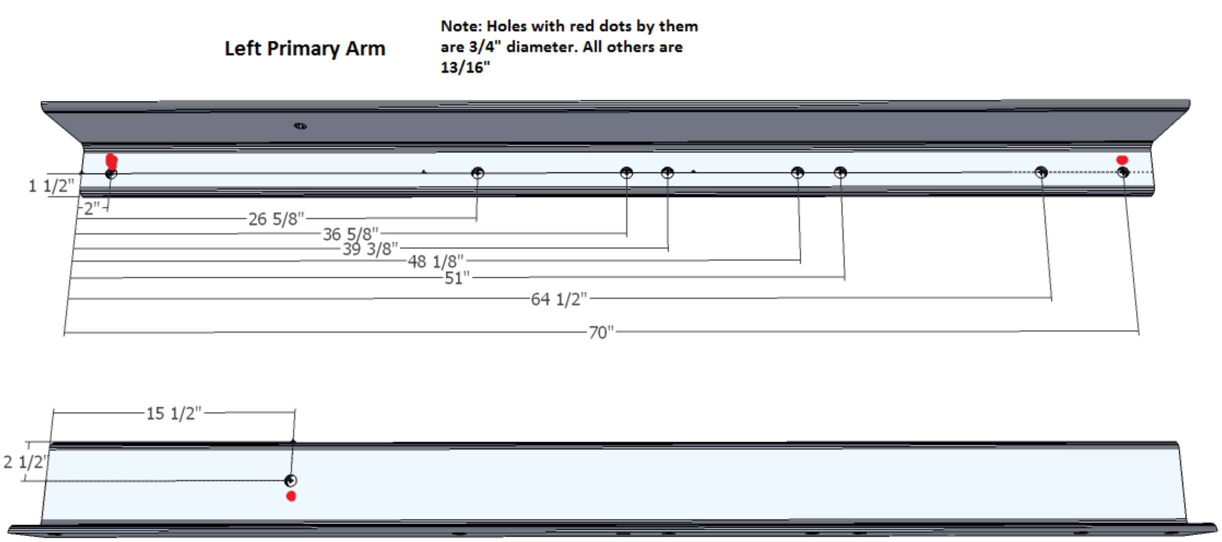
1. Punch the 3/4" holes
2. Place the leg holders in their proper locations.
    - Make sure they are square with the angle iron and centered vertically.
3. Weld them to the angle.



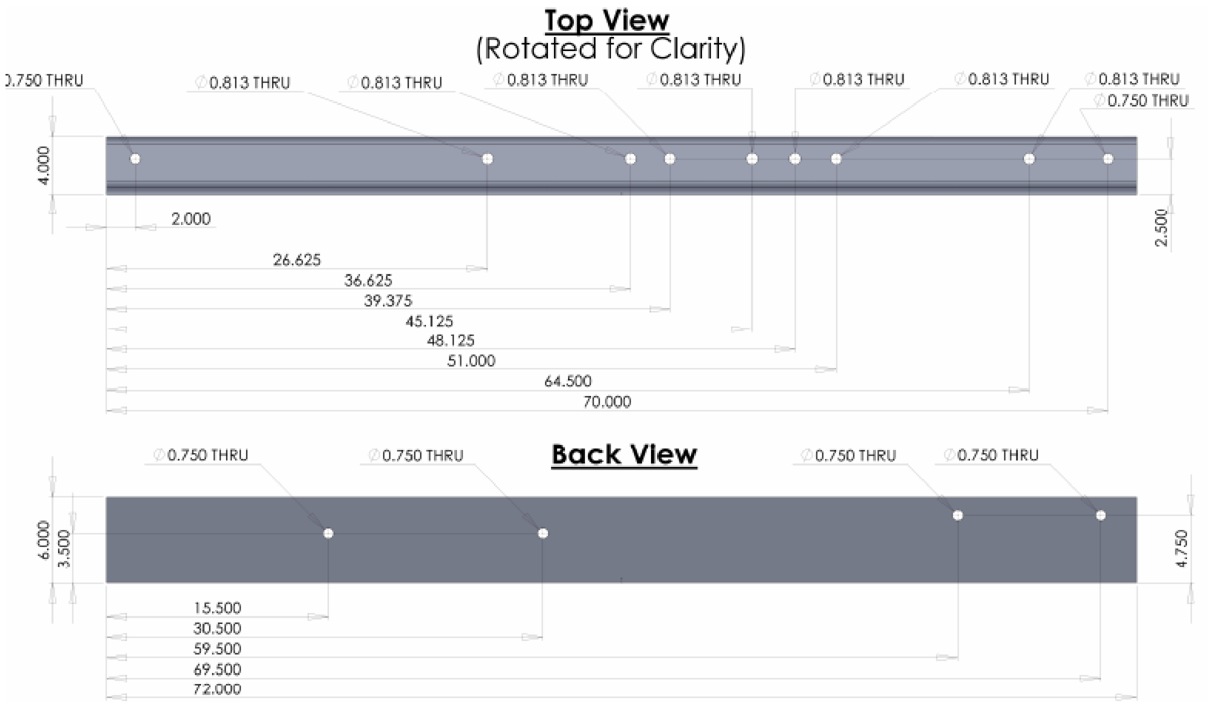
Primary Arms

- These require:
    - ½”x4”x6” Angle- 72” (2)

1. Punch all holes.
2. Label each arm with either "right" or "left."

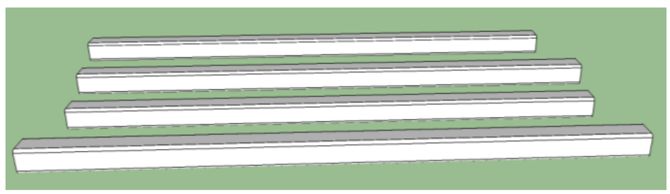


Right Primary Arm

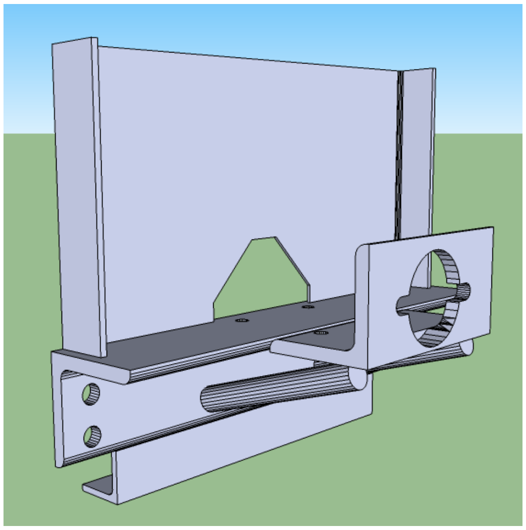


Legs

- These require:
  - ¼"x2"x2" Square tubing- 48" (4)
- There are no steps for these, just cut them.



CEB Shaker – Mount



Sketchup Model

Tools Needed:

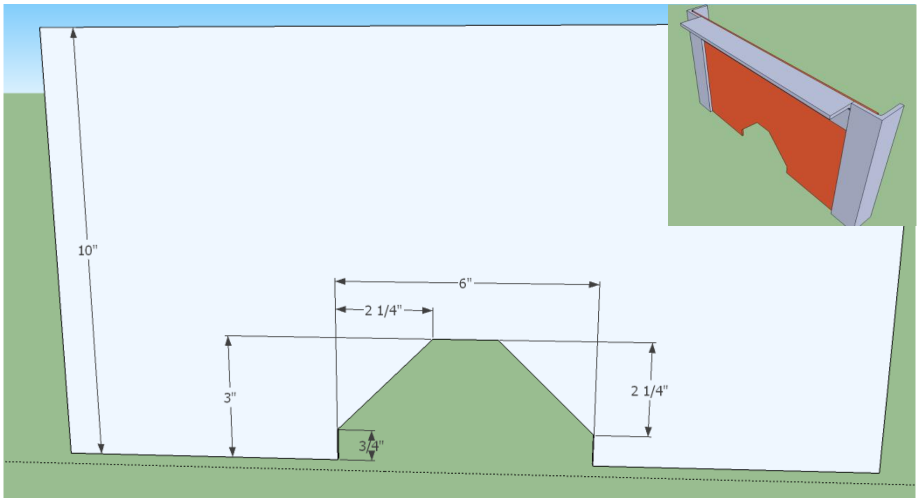
- Angle Grinder
- Welder
- Hole Puncher
- Torch

Materials Required:

- ¼”x2”x2” Angle- 10” (2) Sides of Guard
- ¼”x2”x2” Angle- 16” (2) Top and Bottom of Guard
- 1/8”x10”x16” Sheet- (1) Guard
- ½”x4”x4” Angle-(1) 8”
- ½”x4”x4” Angle- (1) 21”
- 1” Rebar- 7” (2) Braces

The Guard

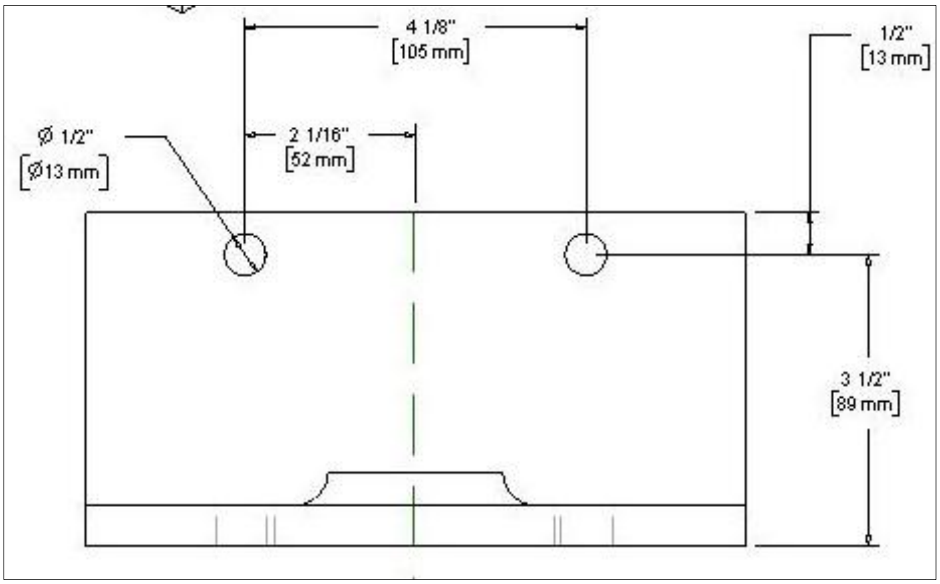
1. Torch the guard sheet metal as in the image.
    - Note: the shape shown is centered.
2. Weld the top and side 2x2 angle pieces to it as shown.

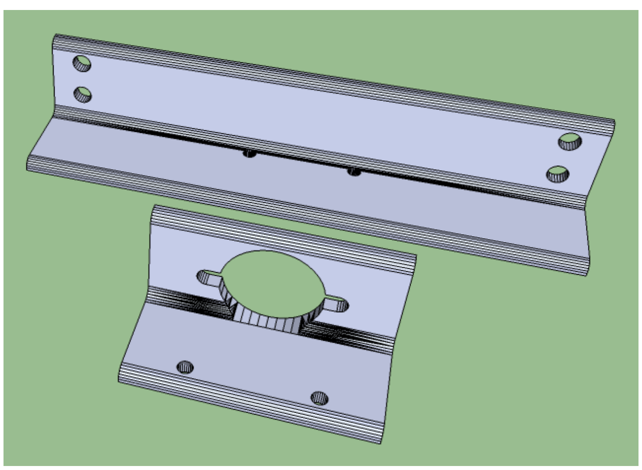


Mount Base

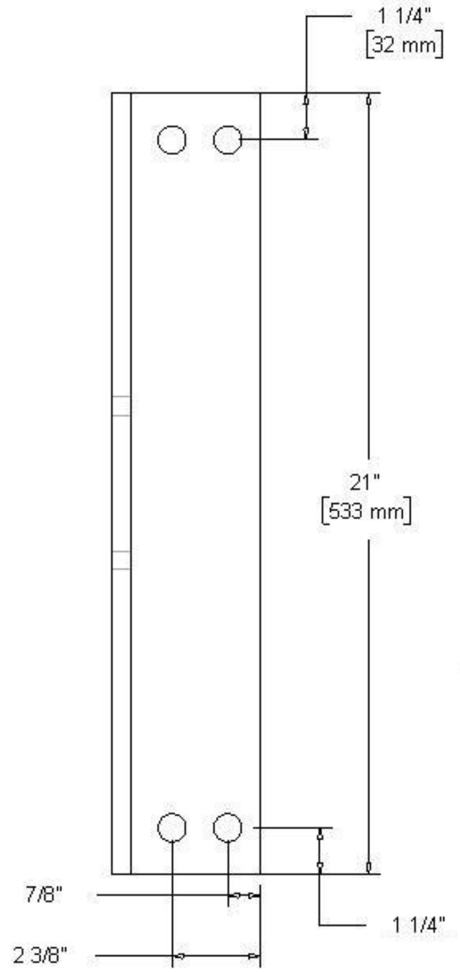
1. **Punch the holes in the 4x4 angle.**
    - Not all holes will be accessible with a punch. Torch the rest.

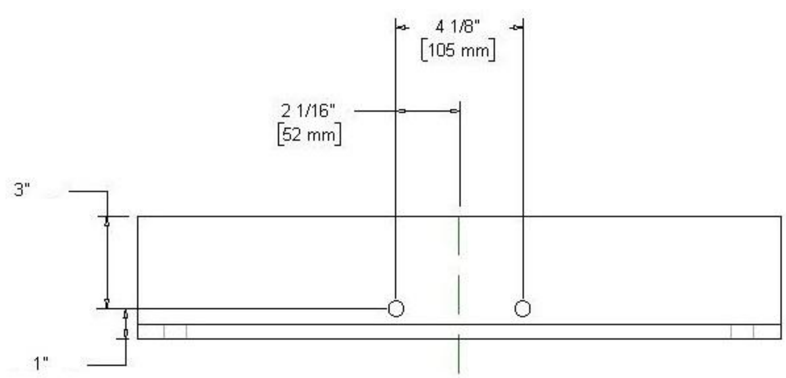
8” Angle

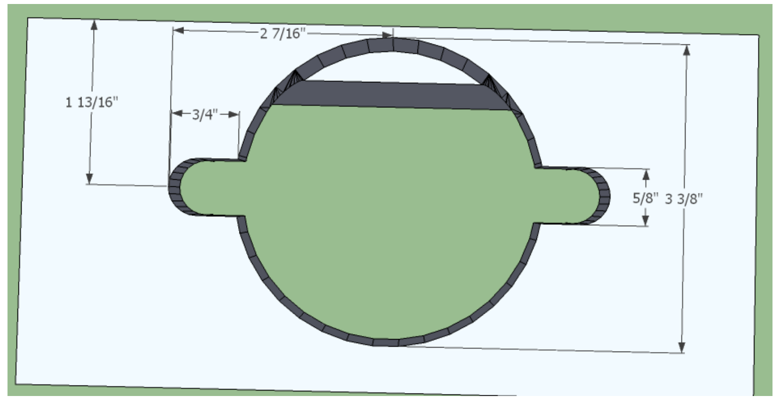




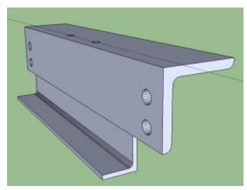
21” Angle

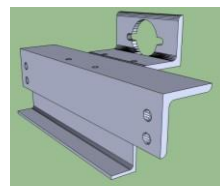


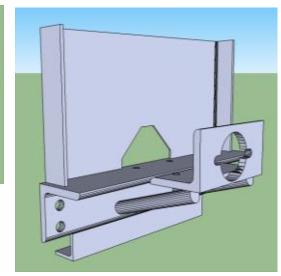




2. **Torch the hole for mounting the motor in the 8" piece of 4x4 angle. Grind off the slag.**
    - Double check that the hole is large enough by putting on the motor and making sure the raised portion in the center goes all the way thru.
    - You can torch separate holes for the bolts, or do one large, odd shaped one like is pictured.

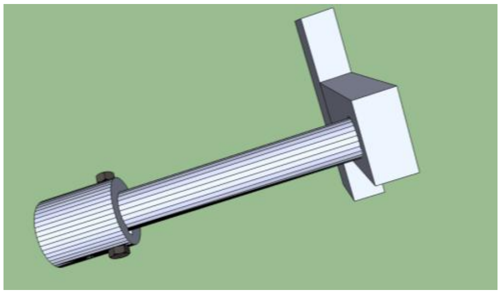






3. **Weld it together**
    - Weld the bottom 2x2 to the 21" 4x4.
    - Weld the two 4x4 angle pieces together as pictured, insuring they are perfectly flush and square.
        - Skip around while welding so it doesn't warp one way or another.
    - Grind off the top weld linking the 4x4's so the bearing will be able to sit flush on it
    - Also grind off near the bolt holes on the bottom.
    - Weld the guard and braces to the mount.

CEB Shaker - Hammer and Shaft



Sketchup Model

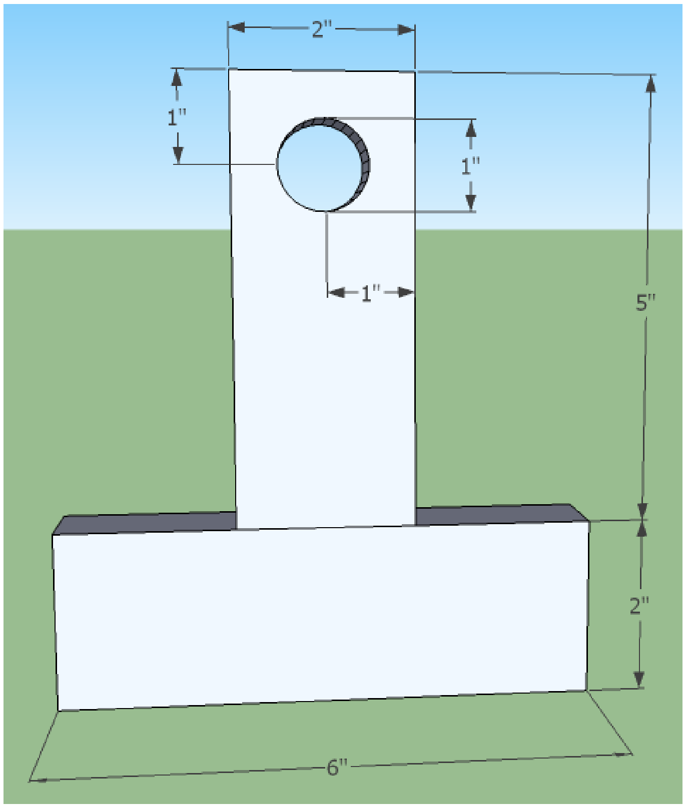
Tools Needed:

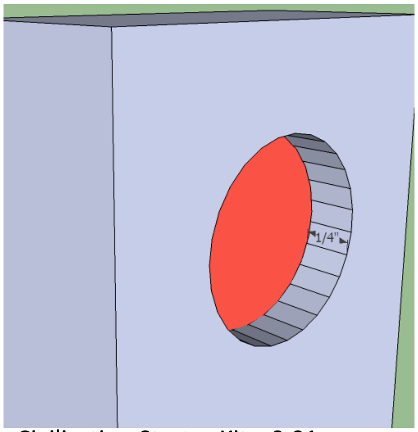
- Welder
- Something to mark steel with
- Drill Press
- Hole puncher

Materials Required:

- 1”x2” Flat- 6” (1) Hammer
- 1”x2” Flat-5” (1) Hammer
- 1” Round- 7.25” (1) Shaft
- 1” Keyed Coupler (1)
- ¼”x2” Bolt (1)
- Shaker Motor
- Shaker Mount

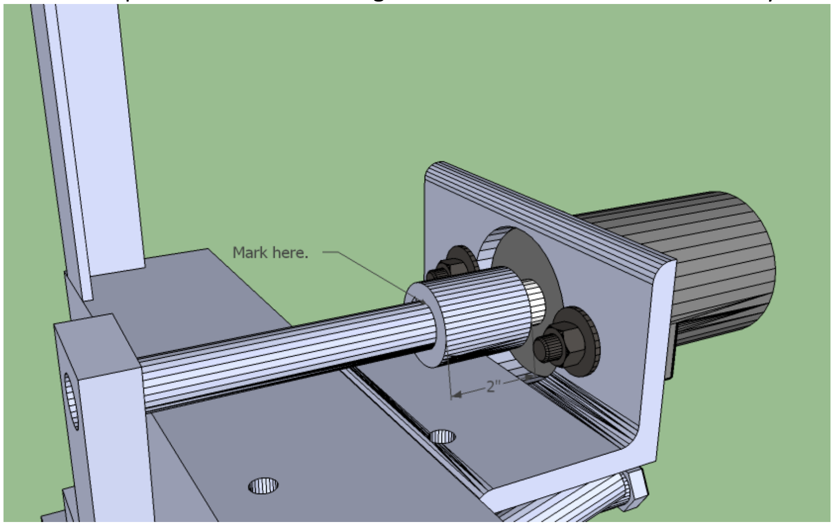
1. **Prepare the hammer**
    1. Drill or punch the hole in the flatbar.
    2. Weld the two pieces of flatbar together
        - This needs to be a really strong weld! The hammer will be under a lot of stress, and if it's not a solid weld, it could fly off! (This is why the guard is there).
    3. Tack the shaft into the hole so there's about a 1/4" distance between the end of the shaft and the opposite side of the hammer.



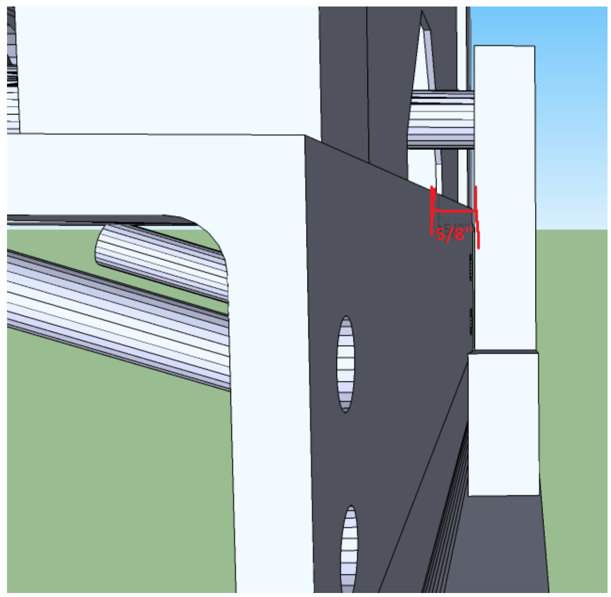


2. Couple the shaft

1. Cut the coupler down so it's 2" long. It doesn't matter from which side you cut it.

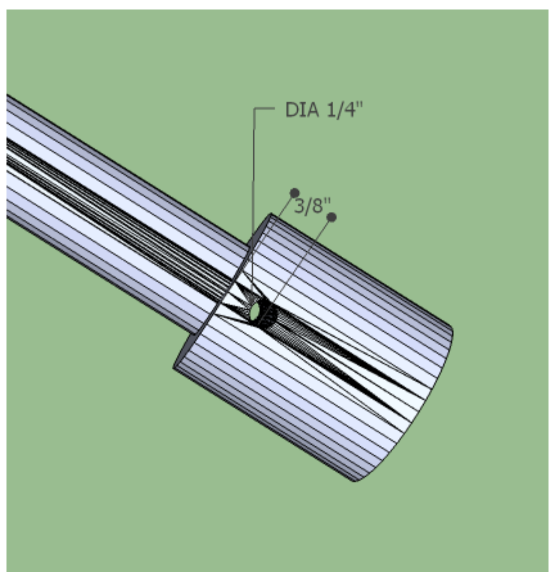


2. Get the shaker motor, the mount you made, the shaft/hammer, and the coupler.
3. Put the shaker motor onto the mount and couple the shaft to it. Mark where the shaft enters the coupler.
    - Make sure the coupler won't be rubbing on mount while it spins.
4. Make sure the hammer has about 5/8" clearance from the mount.
    - If not, you can pull it out of the coupler a little, but make sure the bolt won't be too close to the edge.
    - Otherwise, you can grind away the tacks on the hammer and tack it properly.



3. Drill Hole for bolt in coupler

1. Remove the motor and shaft from the mount
2. Put the coupler back onto the shaft.
3. Drill the 1/4" hole thru the coupler and rod, using the mark you made to make sure the rod is inside the coupler the proper amount.
    - The hole should be 3/8" away from the edge of the coupler.
    - Drill thru both at the same time. You will need some sort of vice to hold it down while you drill.
4. Double check that your bolt will fit thru. If not, either re-drill it.



CEB Shaker – Hydraulics Assembly

Tools Needed:

- Vise
- Various Wrenches

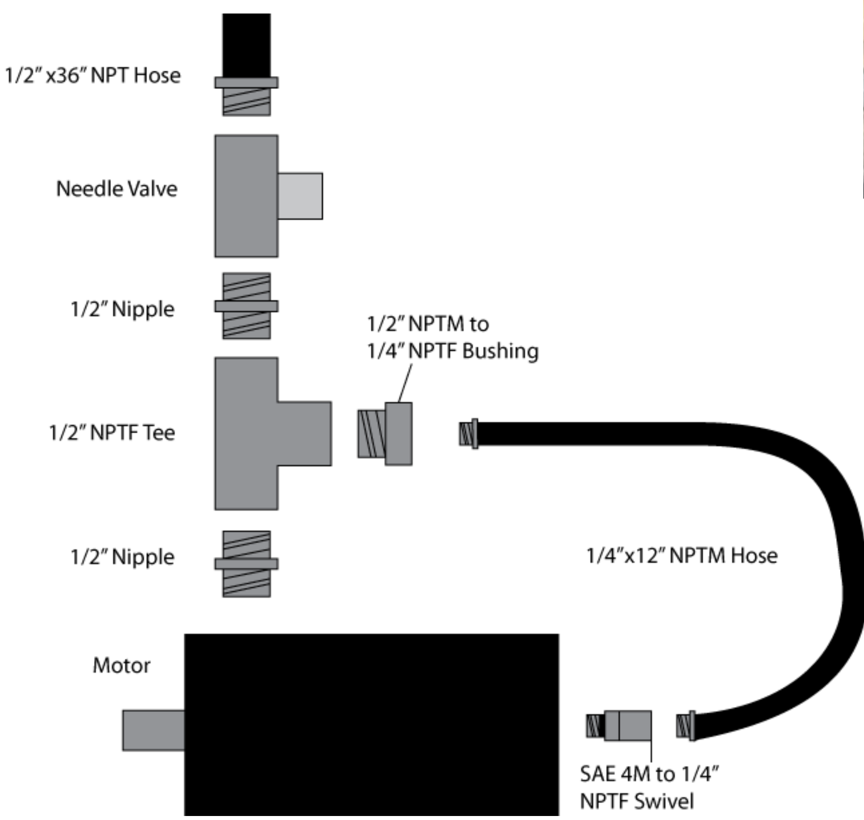
Materials Required:

- Thread tape
- Shaker motor Buy
- 1/2" NPT Needle Valve (1) Buy
- 1/4"x12" NPTM Hydraulic hose (1)Buy
- 1/2"x36" NPTM Hydraulic hoses (2)
- SAE 4M to 1/4" NPTF Swivel (1)Buy
- 1/2" NPT Hex Nipple (2) Buy
- 1/2" NPTF Tee (1) Buy
- 1/2" NPTM to 1/4" NPTF bushing Buy

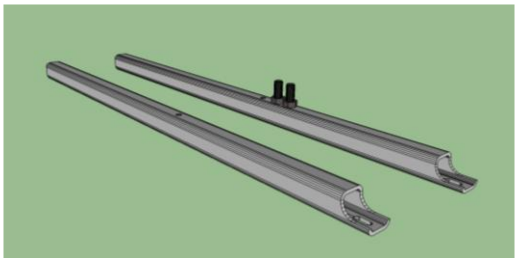
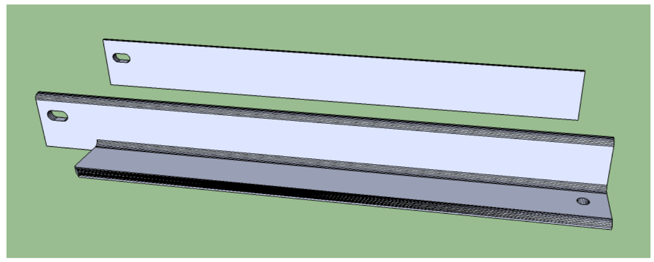
Things to know about working with hydraulics:

- Thread tape is necessary between each connection unless otherwise stated.
- Always wrap thread tape clockwise when facing the threaded portion.
- Always keep the end caps on hoses and fittings until you need to take them off. They need to stay protected inside.

1. Attach all of the fittings and the 2 hoses to the Tee, except the small swivel.
2. Tighten the tee assembly into the correct port (see the photo)
3. Install the swivel and tighten the small hose to it.
   - The swivel doesn't need thread tape.
4. Put the other 36" hose into the remaining port on the motor.



CEB Hopper and Grate Supports

- Hopper Support Model
- Grate Support Model

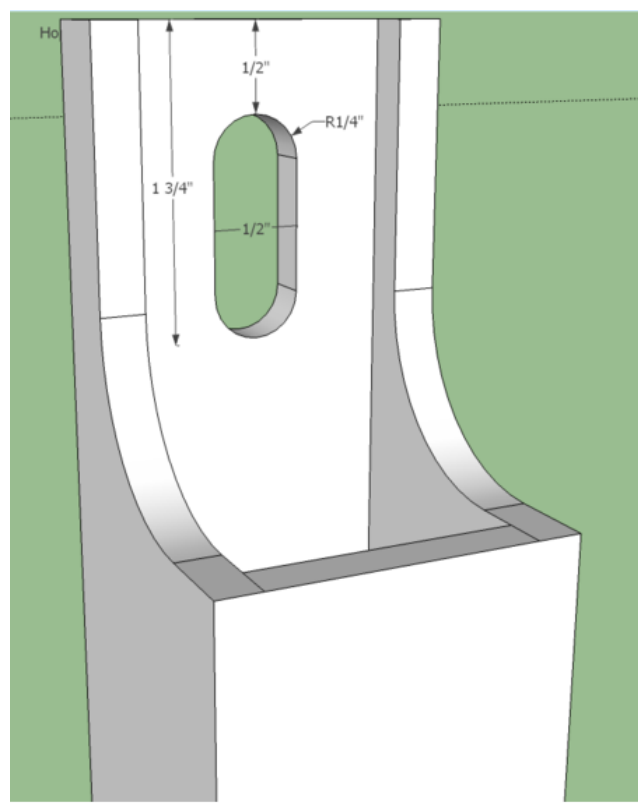
Tools Needed:
- Angle Grinder
- Welder
- Hole Puncher
- Torch

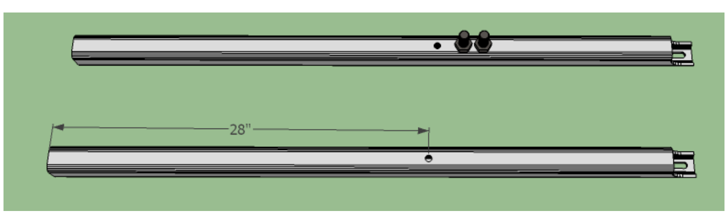
Materials Required:
- ¼"x2"x2" Tubing- 48" (2) Hopper supports
- ½"x4"x4" Angle- 38" (2) Grate Supports
- Shaker mount
- ¾"x1.5" Bolts (2)
- ¾" Nuts (2)

Hopper Supports

1. **Torch away the necessary areas**. See diagrams.

    - The holes for the hopper mounting need to be 28" away from the bottom side. Mark 28" on the opposite tubing walls and torch 1/2" holes. Insure a 1/2" bolt goes all the way thru.
    - Torch the cutaway at the top and the slot.

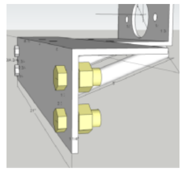




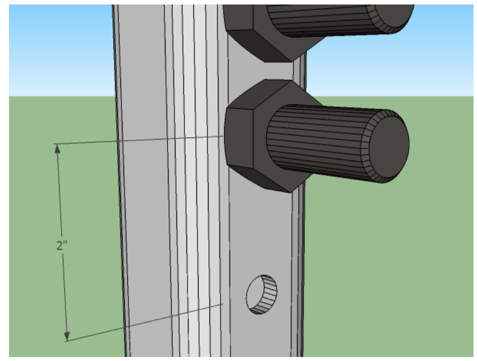
2. **Grind away any slag.**

3. Weld the shaker mount bolts to it

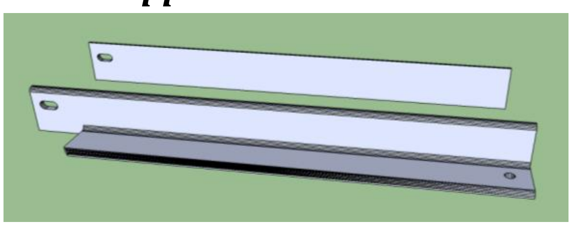
- Lay one support on the table, with the grate mount slot touching the table.
- Get the Shaker Mount and tighten 3/4" bolts with nuts to the Soil Shaker as shown.



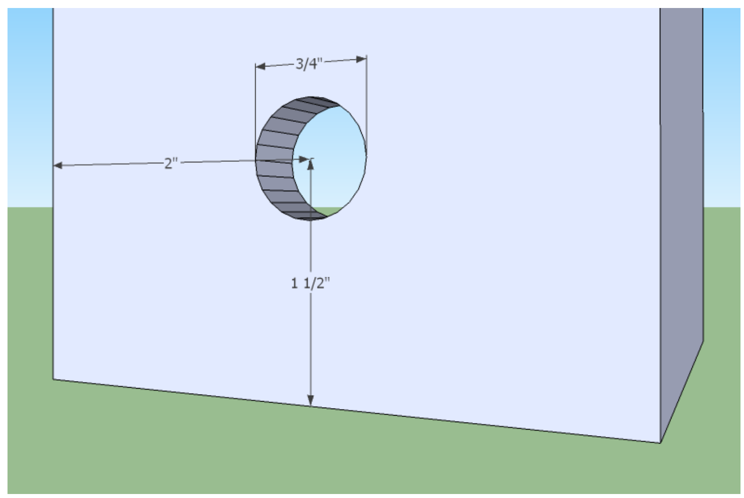
- Prop this up on the hopper support, so the first bolt is about 2" above the 28" hole and both bolts are touching the support.
- Mark on the mount which side of the shaker you are welding the bolts for.
- Tack the bolts in place, remove the nuts and dismount the shaker.
- Protect the threads, and finish welding the bolts to the support.
    - You are only doing this on one of the supports. The other side, you will do in place, so the spacing is correct.

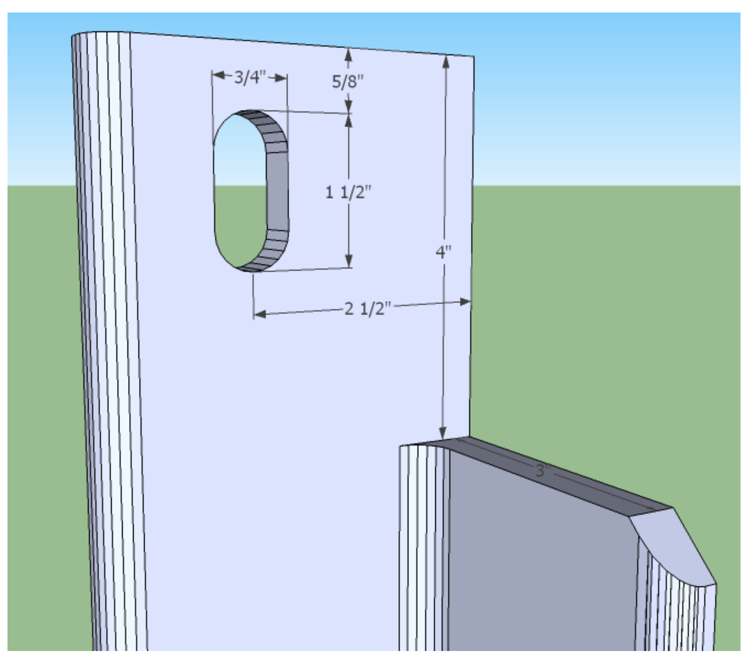


Grate Supports

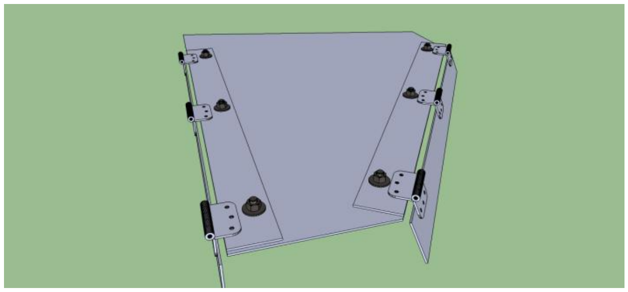


1. Torch away a 4" section on the top of each grate to make it like the model shown.
    - Remember that the two are mirrored.
2. Cut away the corner so the hopper won't hit it, about a 1" 45 degree triangle.
3. Torch a slot for a 3/4" bolt at the top of the mount, as shown.
4. Grind away all the slag.





CEB Hopper Sheet metal



Sketchup Model

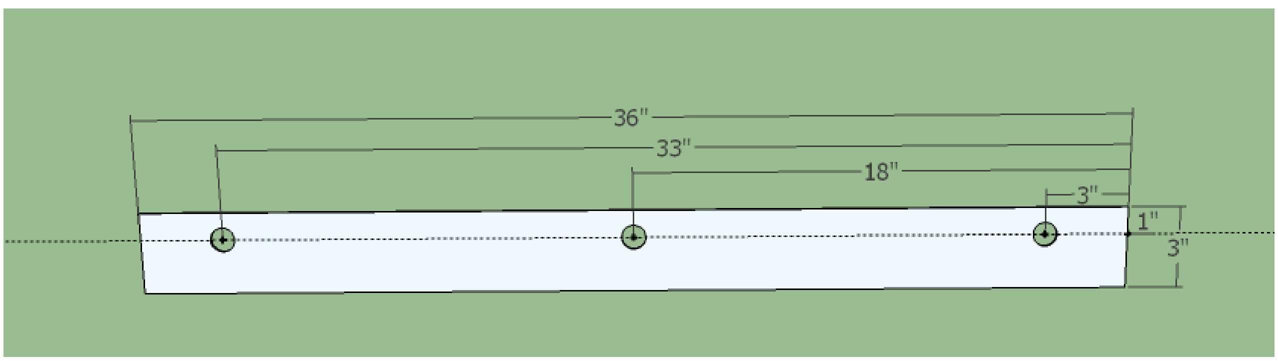
Tools Needed:

- Angle Grinder
- Welder
- Hole Puncher
- Torch
- Wrenches or Sockets

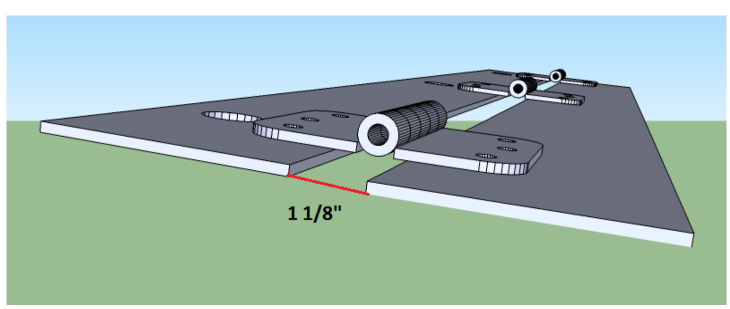
Materials Needed:

- Torched Hopper Sheet Metal (see cut list)
- 1/8”x3” Flat- 24” (12) Hinge plates
- Hinges (12)
- 1/2"x1" Bolts (12)
- 1/2" Nuts (12)
- 1/2" Washers (12)

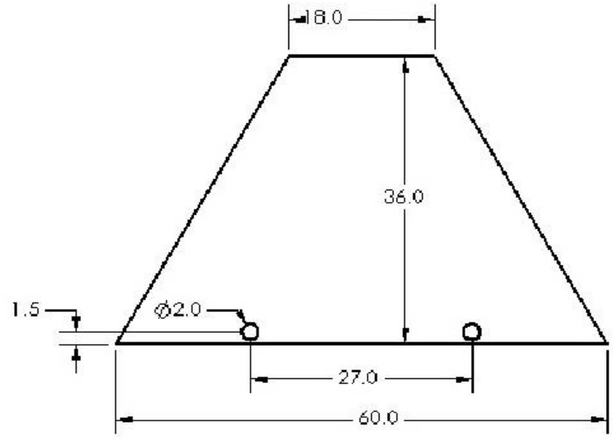
1. Prepare the Hinge plates

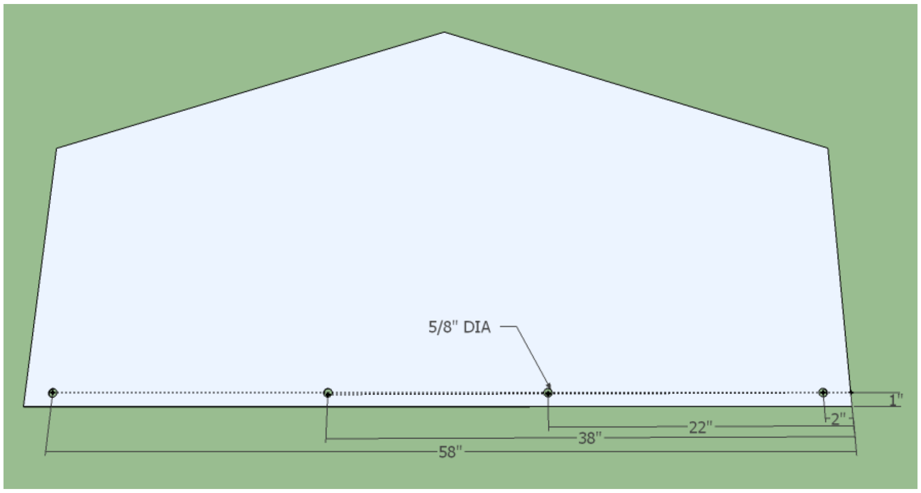


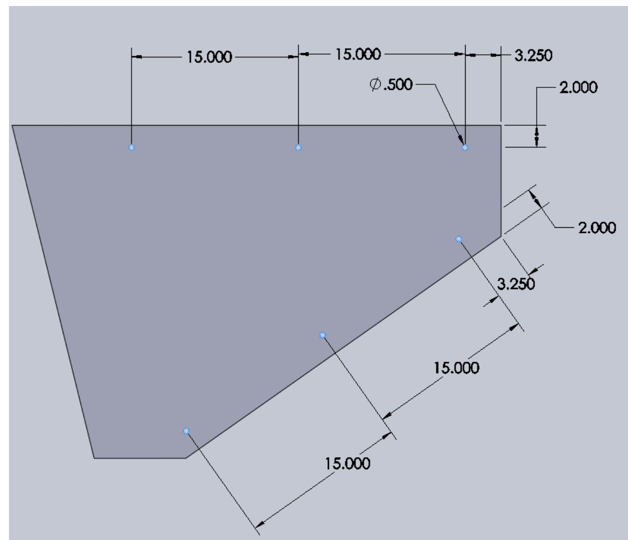
- Punch holes in 4 of the hinge plates as shown
- Weld one plate with holes, one without holes, and 3 hinges together as shown.
  - Make sure the side of the hinge that sticks out most is on the top; this way it won't interfere with the hopper metal below when installing the hopper. (See photo)
- Make 3 more of these. (4 Total)



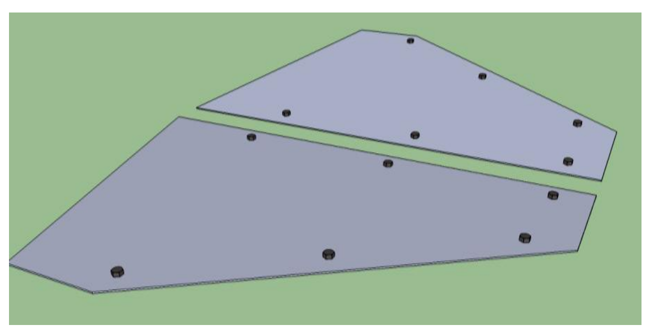
2. **Hopper Sheet Metal**
   - Torch the holes shown in the front piece.
   - Punch all of the holes shown in the side pieces and dirt deflector.



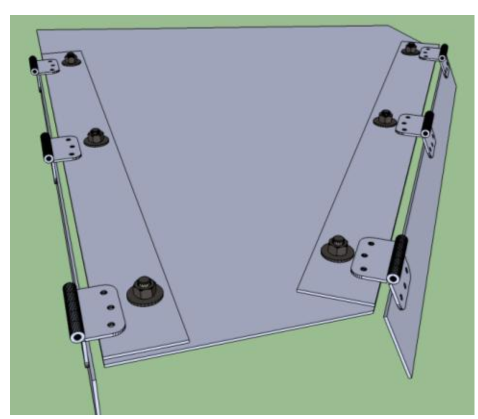




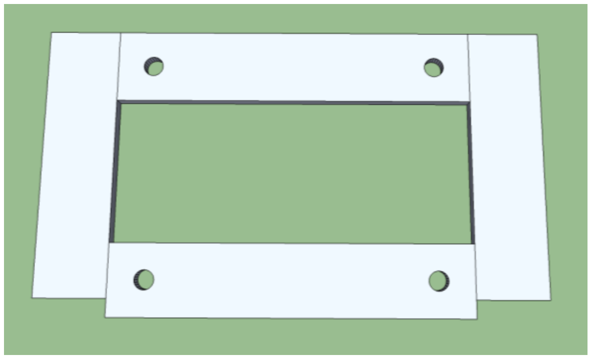
3. **Weld the bolts**
- Place 1/2" bolts thru the side pieces and weld them.
  - Make sure you are making them mirror images of each other.



4. **Assemble**
   - Bolt the hinge plate assemblies to the side pieces using a washer, lock washer, and nut on each bolt



CEB Hopper Mounting Plate



Sketchup model

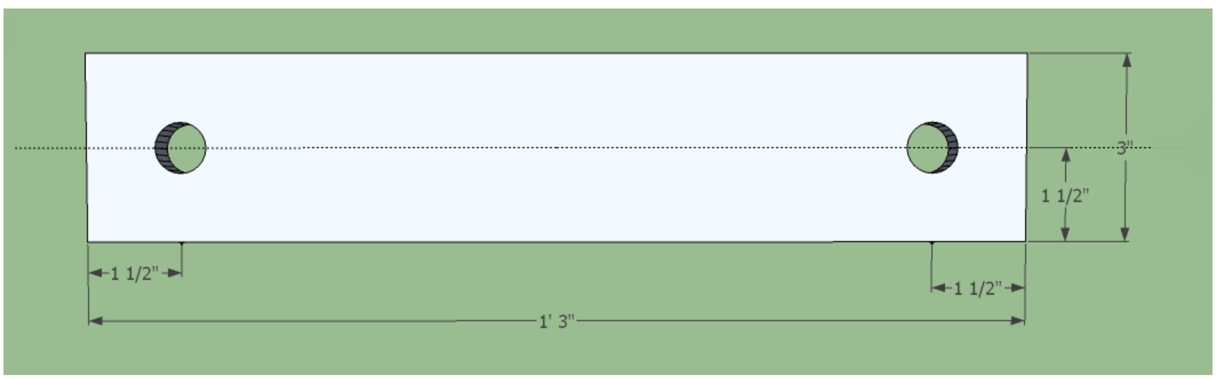
Tools Needed:

- Angle Grinder
- Welder
- Hole Puncher

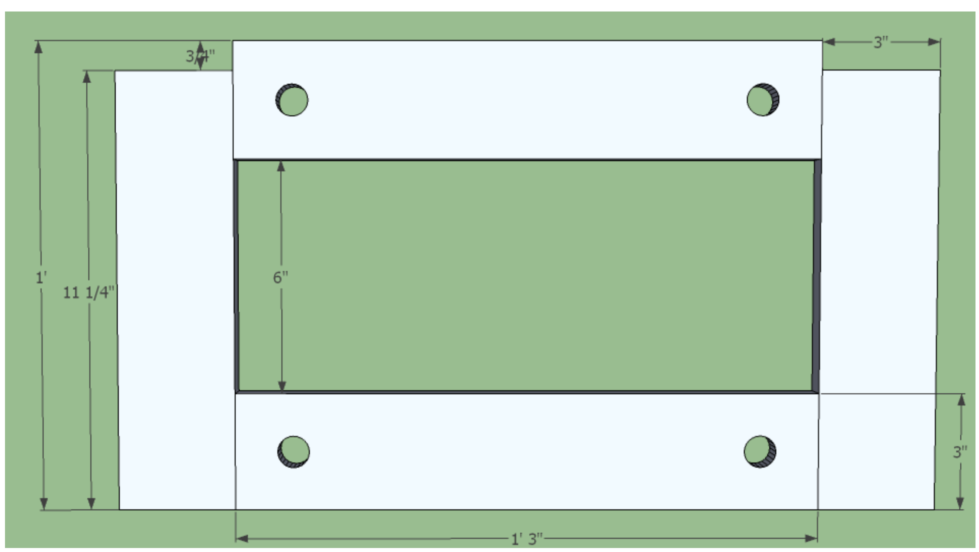
Materials Needed:

- ½"x3" Flat- 15" (2)
- ½"x3" Flat-11.25" (2)

1. Punch the holes in the 15" pieces. They are both the same.



2. Weld the pieces together, insuring everything is square.
   - There should be a 6" space between the 15" pieces.
   - Skip around so the plate doesn't warp.
   - Weld both sides on all seams
3. Grind away the welds on one side of the plate.



CEB Grate

Sketchup Model

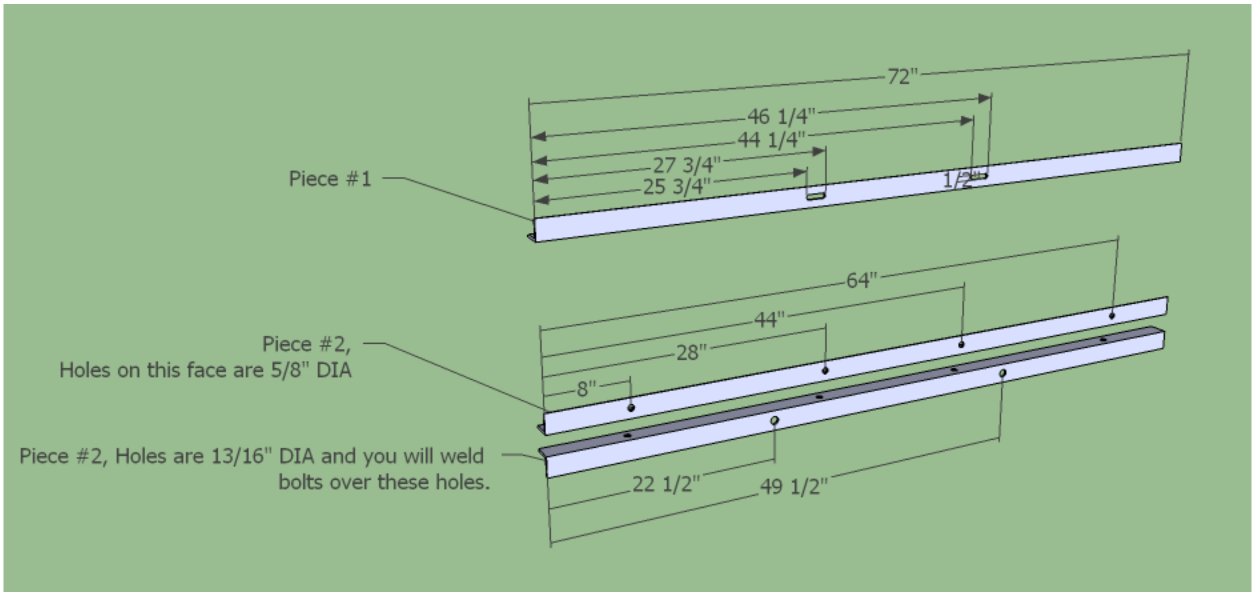
Tools Needed:

- Angle Grinder
- Welder
- Torch

Materials Needed:

- ½”x2”x2” Angle- 72” (2)
- ½”x2”x2” Angle- 35.5” (2)
- ½”x2 Flat- 71.5” (1) Cross Piece
- ½” Rebar- 34” (33)
- ¾” Steel Nuts (2)

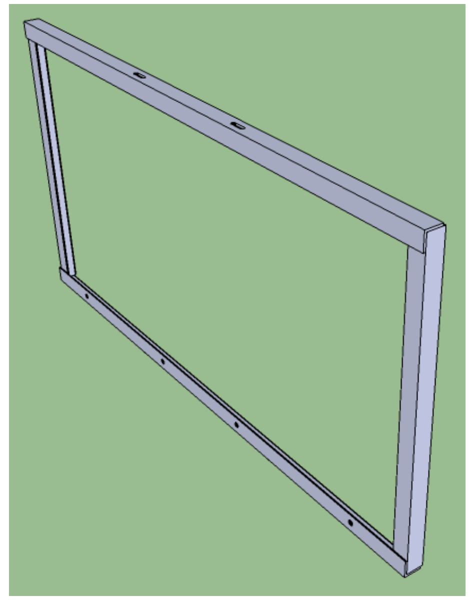
1. **Prepare the frame**
   1. Torch all holes and slots in the 72” 2x2’s as shown. Note that the slots are ½” tall.



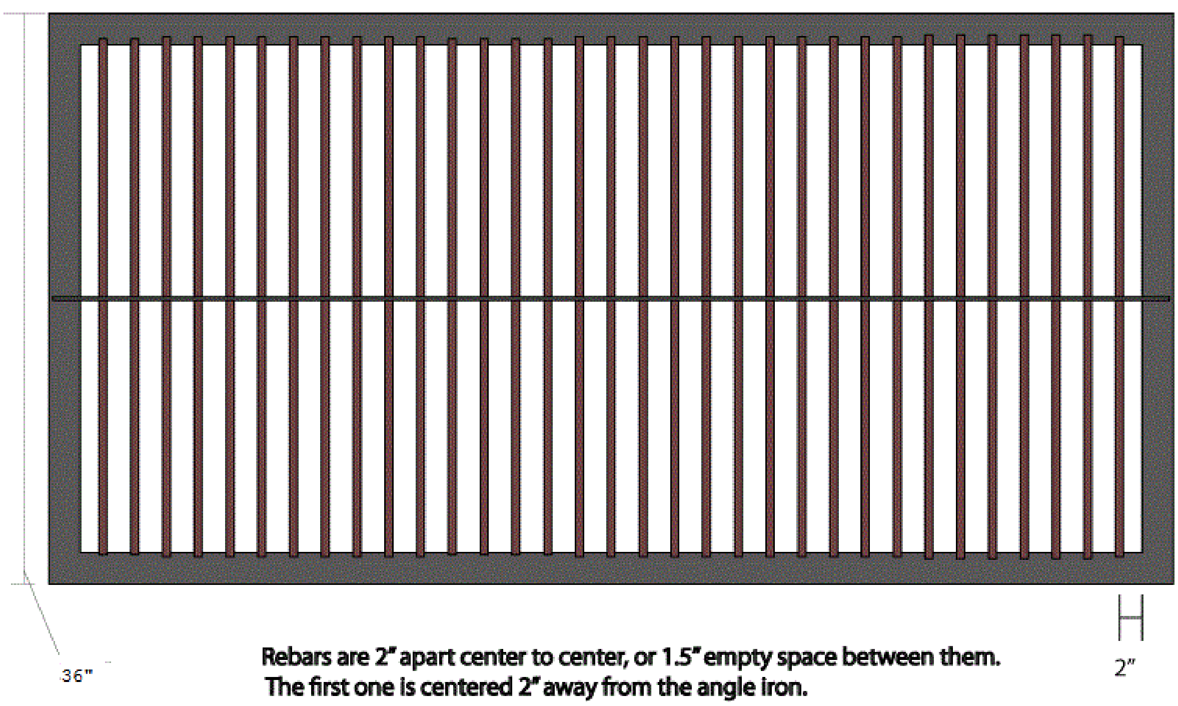
- Make sure you can fit the proper size bolt through each hole.

2. Grind away any slag
3. Weld the nuts to the proper 2x2.
   - Protect the threads while you weld.

2. **Weld the angle together to make the frame.** The short pieces are sandwiched between the long pieces. See the diagram.



3. **Weld all of the rebar inside of the frame.**
    - It would help to find some 1.5" spacers laying around the shop so you can place them between the rebars quickly and be sure they are square. Nuts and hydraulic fittings might be the right size.

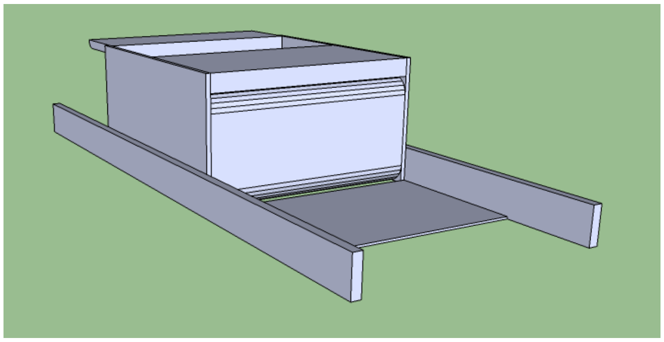


The rebar is welded into the frame first, and then the cross support.

-

4. **Weld the cross support** (the 1/4 x 2 flatbar) in centered and perpendicular to the plane of the frame

CEB Soil Loading Drawer



Sketchup model

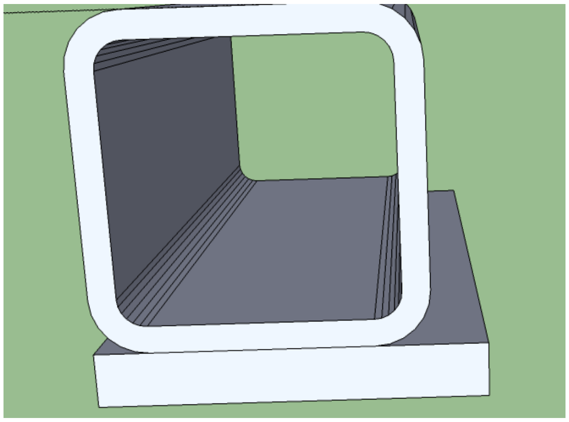
Tools Needed:

- Angle Grinder
- Welder
- Squares

Materials Needed:

StockSize	Size (Inches)	Length (Inches)	QTY.	Primary Part Name
Angle	.5x4x7	12	1	Back
Flat	.1875x2.5	36	2	Outer Rails
Flat	.25x7	13.5	2	Sides
Flat	.25x8	12.5	1	Roof
Flat	.5x2	36	2	Inner Rails
Flat	.5x3	3	1	Tongue
Flat	.5x6	12	1	Vertical Supports
Flat	1x7	12	1	Press Plate
Tubing	.5x6x6	12	1	Spacer

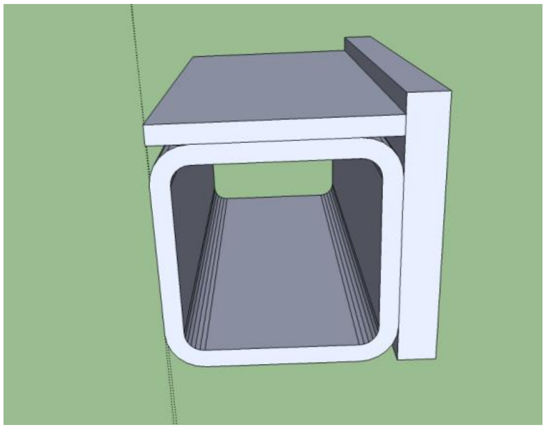
Step 1 — Weld Press Plate to Spacer



1. Lay the spacer tube on top of the press plate, align the sides and make the back edge flush.
    - Insure all edges are tight and squared; this piece is critical, it must be a uniform height throughout the entire item. Grind off any imperfections.
2. Tack weld the two together in many places (at least 3 on each seam).
    - Double check everything for squareness!!
3. Weld the two together on all edges where they touch
    - It is a good idea to weld in 1" or 2" increments, skipping around to different places to prevent warpage. You will need to weld multiple layers where the tubing is rounded.

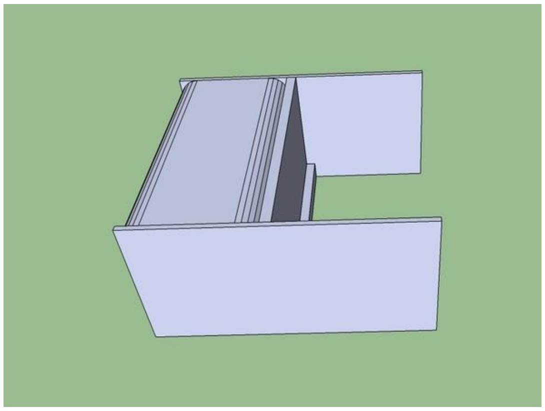
Step 2 — Weld the vertical support

1. Place the vertical support and tack it in multiple places
2. Weld the vertical support to the press plate and spacer tube assembly.
3. Grind down the welds on the open end of the tube so they are flush with the rest of the tube.



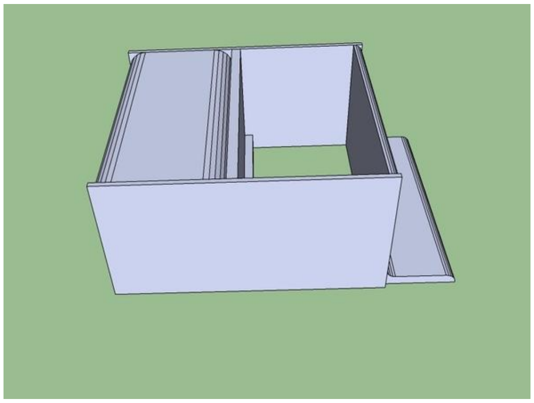
Step 3 — Tack Sides

1. Lay the spacer/press plate assembly down so the press plate is touching the table.
2. Align side pieces with spacer and press plate assembly.
3. Insure the two are square vertically and horizontally with the spacer, that they are parallel, and that everything is touching the table.
    - It helps to use angle iron tacked to your table and the sides, so it insures they are vertically square. This also makes it a bit easier to align everything else. Video Help
    - Also, it may help to use paper shims (see between the sides and the tube to properly space them. Video Help
4. Tack the sides to the tube on all sides in multiple places except where it is touching the table. Add a few 1" seams to prohibit them from moving.
    - Do a few light tacks first, and double check it's still square. If not, grind off the tacks and start over.

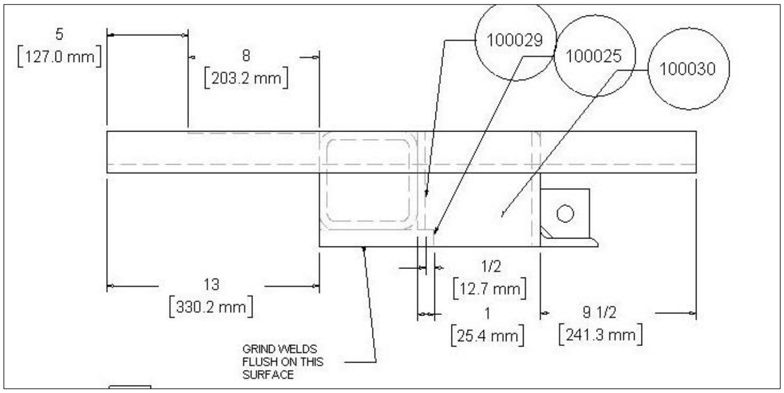


Step 4 — Tack the back

1. Tack the back piece in a few spots, with a 1" seam on each side.

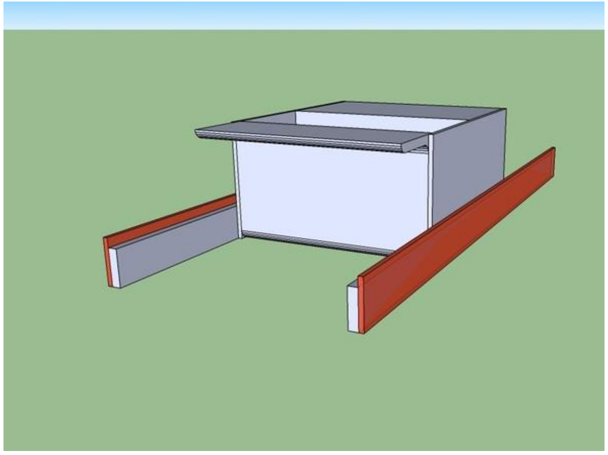


Step 5 — Tack Roof, Inner Rails



1. Grind off the welds for the back and side pieces so that the entire drawer is flush.
2. Flip the drawer over and tack the sides from the top.
3. Place the roof and inner rails in their respective places. See Diagram.
4. Insure inner rails are perfectly parallel (varying no more than a 16th of an inch) and square throughout the entire length.
5. Tack them in multiple places except where they are touching the table.

Step 6 — Tack Outer Rails



- Insure they are perfectly parallel; otherwise they will leave the roller guides. Insure they vary no more than 1/16" over the entire length.
- Hint: Use paper shims for this.

Step 7 — Weld Entire Drawer

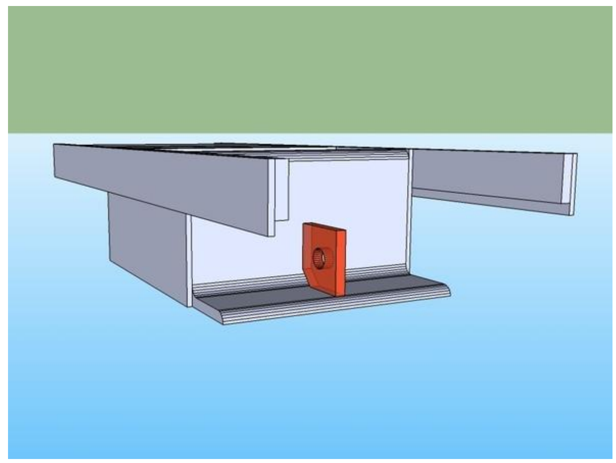
- All the seams should be completely welded except the difficult to reach places between the inner and outer rails, those can be welded about 50%.
- Weld short lengths at a time and jump around a lot to minimize warping.
- You may want to grind off the welds in between passes around the drawer to allow it to cool.

Step 8 — Grind the entire drawer flush

- There cannot be any outstanding bumps or welds anywhere; the drawer will be sliding in and out of a tight spot and bumps will catch on the frame crossmembers.
- Make sure there's no welding spatter where the rollers will be rolling. Grind any off with a small grinder.

Step 9 — Check the Rails

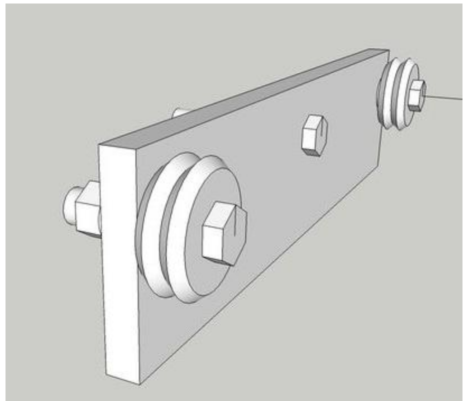
- The rails likely got warped outwards on the side with the back while you were welding.
- If they are not still parallel, you will need to pinch them inwards so that they are. You can do so using two C-Clamps as shown.



Step 10 — Weld Tongue In place

- Prepare as shown in the diagram
- Weld it to the back of the drawer, insuring it is square and centered.

CEB Roller Guides



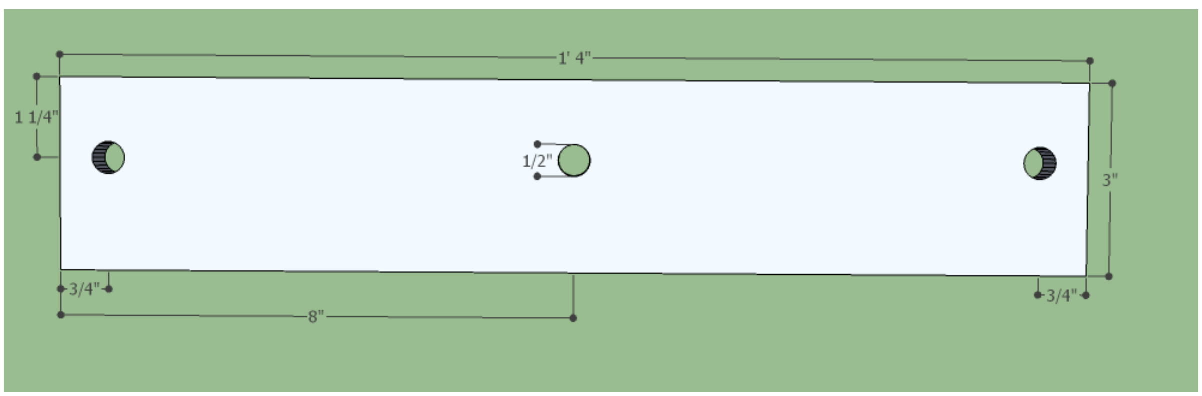
Sketchup Model

Tools Needed:

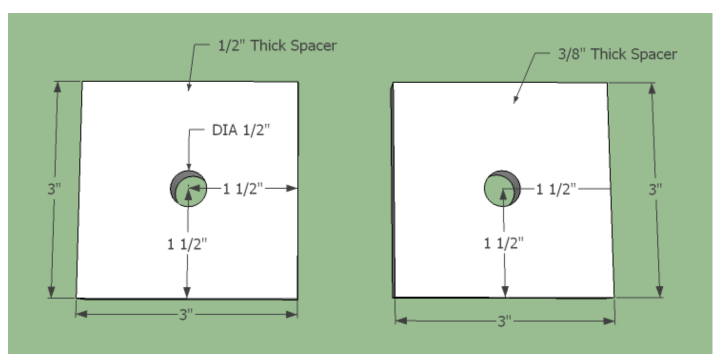
- Angle Grinder
- Welder
- Hole Puncher
- Wrench

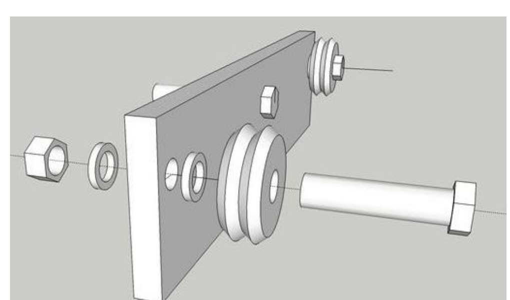
Materials Needed:

- ½”x3” Flat- 16” (2)
- V-Groove Bearings (4)
- 1/2"x 2.5" Bolts (2)
- M12x55mm Bolts (4)
- M12 Nuts (4)
- Washer, Lock 12mm (8)

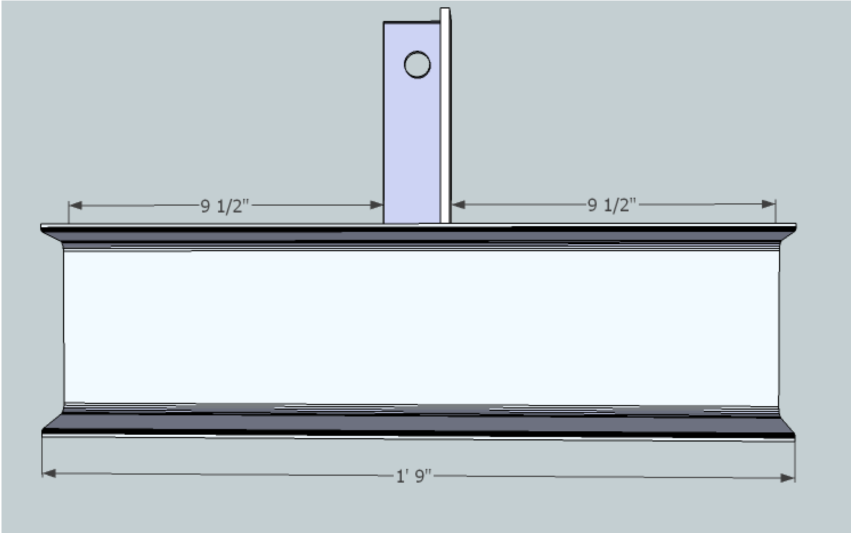


1. Punch the holes in the main plates and the spacer plates.
2. Weld the 1/2" bolts in the center hole, from the bolt head side.
3. Grind off the top of the 12mm bolts so that the head is 1/4” thick or less.
    - This is so that the bolts will not be touching the drawer as it slides in and out.
4. Assemble the bearings to the plate as shown, with lock washers on each side of the main plate.





CEB Wide Cylinder Supports



Sketchup Model

Tools Needed:

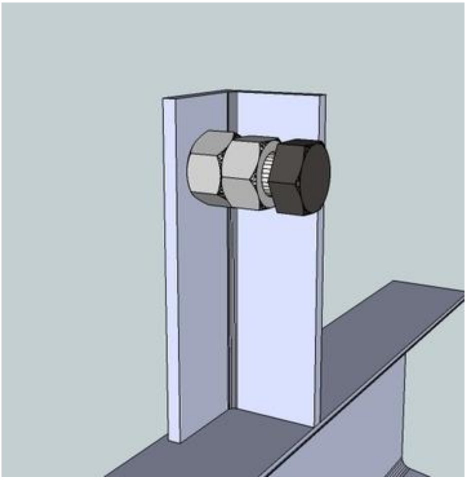
- Angle Grinder
- Welder
- Square

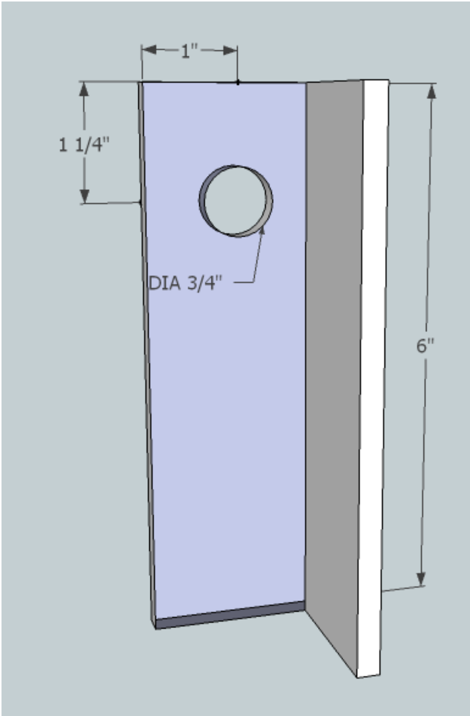
Materials Needed:

- 6” Heavy U-channel - 21” (2)
- ¼”x2”x2”Angle - 6” (2)
- ¾” Steel Nuts (2)
- ¾” Galvanized nuts (2)
- ¾”x2” Bolts (2)

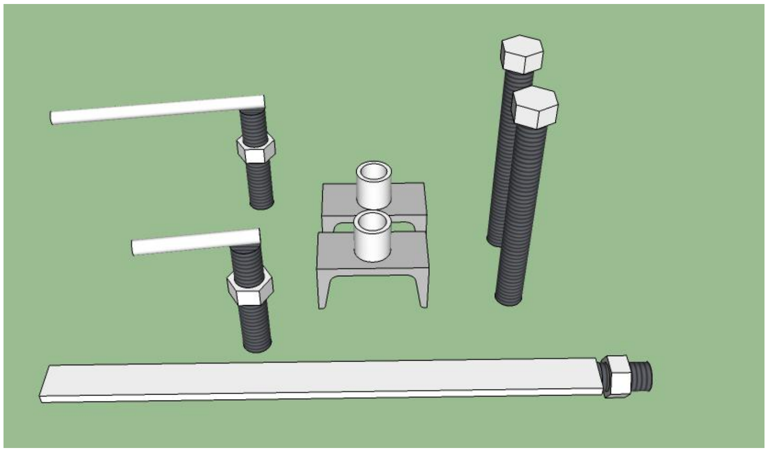
You need to make two of these. They can be exactly the same.

1. Torch the hole in the 2x2 angle as shown.
2. Weld the angle centered on the U-channel. (see image above)
3. Weld a 3/4" bolt over the hole.
    - Protect the threads
4. Put a galvanized nut on a 3/4"x2" bolt and thread through the welded nut on each side.





CEB Main Frame
Small Components



[Sketchup Model](#)

Tools Needed:

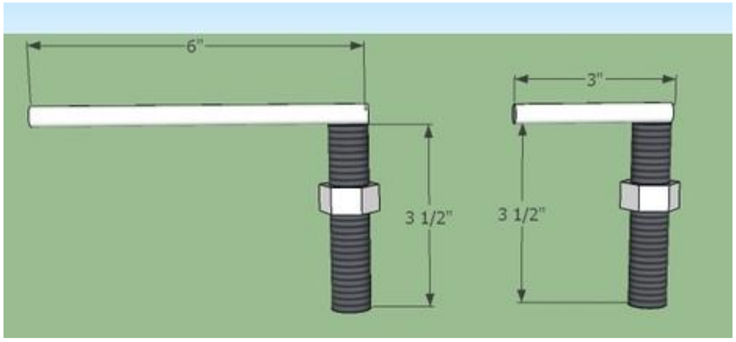
- Welder

Materials Needed:

- ¾" Steel Nuts (2)
- ¾" Galvanized Nuts (3)

StockSize	Size (Inches)	Length (Inches)	QTY.	Primary Part Name
C-Channel	3	1.5	2	Thin Cylinder support
Flat	.25x1	14	1	Magnet Holder
Pipe	.75ID 1OD	1	2	Thin Cylinder support
Rebar	0.375	3	1	Sensor Holder
Rebar	0.375	6	1	Sensor Holder
Threaded Rod	0.75	1.25	1	Magnet Holder
Threaded Rod	0.75	3.5	1	Sensor Holder
Threaded Rod	0.75	3.5	1	Sensor Holder
Threaded Rod	0.75	6.25	2	Thin Cylinder support

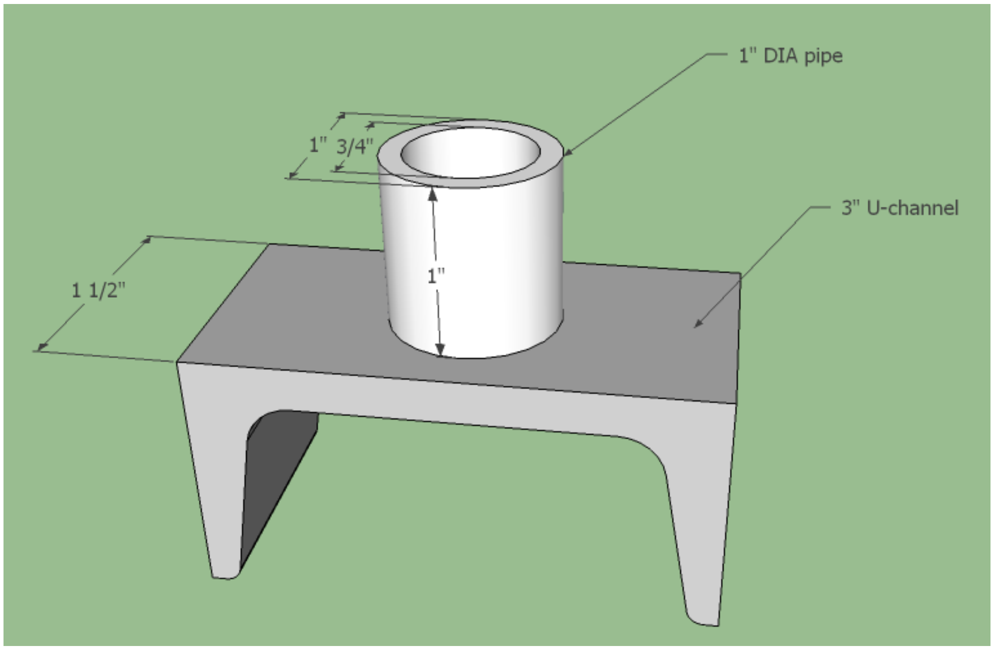
Sensor Holders

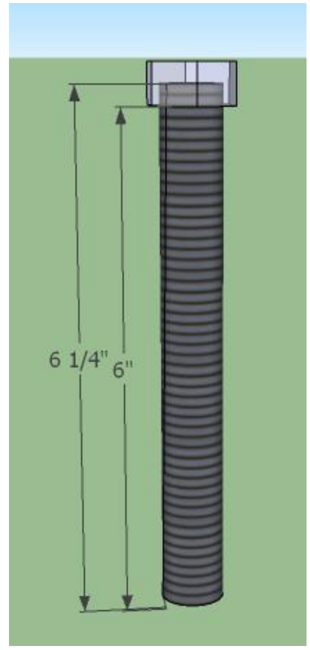


- One is for the main frame, and one goes in the primary arms.
  1. Weld the rebar to the threaded rod at a right angle.
     - Protect the threads on the threaded rod by welding. (A small pipe works well)
  2. Thread a nut onto it.

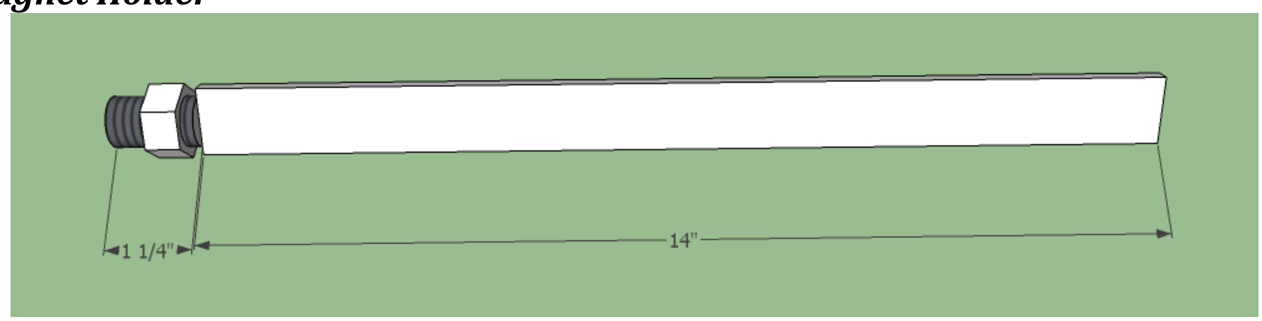
Thin Cylinder Supports

- Weld the 1" pipe to the 3" U-channel, in the center. 4-8 good tacks is sufficient.
- Make (2) 6" long 3/4" bolts, by using a nut and 6.25" of threaded rod. See Making Bolts.



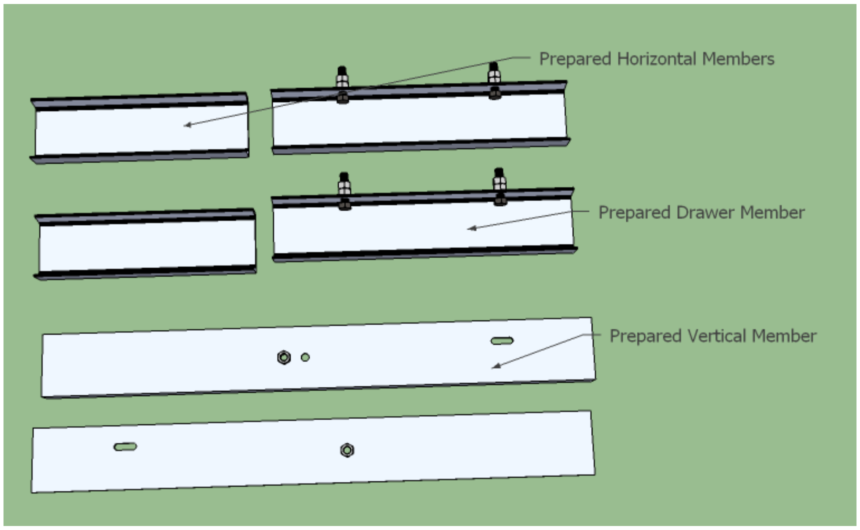


Magnet Holder



1. Weld the flatbar to the 1.25" piece of threaded rod.
    - Protect the threads.
    - Make sure they are perfectly paralell!
2. Thread a nut onto the threaded rod.

CEB Main Frame U-Channel Prep



[Sketchup Model]

Tools Needed:

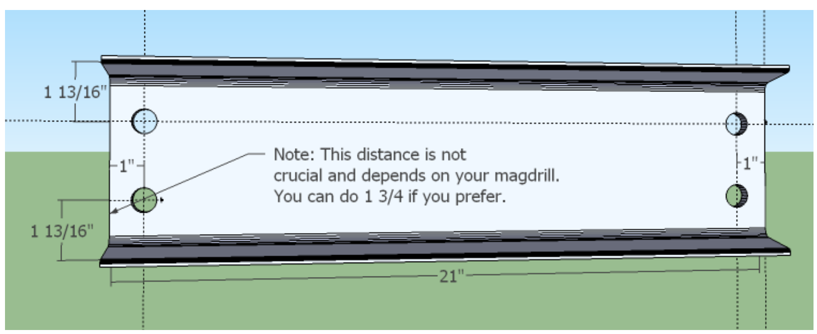
- Angle Grinder
- Welder
- Hole Puncher
- Torch

Materials Needed:

- 6" Heavy U-Channel- 21" (2) Horizontal Members
- 6" Heavy U-Channel- 53" (2) Vertical Members
- 6" Heavy U-Channel- 29" (2) Drawer Members
- ¾" Steel Nuts (10)
- ¾" Galvanized Nuts (4)
- ¾" Threaded Rod- 3.75" (4) Drawer Adjustor bolts

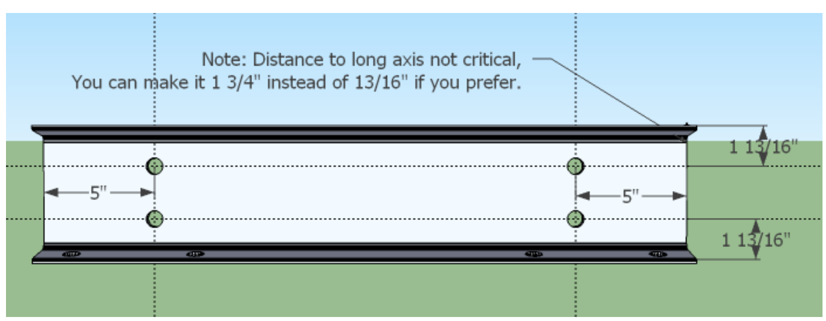
Prepare the Horizontal Members

- Mark the holes in the horizontal members as shown in the diagram. Center punch them.
- DON'T PUNCH THEM! They will be mag-drilled in a later guide.

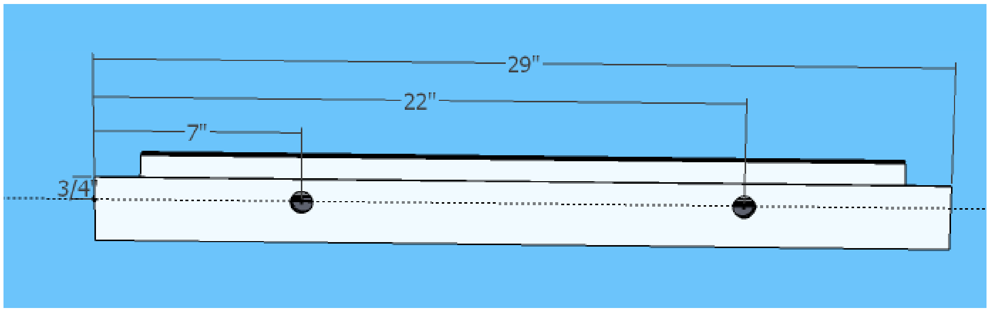


Prepare the Drawer Members

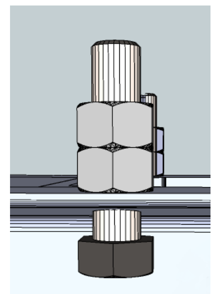
1. Mark and center punch the 4 holes on the face of the U-channel.
   - DON'T PUNCH THEM! They will be mag-drilled later.



2. Torch holes for 3/4" drawer adjustment bolts as shown in the diagram.

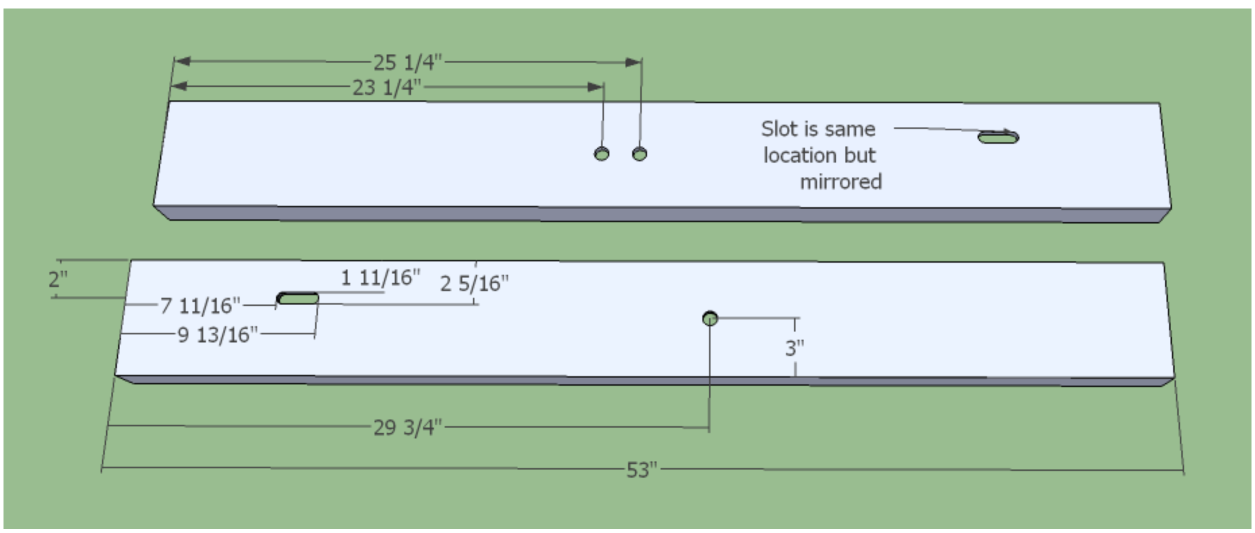


3. Grind away the slag.
4. Weld 3/4" nuts to the outside of the U channel where the holes are torched.
    - Weld it with a bolt coming thru the other side so it protects the threads and so you know the nut won't get off center.
5. Grind away any spatter between the bolts.
6. Make (4) 3/4" x 3.5" bolts using 3.75" threaded rod and steel nuts. See Making Bolts.
7. Thread the bolts through the nuts and thread another nut on top as shown.

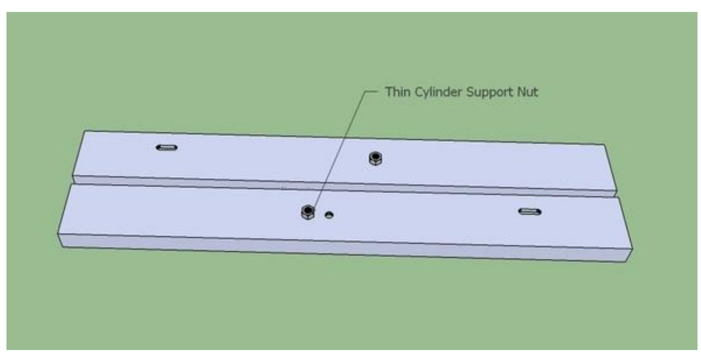


Prepare the Vertical Members

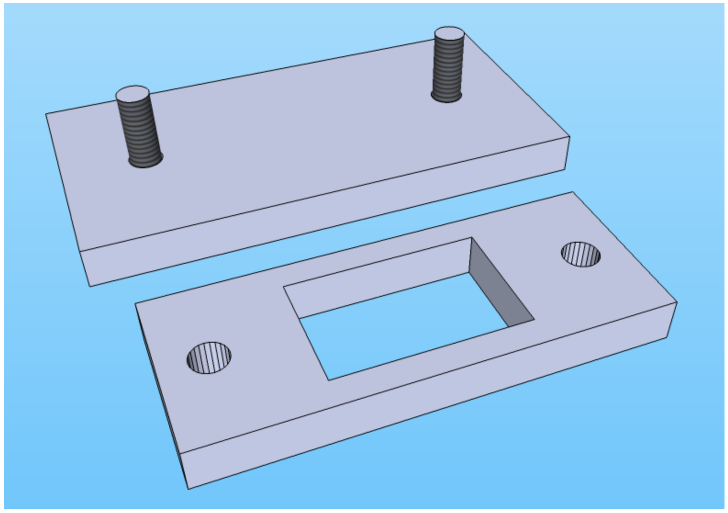
1. Punch the holes as shown.
2. Torch the roller slots as shown.



3. Grind away the slag.
4. Weld the the thin cylinder support nuts, taking care to protect the threads.



CEB Prepare the Press Feet



Sketchup Model

Tools Needed:

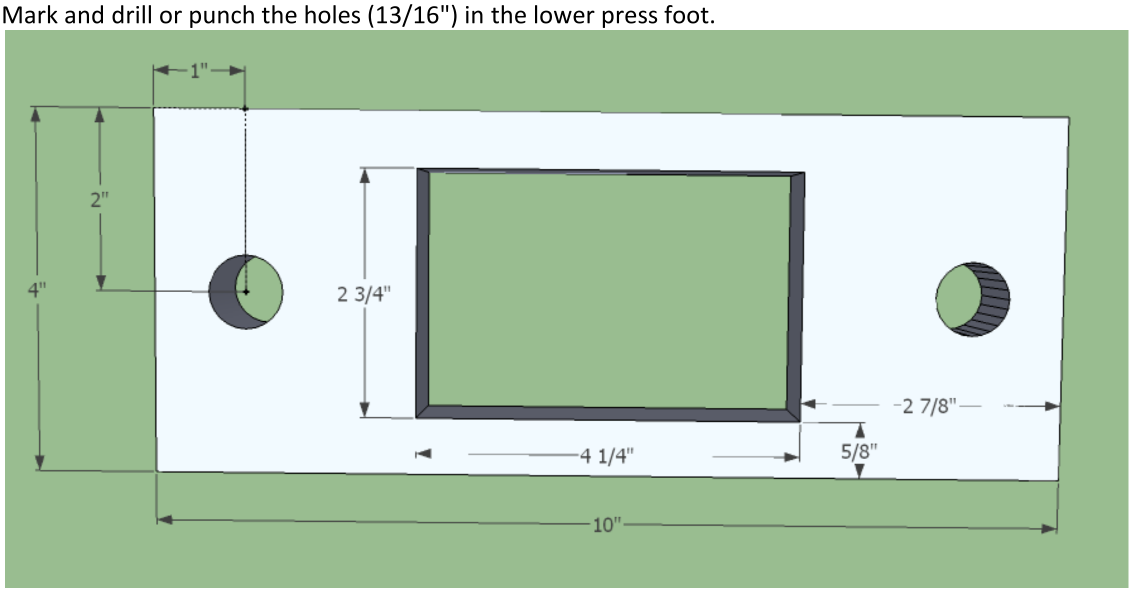
- Angle Grinder
- Welder
- Hole Puncher
- Drill Press or Mag Drill with 13/16" Bit

Materials Needed:

- 1"x4" Flat- 10" (1) Lower Press Foot
- 1"x6" Flat- 12" (1) Upper Press Foot
- ¾" Threaded Rod- 2.5" (2) Upper Press Foot

Lower Press Foot

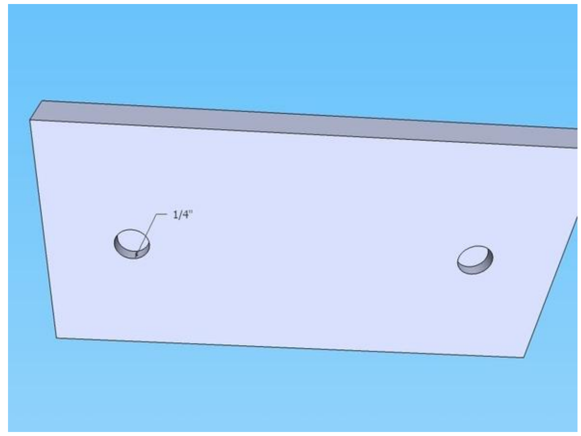
1. Mark and drill or punch the holes (13/16") in the lower press foot.



2. Place this centered on the upper press plate and transfer punch the hole locations.
3. Mag-drill these holes.

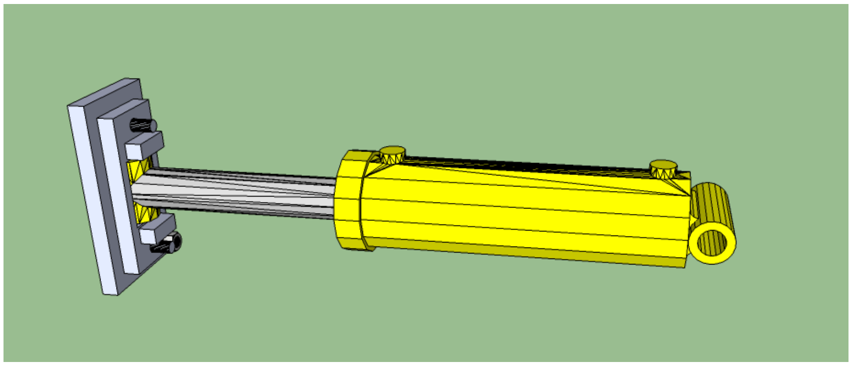
4. Torch out the hole in the center of the lower press plate.
5. Grind it smooth.

Upper Press Foot



1. Plug weld the threaded rod into the upper press plate, so that the threaded rod is about 1/4" deep in the plate.
2. Fill the hole with weld, then grind it flush.
    - The upper press foot NEEDS to be 12" exactly across at the top of it (the side without the bolts sticking up) or there will be "fuzzy edges" on your bricks. See the video for more info.

CEB Prepare the Main Cylinder



Sketchup Model

Tools Needed:

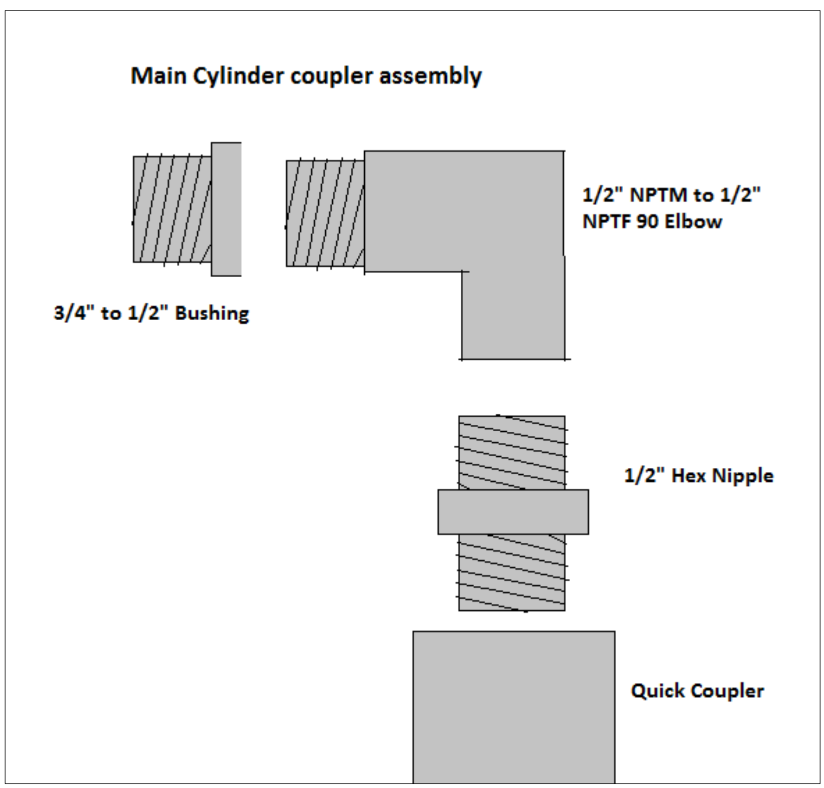
- 3/8" Allen Wrench
- Bucket and Water for cooling cylinder
- Hydraulic Pump
- Large Square
- Speed Square
- Thread Tape
- Vise
- Welder
- Various wrenches

Materials Needed:

- The Press Feet
- The Main Cylinder
- 1/4" to 1/2" Bushing (2)
- 1/2" NPTM to 1/2" NPTF Elbow (2)
- 1/2" Hex Nipple (2)
- 1/2" Quick Coupler Set (1)
- 3/4" Galvanized Nuts (2)
- 3/4" Steel Nuts (1)

Step 1-- Prepare the Hydraulic Couplers

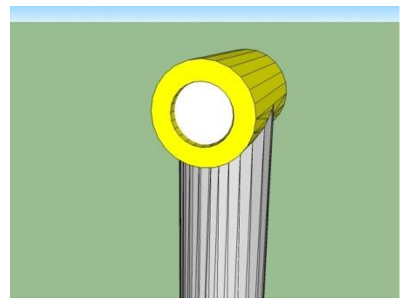
- Thread tape is necessary between each connection. Always wrap thread tape clockwise when facing the threaded portion.
- You will need to make 2 of these, one with male quick couplers and one with a female.
    1. Put the hex nipple in the vise and tighten the quick coupler onto it. Put the elbow in the vise, male side up, and tighten the bushing onto it.
    2. Rotate the elbow in the vise and tighten the quick coupler/ nipple onto it.



Step 2 — Install the Couplers

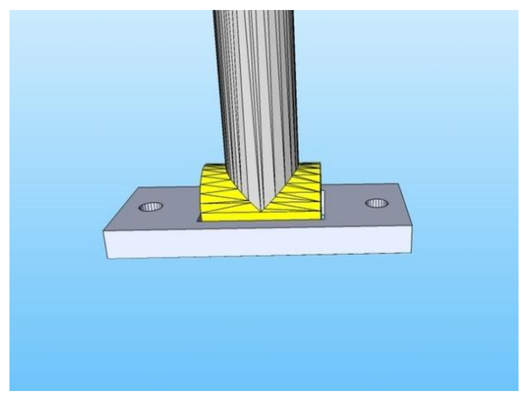
1. Remove the plugs on the cylinder.
    - The Prince brand cylinder uses a really large allen wrench for their plugs. If you can't find one, you can make one like we did.
    - Make sure the ports are facing up as there might be fluid in the cylinder and you don't want it to leak.
2. Tighten the coupler assembly into the holes, so that when the cylinder is lying on its side, neither one will hit the table.

Step 3 – Weld the Filler Rod



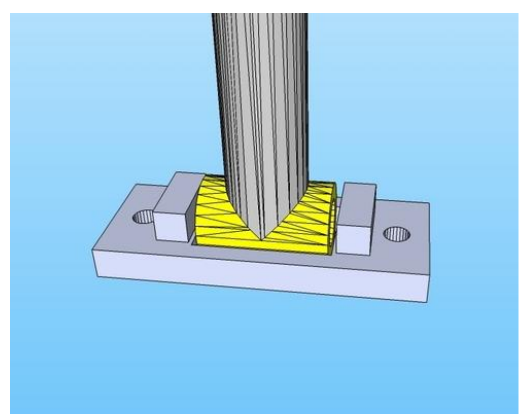
1. Expand the cylinder so the shaft is fully extended, using a hydraulic pump.
2. Weld a 3.5" piece of 1.5" DOM roundstock inside of the tubing at the end of the shaft
    - Take care that the top of the shaft doesn't get hot; there is a rubber seal between that and the cylinder that will melt and cause leaking if you're not careful. If it starts getting warm, dunk the shaft in water to cool it down.

Step 4 — Tack the Lower Press Foot to the Cylinder



1. Stand the cylinder up vertically and prop it up using some sort stand so it is as close to square vertically as possible. Another option is to support it using some sort of rope.
2. Place the tubing at the end of the shaft inside of the hole in the lower press foot.
3. Insure the cylinder is square to the plate in all directions. See video.
    - Since there is a lip on the cylinder, its hard to tell if it's square unless you use two squares, one on the lip and against the other one which rests on the table.
4. Tack the lower press foot from all accessible dimensions.
5. Insure the cylinder is still square with it, if not, remove the tacks and fix it.

Step 5 – Weld the top



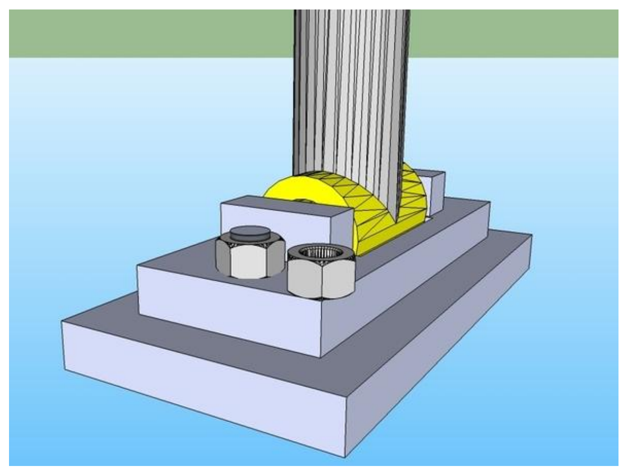
1. Weld the two together on the top. There will need to be at least 2 layers of weld.
    - Warning: Dunk this frequently, even if the shaft is not getting hot! The plate will warp upwards and cause you lots of woe if you do not.
2. Weld the press foot support pieces as close as you can to the tubing and the press plate.

Step 6 – Weld the Bottom

1. Lower the cylinder and flip it upside down.
2. Fill in the bottom side of it with welds.
    - This will require many layers of welds and many dunks to cool it.
3. Grind it flush with the rest of the plate.
    - A few spots where the welds are below the surface is OK, but the majority of the surface should be level.

Step 7 — Install the Upper Press Plate

1. Put the upper press foot into the lower one and tighten nuts onto the threaded rod.
2. Stand the cylinder up again and insure the press plate is still square with the cylinder. See video.
    - If it’s not, you'll need to add shims between the two press plates until they are square with the cylinder.



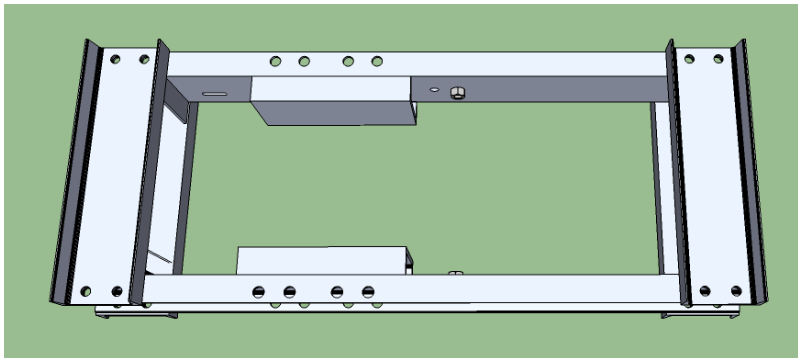
Step 8 — Weld the magnet holder nut

Weld the nut in the corner of the lower press plate, as shown.

- This should be on the opposite side of the ports of the cylinder, flush with the press foot, and as near to the corner as you can get it. It can even hang off a bit.

o Make sure you protect the threads.

CEB Frame U-Channel Assembly



Sketchup Model

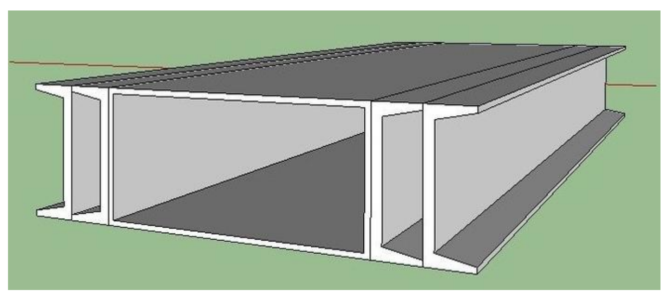
Tools Needed:

- Large Square
- Mag-Drill
- Vise Grips
- Welder
- c clamps

Materials Needed:

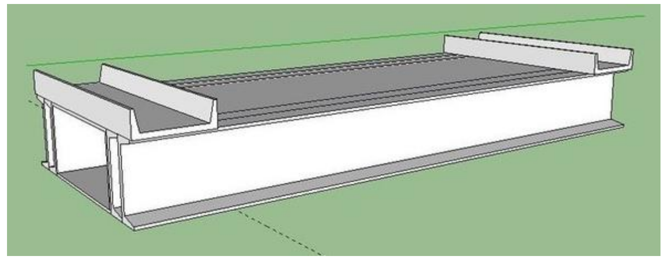
- The Prepared U-Channel
- Wide Cylinder Supports
- ¼"x2"x2" Angle- 6" (2) Dirt Blockers
- 3/8"x3" Flat- 24" (2) Drawer Member Reinforcements
- 6" Heavy U-Channel- 13" (2) Spacers
- 3/4"x2" Bolts (16)
- 3/4" Galvanized Nuts (16)
- 3/4" Washers (16)
- 6"x12" Tubing – 52" Optional Jig

Step 1 — Clamp the Vertical Pieces



1. Gather materials for the "Jig"; this means 6"x12" tubing (52") and any extra heavy U Channel. If you don't have any laying around, you can use one drawer member, and one spacer on each side.
2. Clamp the vertical pieces to the "Jig" on each end, with extra U channel in between the tubing and the vertical pieces.
    - Make sure they are both orientated properly, that is that both roller slots are at the same end of the jig.
    - Insure the two verticals are flush at the top end.

Step 2 — Clamp the Horizontals.



1. Clamp one horizontal member at each end of the jig.
   - Make sure they are flush with the ends of the verticals and centered on them.
   - Insure they are square with the jig by using a large square.
2. Clamp using 1 or 2 vise grips on either side.
   - If you didn't need to use the drawer members for the jig, you can drill those and the wide cylinder support holes now too so you won't have to handle the material twice. See below for how to do it.

- It really helps to label each member, so that if you end up unbolting the piece later, you'll know exactly where it goes and in what orientation. Mark which side will be the top of the machine (could be either end at this time), and which member goes where.

Step 3 — Mag-Drill the holes and bolt to frame

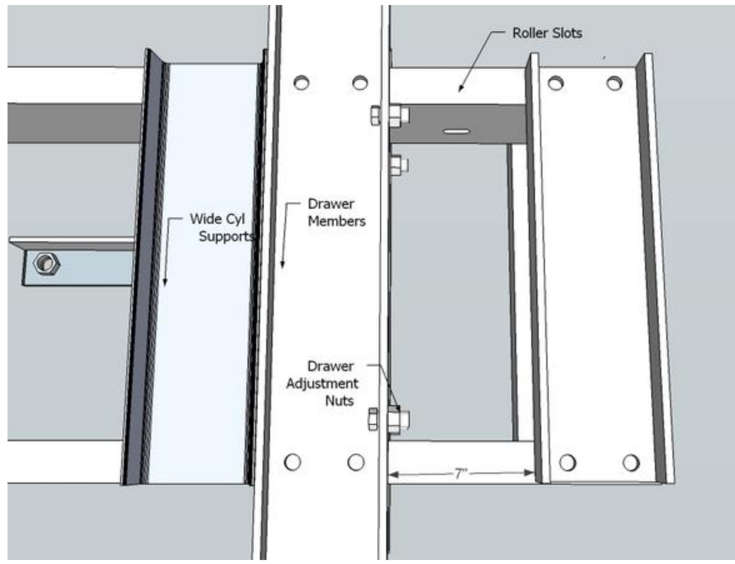
1. Use a Mag-Drill to drill the 3/4" holes each place where the horizontal members overlap the vertical members.

2. Bolt the horizontal members tightly to the vertical members.
3. Flip the jig over so you have access to drill the other holes. See video for help.
4. Clamp the other 2 horizontal members in place.

5. Align the other horizontal members with the ones below the jig, so that they are both at the same location relative to the vertical members.
   - This is crucial so that the machine will stand up straight and there won't be any gap between the drawer and the top horizontal members.
6. Insure once more that the horizontal members are square with the vertical members.
7. Mag Drill them.

8. Remove the clamps and the jig from the frame.
9. Bolt the horizontals tightly to the frame.
10. Double check to make sure everything is still square.
    - If not, loosen the bolts and square it up on what you labeled top first and tighten those bolts. Then square out the other side and torch out any spots prohibiting the bolts from going thru.
    - Bolt it back when you're done.

Step 6 — Mag-Drill the holes for the wide cylinder supports and drawer members

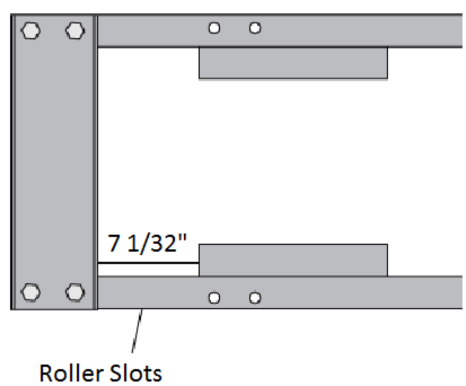


1. Clamp the drawer member centered, 7" from the upper cross member.
    - The drawer slots should be on this side, not opposite.
    - Make sure the adjustment nuts are facing where the drawer was, look at the picture.
2. Clamp the wide cylinder support adjacent to it.
3. Make sure you label each component for re-assembly later.
4. Mag-Drill 1" holes at these centers.
5. Don't bolt these yet, you'll do that later.

Step 7 — Re-inforce the drawer members

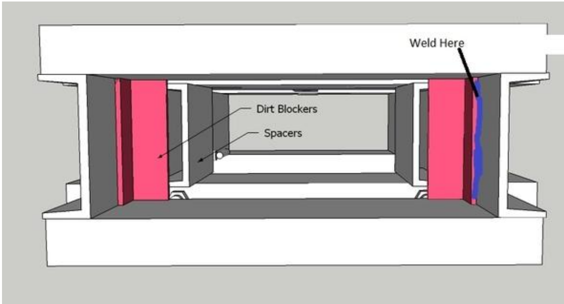
- Place the 1/2"x3"x24" flats on the drawer members centered as shown.
- Weld them in place, using about a 50% weld.

Step 8 — Tack the Spacers



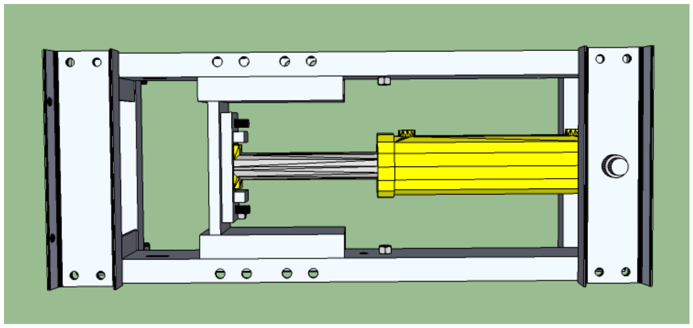
- Note: You not welding them because when you stretch the frame, it may "move" their location.
    1. With the frame laid down, and one of the drawer members under it to support the spacers, place the spacers on each side.
        - The end of them is to be 7 1/32" away from the upper cross member. Look at the diagram.
    2. Insure they are parallel and flush with the U-channel and C-clamp in two places for each.
    3. Tack them on this side in 3 spots.
        - You may need to grind this off later, so make sure the tacks aren't longer than 1/4" or so.
    4. Flip over the frame and tack the other side.

Step 9 — Weld the Dirt Blockers



1. Put the dirt blockers in place, between the vertical members, so the bottom side of them is about 1/8" above the bottom of the upper crossmembers.
2. Weld the portion inside of the vertical members, taking care to not weld them to the crossmembers.

CEB Fit the Main Cylinder



Sketchup Model

You need to fit the cylinder into the frame so that when it is fully extended, the press foot is in the correct spot to eject the brick. You will need to torch holes in the horizontals for the pin which goes thru the cylinder, and weld DOM tubing to hold the pin. We recommend you watch the instructional video.

Tools Needed:

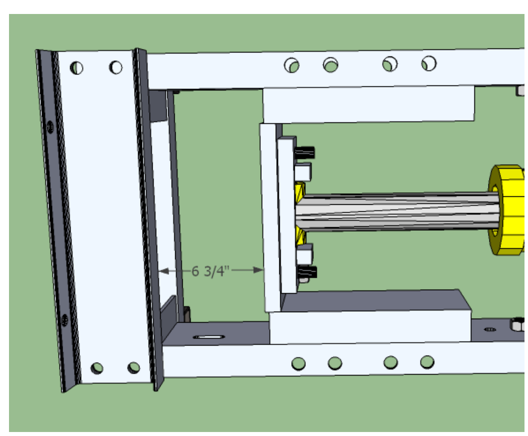
- Angle Grinder
- Welder
- 1/8” thick washer
- MIG welder
- Speed Square
- Spray paint
- Torch

Materials Needed:

- Prepared main cylinder
- Pin-1 1/2" DOM Roundstock, 11"
- Pin Receptors: 1.5" inner diameter, 2" outer diameter DOM tubing: 1.5" (2)

Step 1 — Position the Cylinder

1. Lay the frame down, with all of the crossmembers and drawer members in place except the upper crossmember and drawer member which are facing up.
2. Place the assembled cylinder lying down so that the press feet are between the spacers. You need to insure that the vertical height is correct, and that the cylinder is centered.
    - Insure the magnet holder nut (welded to the press feet) is on the same side as the sensor holder hole (hole in one vertical).
    - The top of the upper press foot should be 6 3/4" for monster away from the bottom of the upper crossmembers.



Step 2 — Squaring the cylinder

- Add a 1/8" spacer (big washers work great) under the cylinder, where it contacts the lower crossmember. This insures the cylinder is centered vertically. Where to put it is circled in the first image.
- Make sure the cylinder is centered, using a speed square pressed against the side of the cylinder, and a tape measure to the to the vertical members as shown.
- Make sure the tubing for the pin is square with the lower crossmember using a speed square.

Step 3 — Marking hole locations

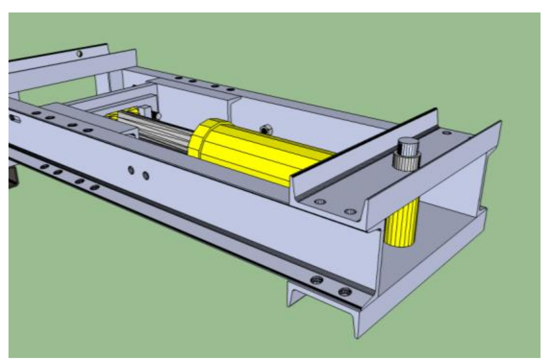
1. Mark the location for the hole for the pin on the bottom horizontal member using spray paint.
2. Put the top horizontal member on, and put in at least 3 bolts.
3. Spray mark this location as well, from the other side.
4. Remove the horizontal members from the frame.
    - This is possible to do without removing the cylinder, just prop it up on something to remove the lower member.
5. Place one of the DOM tubing pieces in the center of each of the sprayed marks and spray paint around this to mark where you will torch.

Step 4 — Torching

1. Torch out the hole, and grind away the slag.
   - Insure the tubing will go thru each hole. If not, retorch it. Grind off the slag.
2. Lay the cylinder back down, with the 1/8" spacer in, and replace the crossmembers, with their bolts. Place the tubing in the torched holes.
3. Insure the pin will go thru the tubing and the cylinder. If not, retorch the holes so that it will.

Step 5 — Welding

1. With the pin held in, tack the tubing on the top in place.
   - Make sure the tubing is pressed up against the cylinder, that is that it's as far into the hole as possible.
   - You'll want to tack it in many places before welding around it, at least 8 on each side.
2. Tack it as best you can on the bottom by hanging the frame off of the table and overhead welding. Again, insure the tubing is pressed up against the cylinder.
3. Remove cylinder and pin, as well as the two crossmembers.
4. Fully weld the tubing on both sides. Jump around a lot to minimize any warping on the tubing.
   - Block the insides of the tubing so no spatter goes inside. Big washers work well for this.



Step 6 — Re-Assembly

1. Replace the crossmembers and the cylinder.
2. Insure the pin still fits and hammer it thru.
   - If the pin doesn't fit, you will need to make it fit.
     - Tighten the bolts on only the bottom crossmember. Put the pin thru the crossmembers and the tube.
     - Mark where the bolt holes need to be torched away for the bolts to fit through. Torch it and you're done.

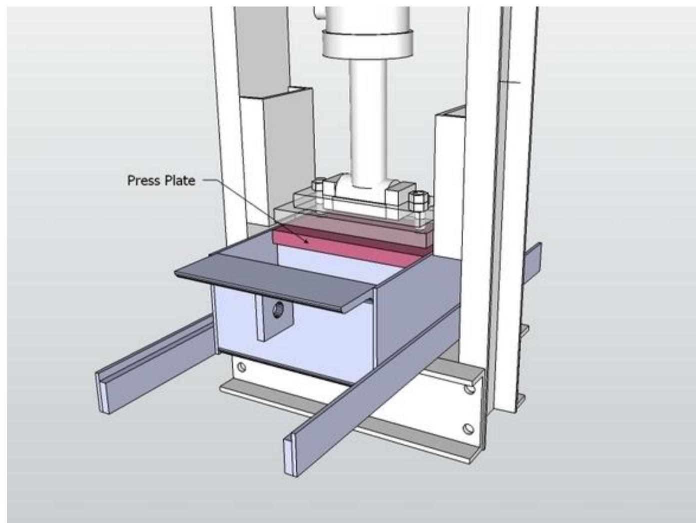
CEB Stretching the Frame

Tools Needed:
- Hydraulic Pump

Materials Needed:
- Main Frame
- Wide Cylinder Supports
- Soil Loading Drawer
- ¾”x2” Bolts (8)
- ¾” Nuts (8)

See the Video.

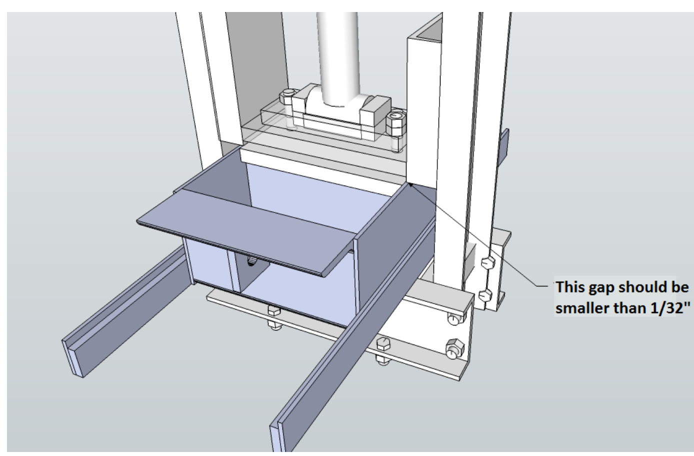
Step 1-- Stretch the frame



1. Attach the cylinder to a hydraulic pump or power cube and contract the cylinder at least 1".
2. Stand up the frame so the press feet are facing down.
3. Insert the Soil loading drawer on top of the horizontal members so that the press plate is facing the press feet.
    - If the drawer doesn't fit because of the spacers, you welded them too close. Grind off the tacks and tack them a little higher.
4. Position the drawer so that the press plate will be fully contacted by the press feet.
5. Bolt the drawer members on finger tight.
6. Use the pump to expand the cylinder as much as possible. The pump will likely stall out.
    - If the pump stalls, turn it back on and expand it fully once more.
7. Expand at least 3 times.
8. Contract it, so you can weld the spacers in. Then detach from the pump.

Step 2 — Observations

1. Remove the drawer members.
2. Look where the spacers are near the drawer.
    - The spacers should be very close to the drawer (less than 1/32")
      See quality control video if you wonder why.
    - If they are too far, grind off the welds and re-tack them so they are lightly contacting the drawer. Yet again, make sure they are perfectly square with the verticals.

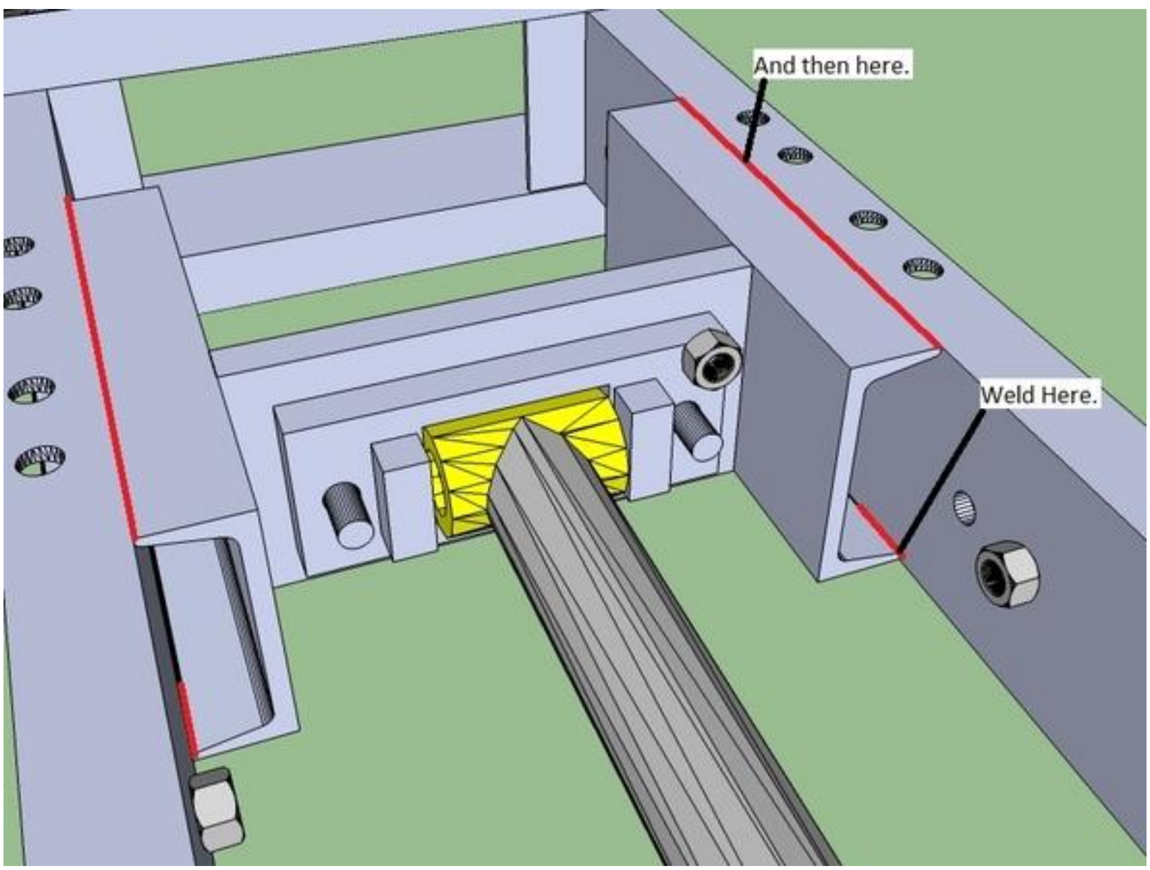


CEB Welding the Spacers

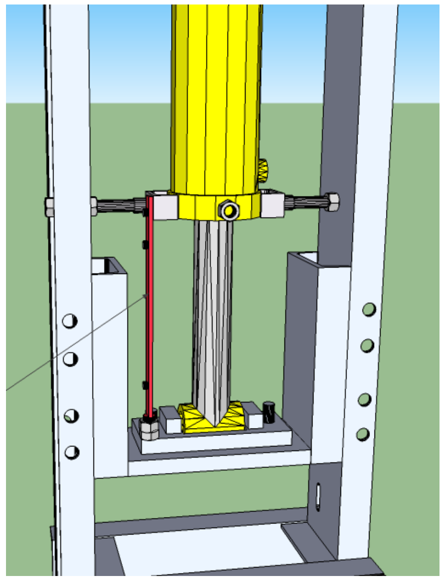
Tools Needed:
- Angle Grinder
- Welder

Materials Needed:
- Main Frame

Weld The Spacers
1. Lay the frame on its side.
2. Protect the cylinder and press feet so that when you weld, spatter won't stick. You could use some piece of metal or a nonflammable cloth.
3. On the inside, bottom edge, weld the interior of the spacer inwards as far as you can. This should be an inch or more. Do this in all 4 corners accessible from this side of the frame. See the photo.
4. Weld the top 100%, and grind it flush.
5. Flip over the frame.
6. Weld this side as you did the other side, also welding inside the spacers.



CEB Frame- Installing the Small Components



[Sketchup Model]

Tools Needed:

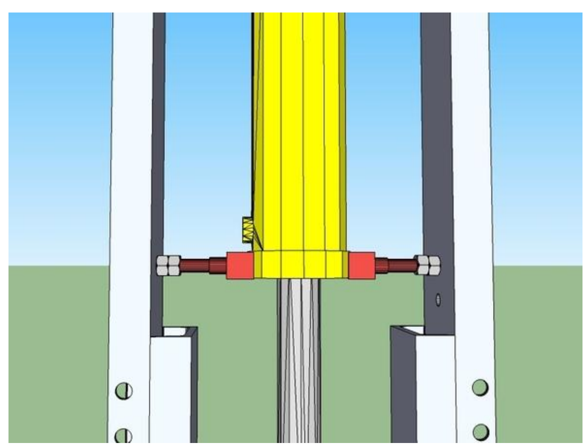
- Wrenches
- Welder

Materials Needed:

- Main Frame
- Sensor Holder
- Thin Cylinder Supports
- Magnet Holder
- Leg Holders (2)
- ¾" Nuts (3)

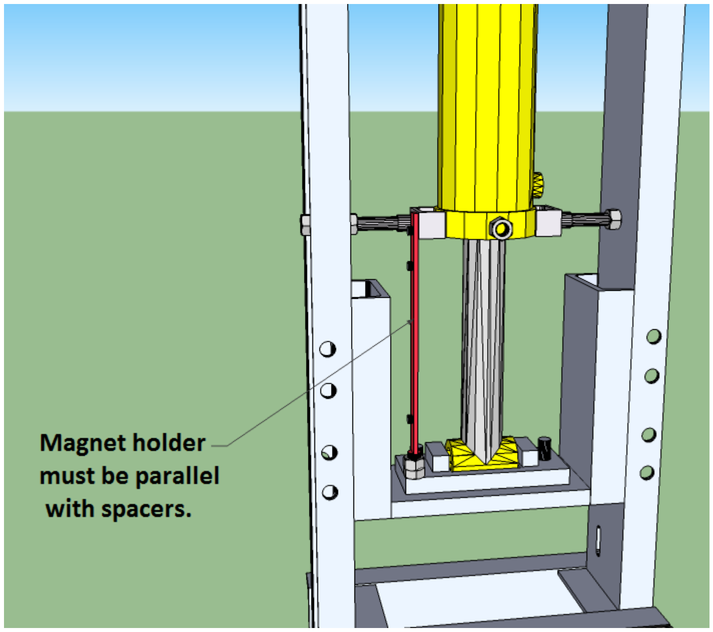
Step 1 — Install the thin Cylinder Supports

1. Install the thin cylinder supports by screwing the bolt in with an extra nut on it as shown, and placing the u-channel against the cylinder.
2. Get both of them snug so the cylinder is centered with pressure on each side.
3. Tighten down the nut to lock it.



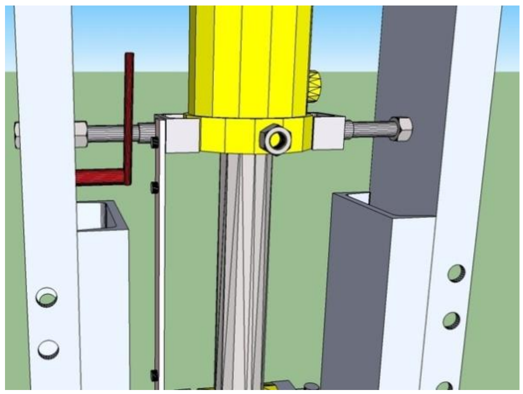
Step 2 — Install the magnet holder

1. Install the magnet holder onto the press foot.
   - The flatbar needs to be parallel with the verticals. If not, bend it so it is.
2. Lock it down with the nut.



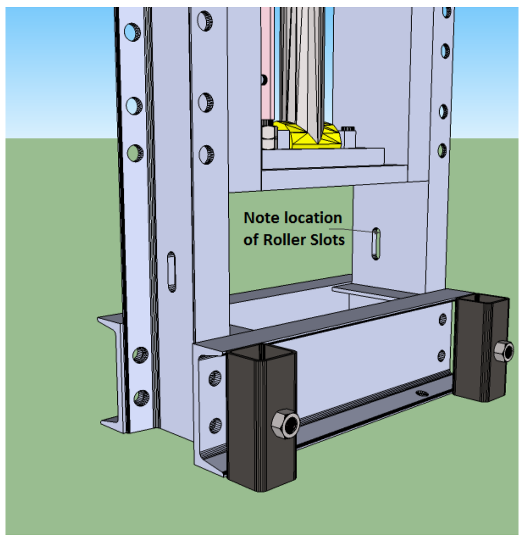
Step 3 — Install the Sensor Holder

- Install the 6" sensor holder so the end of it is overlapping the path of the magnet holder as shown. The other sensor holder will be installed later.

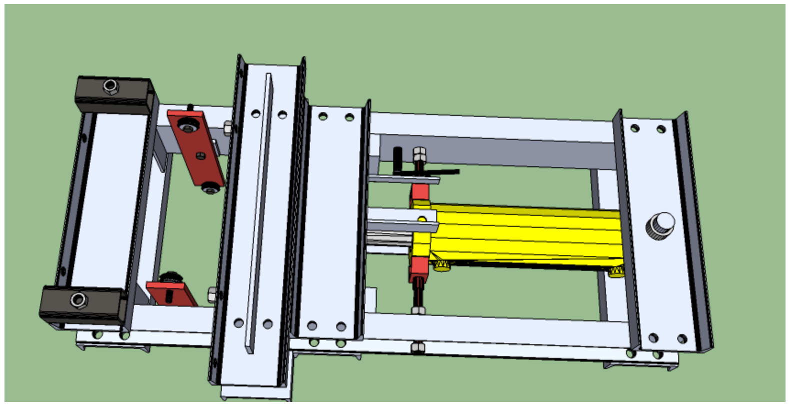


Step 4 — Weld the Leg Holders

1. Position them on the upper horizontal members as shown.
   - Use the location of the roller guides to insure you attach them to the right side.
   - Insure they are square in all directions
2. Weld them to the horizontal members fully.



CEB Fit the Drawer Members



Sketchup Model

Tools Needed:

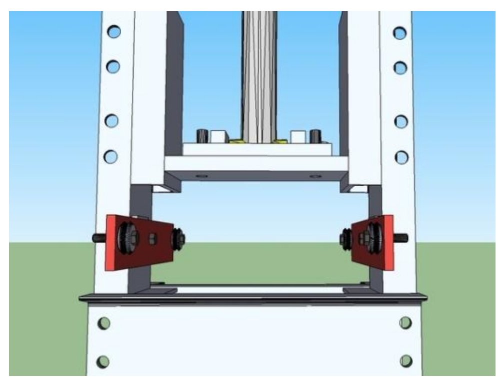
- Various Wrenches

Materials Needed:

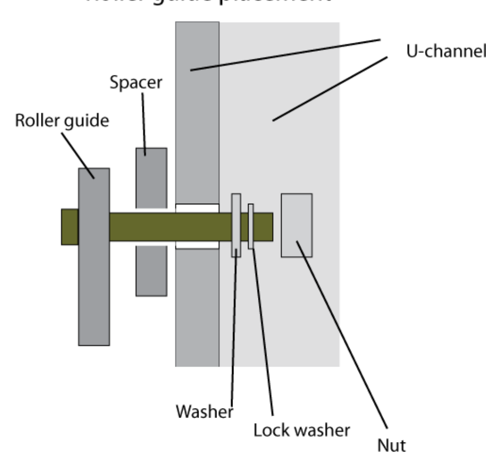
- Roller Guides
- Soil Loading Drawer
- Wide Cylinder Supports
- Drawer Members
- 3/4"x2" Bolts (16)
- 3/4" Nuts (16)
- 3/4" Washers (16)
- 1/2" Washer (2)
- 1/2" Lock Washer (2)
- 1/2" Nut (2)

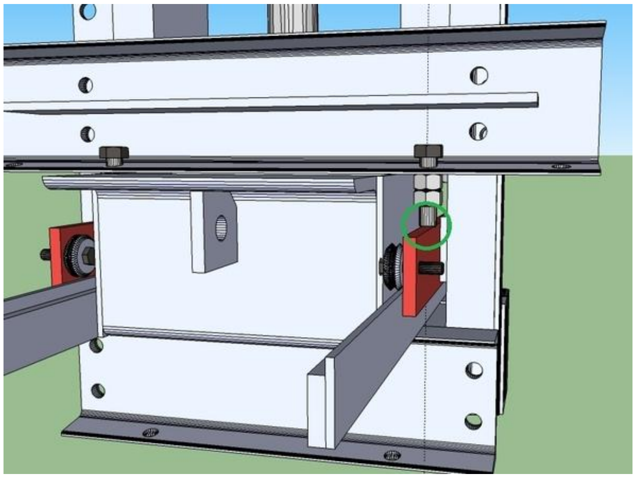
Step 1 — Install the Roller Guides

1. Position frame so it is standing upside down as in picture on right.
2. Install the Roller guides as shown in the illustration. One side should have a 1/2" spacer, and the other should have a 3/8" spacer plate.
3. Tighten the bolts snug, but so that they can still move up and down.



Roller guide placement



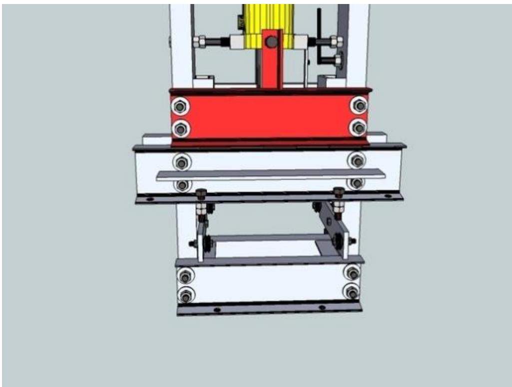


Step 2 – Bolt in Drawer Members

1. Replace the drawer as if you're going to stretch the cylinder again.
    - The roller bearings should be on top of the rails on the drawer, and be putting no pressure on the drawer.
2. Loosely bolt on the drawer members.
3. Adjust them horizontally so that the adjustment bolts are centered on the roller guides. See image.
4. Finger tighten the bolts on the drawer members, as they are sitting on top of the drawer.

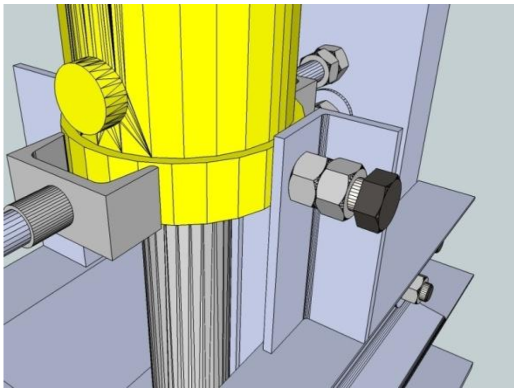
Step 3—Adjust Drawer Members

1. Try to slide the drawer in and out. If the drawer gets stuck somewhere, investigate and find where it's hitting. (It almost certainly will).
    - You'll probably need to loosen one, or both of the drawer members and move it up a bit.
    - This can be done uniformly using cardboard shims. See photo. Place the shim between the drawer and the crossmember. Tighten the bolts again. Remove the shims by "jiggling" the drawer.
    - If it's hitting a spacer, grind down the spacer.
    - If the drawer itself is prohibitive in some spots, it wasn't grinded evenly. Grind down the high spots.



Step 4- Tighten all Bolts

1. Once the drawer is properly adjusted, tighten these bolts all the way.
    - Make sure the drawer adjustment nuts are still centered on the roller guides.
2. Tightly bolt the wide cylinder supports to the frame, leaving no gap between them and the drawer members.
3. Tighten the bolts at the top of the wide cylinder supports so they are touching the cylinder on each side. Tighten the lock nut.
4. Go back through the entire frame and make sure every bolt is tight.



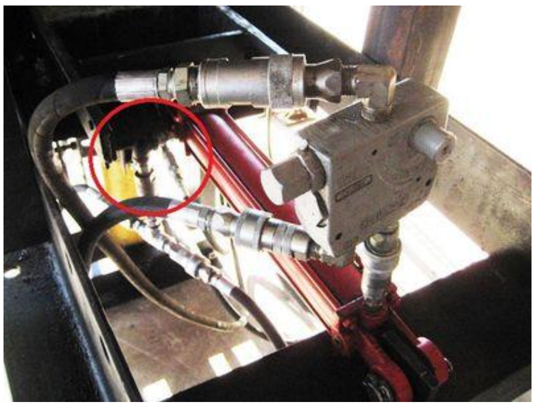
CEB Secondary Cylinder Hydraulics Prep

Tools Needed:

- Various wrenches
- Vise

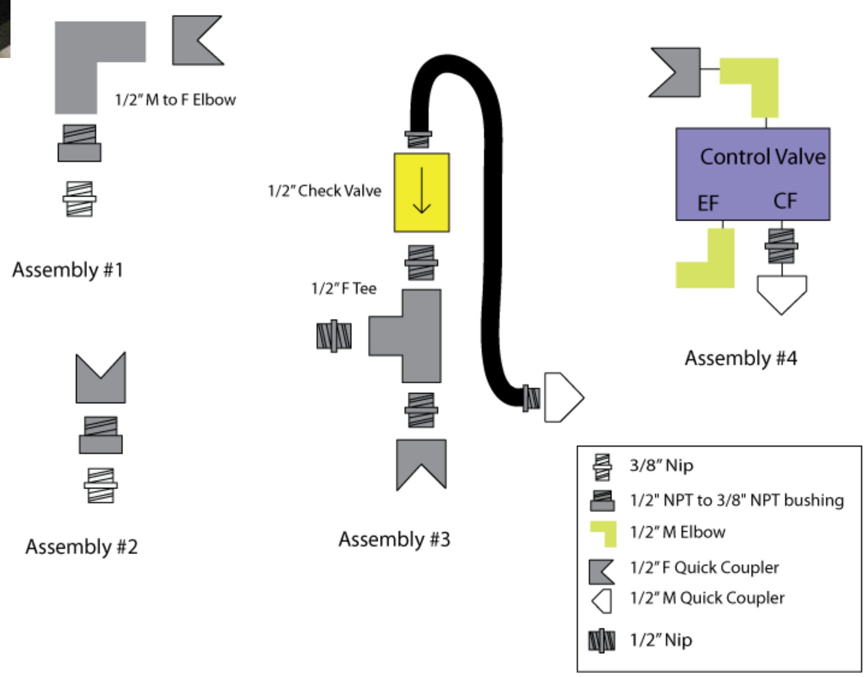
Materials Needed:

- Thread tape
- 3/8" NPT Hex nipple (2) Buy
- 1/2" NPT to 3/8" NPT bushing (2) Buy
- 1/2" NPTF to 1/2" NPTM 90 Elbow (1) Buy
- 1/2" M Elbow (2) Buy
- 1/2" Flow Control and Relief Valve Buy
- 1/2"x36" NPTM Hydraulic hose (1)
- 1/2"x96" Hose (2)
- 1/2" Quick Coupler Set (5) Buy
- 1/2" Check Valve (1) Buy
- 1/2" F Tee Buy
- 1/2" Hex Nipple (4)Buy



Procedure

- Thread Tape is needed between each connection.
- Always wrap thread tape clockwise when facing the threaded portion.
- Always keep the end caps on hoses and fittings until you need to take them off. They need to stay protected inside.



1. Assemble the individual assemblies as shown, and prepare the two 96" hoses by putting a male quick coupler onto one end of each.
2. Install Assembly #1 into the rod end of the cylinder (image above). Insure the quick coupler will be facing towards the ground when the cylinder is installed.
   - When you remove the plug on the cylinder, fluid may spill out, so keep some rags or a jar handy.

You will install the remaining components later upon installing the secondary cylinder.

CEB Assembly- Structural Components

Tools Needed:
- Angle Grinder
- Welder
- C-Clamps
- Vise Clamps
- Wrenches
- Torch

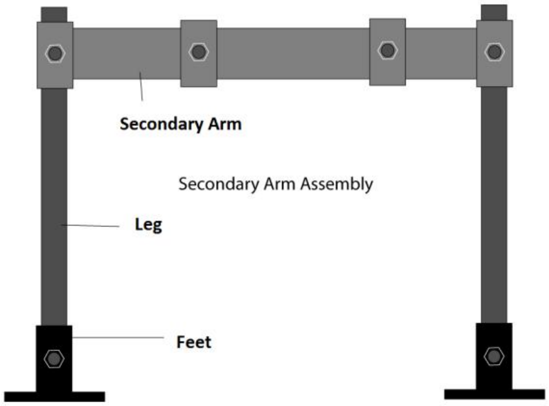
Materials Needed:
- Prepared Structrual Components
- Main Frame
- ¾"x2.5" Bolts (4)
- ¾"x2" Bolts (12)
- ¾" Nuts (17)

Step 1 — Position the main frame

- Set the main frame somewhere on level ground where you have access to a welder and torch and where you have at least an 8' radius of empty space. The CEB takes up a lot of room!
- Set it so the cylinder pin is near the ground.

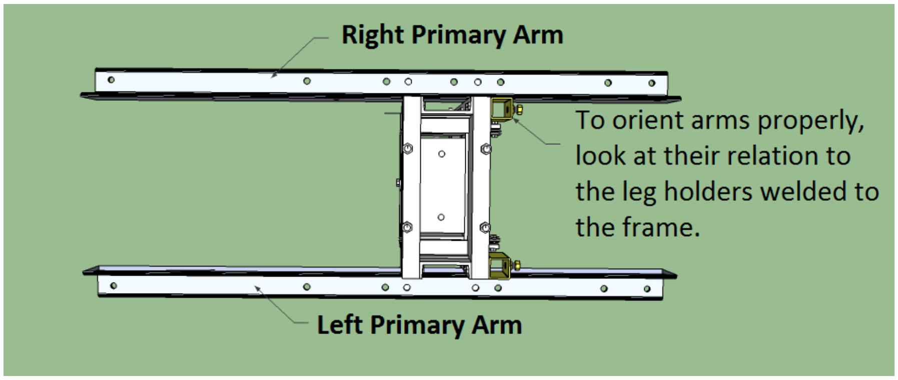
Step 2 — Assemble the Secondary Arms

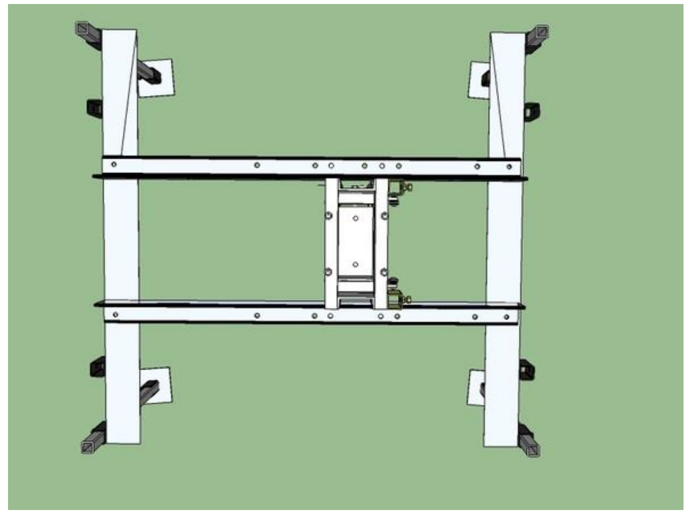
1. Gather the secondary arms, the legs and the feet.
2. Onto the end of each leg, tighten a foot to one of its ends. Get the bolt tight enough so it won't fall off.
3. Insert one leg/foot into each of the outside leg holders on the secondary arms.
4. Adjust the height so that the top of the secondary arms will be very close to the height at the bottom of the primary arms.
5. Tighten the bolts in the leg holders so they are snug, but not too tight.



Step 3 — Place the Primary Arms

- Clamp them on the drawer members on the frame so that they are in the proper orientation. See image.
  - If the machine is going to tip over, have a friend move the assembled secondary arms to support it so it doesn't tip.





Step 4 — Attach the secondary arms to the primary arms

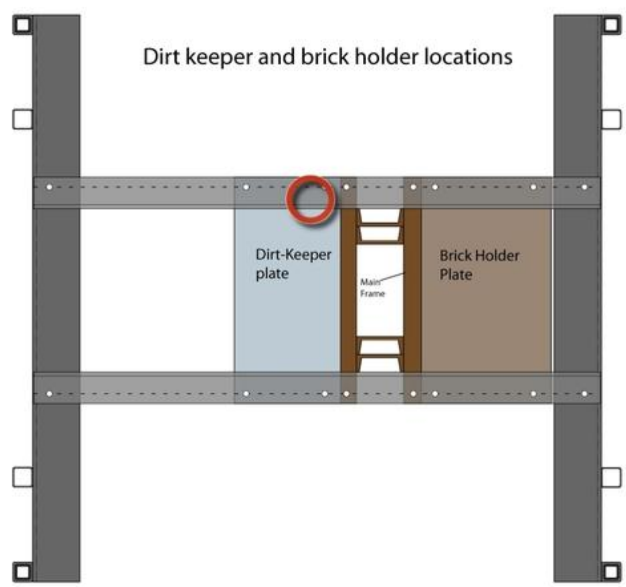
1. Loosely bolt the 2 sets of arms together.
   - You may need to loosen the clamps on the primary arms. This is OK.
2. Make sure the arms are all square to each other.
3. Tighten all bolts.
4. Loosen the clamps attaching primary arms to the frame.
5. Square the arms to the frame.

Step 5 — Attach the primary arms to the frame

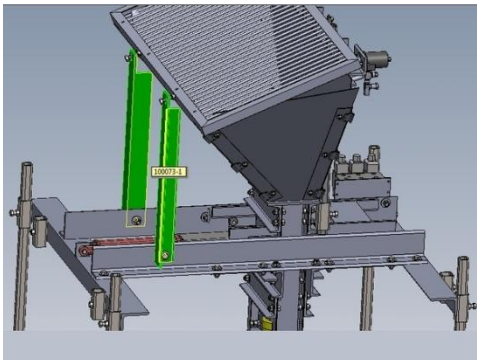
1. Torch the holes in the frame through the holes in the primary arms.
   - Make sure bolts go through all holes.
2. Remove the clamps and grind away any slag
3. Bolt the primary arms to the frame.

Step 6 — Install Brick Holder plate, Dirt keeper plate, and sensor holder

- The plates go on the bottom side of the primary arms.
  - If not all the bolts go through, torch away whatever is preventing it.
- Bolt them down so the bolt head is on the top. Tighten the nuts snug.
- Install the sensor on the right primary arm. Its location is circled in the diagram.



CEB Assembly- Soil Loading System



Tools Needed:

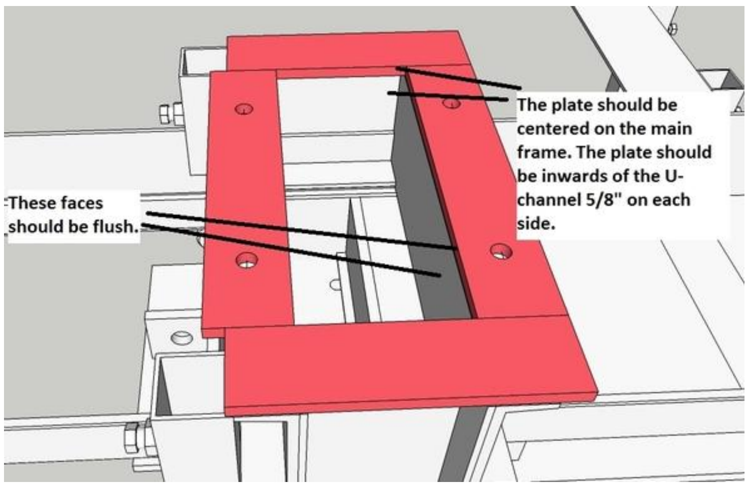
- Angle grinder
- Spray paint
- Vise clamps
- Welder
- C- clamps
- Torch
- Various wrenches

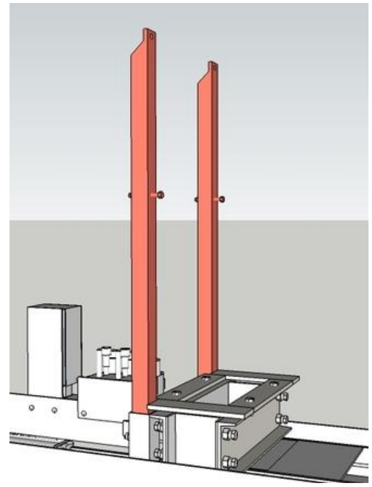
Materials Needed:

- All Components of Soil Loading System
- Assembled Main frame
- ¾" Galvanized Nuts (10)
- 1/2" lock nuts (2)
- 1/2" nuts (2)
- 3/4"x1.5" bolts (8)
- 3/4"x2.5" bolts (2)
- 1/2"x2.5" bolts (2)
- 1/2"x3" bolt (2)
- 1/2" washers (8)
- 3/4" washers (6)
- 1/2"x1" Bolts (4)

Step 1 — Torch the holes for the hopper mounting plate

1. Clamp the hopper mounting plate to the top of the main frame, positioned as shown, with the cutaways positioned by the leg holders.
    - Clamp it so that the side you grinded down the welds on is touching the main frame.
2. Torch the holes thru to the main frame.
    - Check that the fit is good by putting bolts in all the holes.
3. Grind away all the slag.
4. Bolt the mount to the frame.



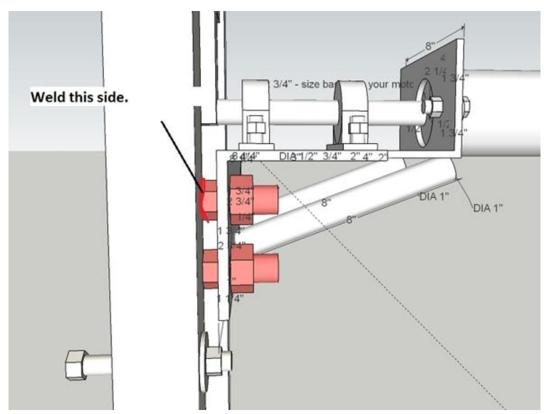


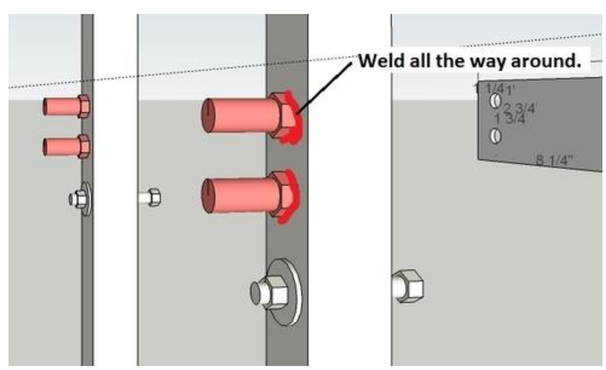
Step 2 — Install hopper supports and prepare shaker mount.

1. Install the hopper supports into the leg holders.
   - Make sure you put the support with bolts on it on the correct side (refer to your shaker motor and look where you marked it.)
   - Their bottom side should be flush with the bottom of the leg holders on the frame.
   - Make sure they are orientated correctly. See photo.
2. On the side of the shaker motor that you didn't weld bolts for, put a bolt (3/4"x1.5") thru both holes and tighten nuts onto them.

Step 3 — Tack shaker bolts to hopper support

1. Place the shaker onto the bolts already welded to the hopper supports.
2. Clamp the other side to the hopper support.
   - Use a square to make sure the shaker mount is square with the hopper supports.
3. Tighten nuts onto the side with the welded bolts.
4. Tack the bolts to the hopper support.
   - Make sure you tack them to the hopper support, NOT the shaker mount.
   - Tack as much as you can from this position.

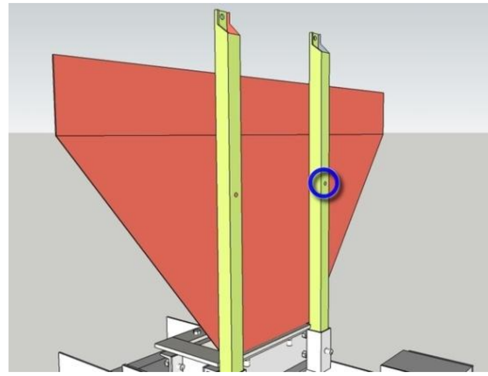




Step 4 — Weld shaker bolts.

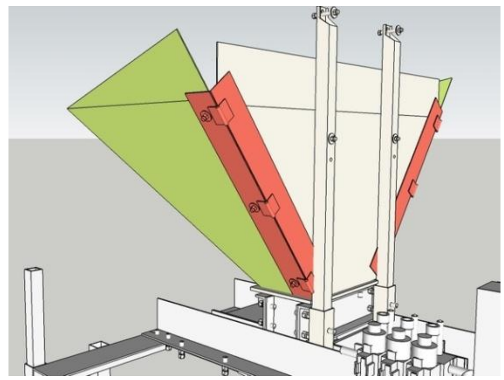
1. Loosen all the nuts and remove the shaker.
2. Protect the threads on the bolts.
3. Weld all the way around the bolt to the hopper supports.
   - Don't remount the shaker yet.

Step 5 — Clamp the hopper back to supports and torch holes



1. Clamp the hopper back to the hopper supports.
   - It should be centered horizontally between them, and touching the supports all the way down to the hopper mounting plate.
2. Torch through the holes circled in the diagram, so you torch through the hopper sheet metal.
   - Torch through it on each side, just enough so you have 2 small holes.
3. Un-clamp the sheet metal and torch 1/2" holes for the bolt.
4. Grind off the slag from torching.

Step 6 — Remount the first plate, and prepare to weld

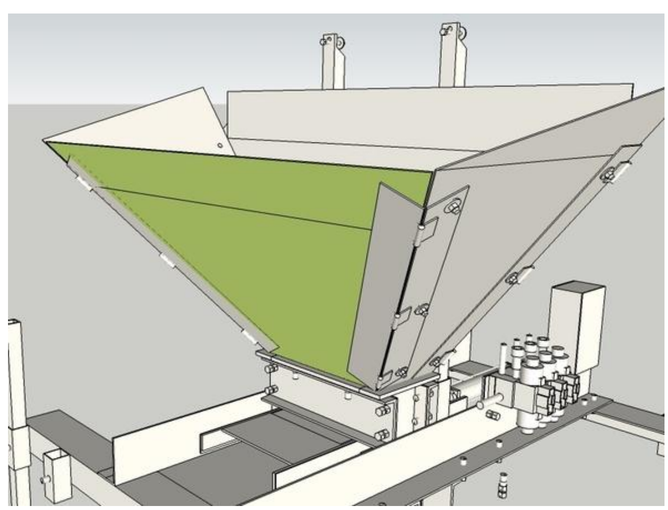


1. Mount the first plate back to the hopper supports.
   - Use a 1/2"x3" bolt and a nut with washers on each side.
2. Lift the side pieces and clamp them to the first plate via the hinge plates.
   - Minimize the gap between them as much as you can by pushing them together tightly.

Step 7 — Weld the hinge plates to the back piece

- Weld it about 50%, as no more is necessary.
  - Weld in 3-4 inch sections.

Step 8 — Clamp and weld the front piece

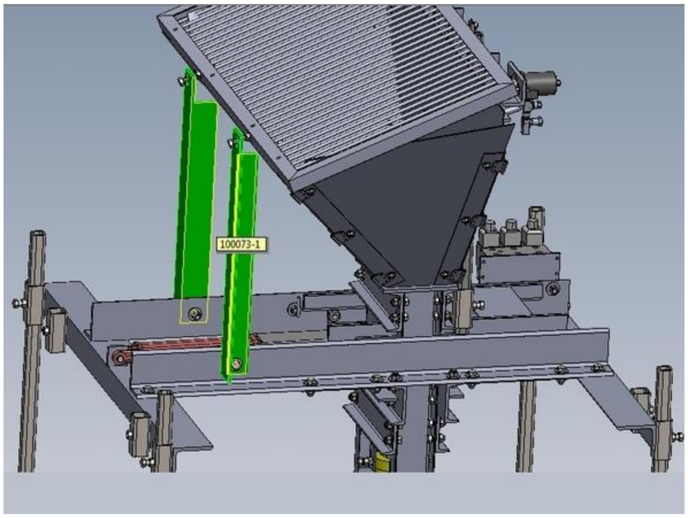


1. Clamp the final piece in place to the other side of the side pieces.
   - Yet again, minimize the gap between the two.
   - You may need somebody to get inside of the hopper and push out so you can clamp it well.
2. Weld the last piece like you welded the first one.

Step 9 — Place the grate and bolt it to the hopper supports

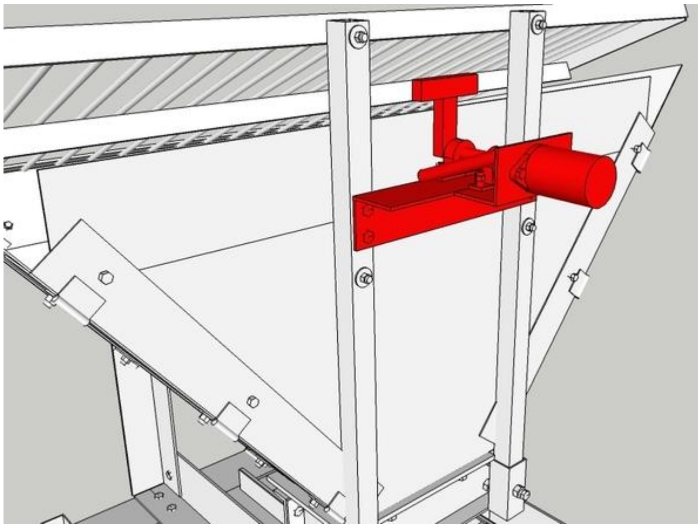
1. Get a friend or two and lift the grate on top of the hopper.
    - The front end (with the slots) should be as shown, and the grate should be inside of the hopper on the other side (the side with the nuts).
    - Have your friend hold the grate in place for the next step, or use C-Clamps to clamp the grate to the supports.
2. Bolt the grate to the hopper supports (1/2"x 2.5" bolt and lock nut). Bolt both loosely, and then tighten them.
    - You'll need 2 washers on each side, as the holes are slots and a 1/2" washer will be too small to prevent the washer from warping. Use a 3/4" washer as the other one.
    - You may want to use a large nut in place of a washer on the hopper support side. (see photo)

Step 10 — Install the grate supports



1. Loosely bolt the grate supports to the primary arms
2. Bolt (3/4"x2.5" bolt) The grate mounts through the hopper to the grate.
    - Use a 3/4" washer where the bolt goes thru the grate support.
3. Tighten all bolts

Step 11 — Re-install the shaker

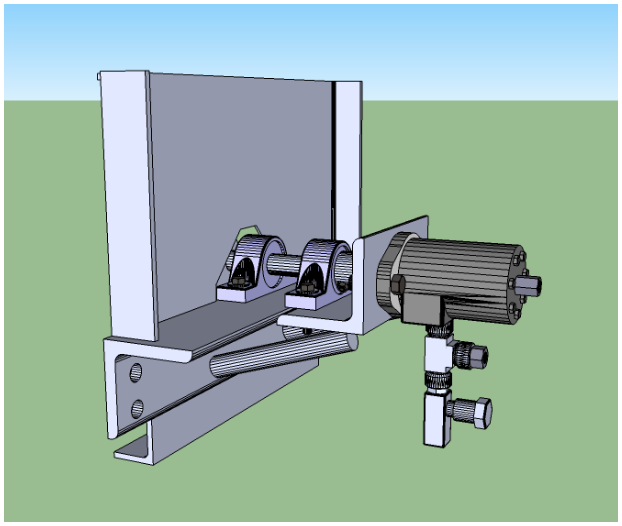


1. <u>Install the motor</u> (next section) on the shaker motor mount if you haven't already.
2. Place it on the bolts on the hopper supports.
    - If for some reason it doesn't fit, torch away whatever metal is preventing it.
3. Tighten nuts onto it.

Step 12 — Install the Dirt Deflector Plate

- Bolt it to the grate.

CEB Shaker Assembly



Sketchup Model

Tools Needed:

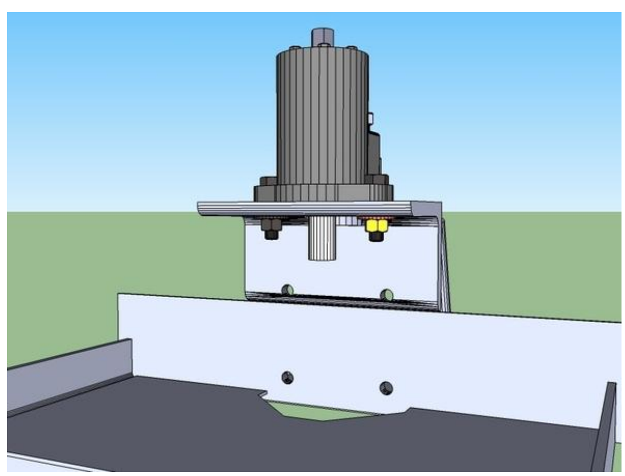
- Allen Wrench
- Various Wrenches

Materials Needed:

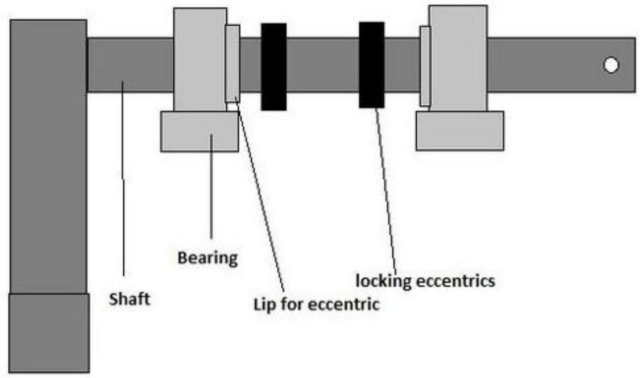
- Shaker Mount
- Shaker Motor
- Shaker Hammer and coupler
- 1" Pillow Block Bearings(2)
- 1/4"x2" Bolt (1)
- 3/8"x2" Bolts (4)
- 1/2"x2" Bolts (2)
- 3/8" Lock Nuts (4)
- 1/2" Lock Nuts (2)
- 3/8" Washers (8)
- 3/8" Lock Washers (4)
- 1/2" Washers (4)
- 1/2" Lock Washers (4)

Step 1 — Mount Motor

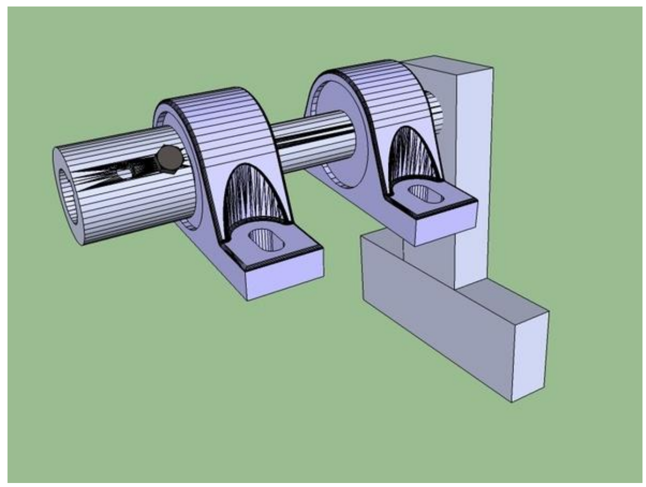
- Loosely bolt the assembled motor to the mount, as shown, using washers on both sides, and a lock washer touching the nut.



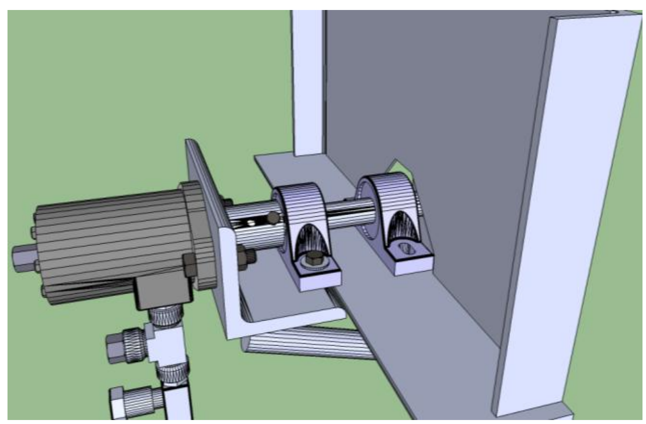
Step 2—Prepare Hammer and Shaft



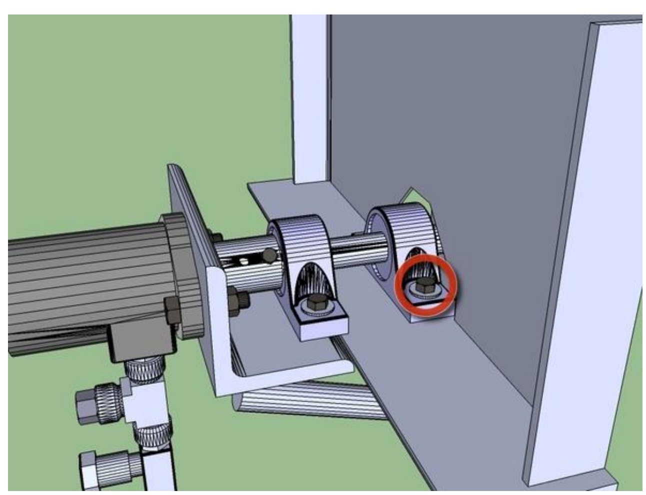
1. Put the bearings onto the shaft, insuring the eccentric side is facing inwards.
    - Remember to put the eccentrics in between the two bearings.
    - The eccentrics are little collars with lopsided circles inside of them. This makes it so it can lock into the bearings.
    - Insure both collars are facing the right direction (So it will lock onto the lip) and so are the bearings.
    - Put the coupler onto the shaft.
    - Make sure you can see thru the holes, (it could be off 180 degrees and a little crooked) then put on the bolt, lock washer, and lock nut. Tighten
2. Couple it to the motor, tightening down the set screw.



Step 3 – Attach bearings



1. Tighten the motor mount bolts.
2. Bolt the bearing closest to the motor to the mount with a washers, a lock washer, and a lock nut. Tighten these down.
3. Insure the hammer rotates freely still.
    - It may require some force, but shouldnt need much.
    - If the hammer won't rotate, loosen the motor mount bolts, retighten them, and recheck it.
4. Position the other bearing and tighten it down, still insuring it will rotate without much force.
5. Lock the eccentrics by pushing them towards the lip on the bearing and twisting it.
6. Tighten the set screw on the eccentrics.



CEB Assembly- Adjusting The Drawer

See Videos:

- Adjusting the drawer
- Properly adjusted drawers

Tools Needed:

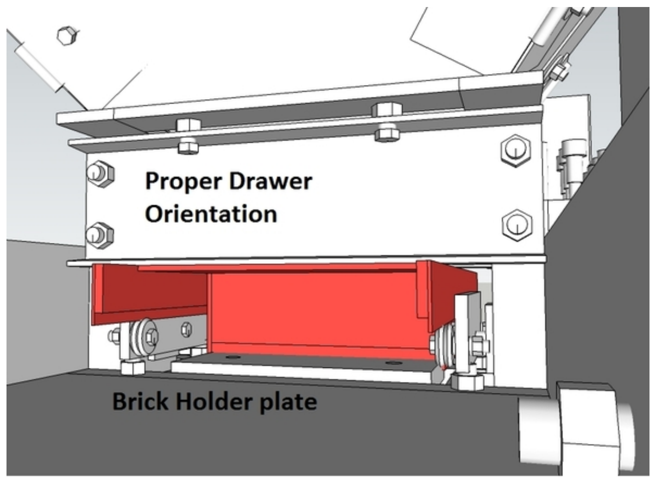
- Mallet
- Various Wrenches

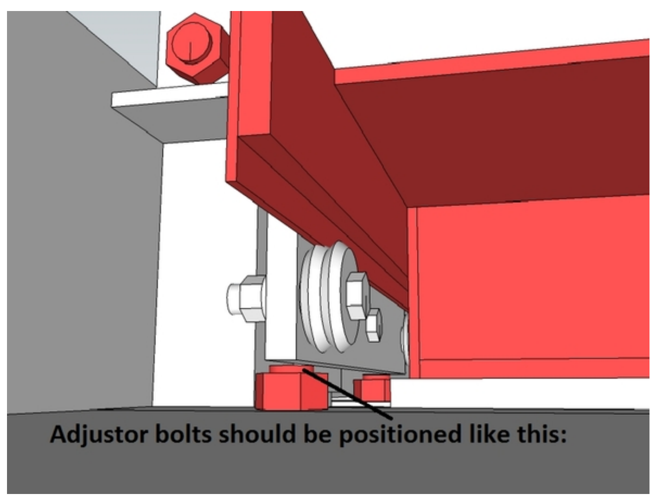
Materials Needed:

- Assembled CEB
- Soil Loading Drawer

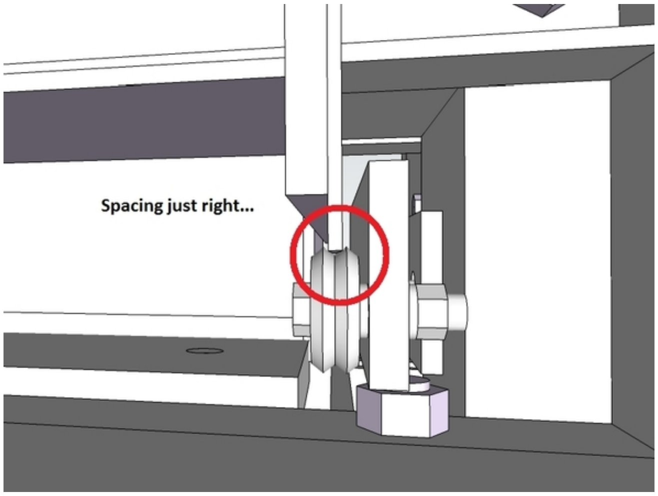
Step 1 — Put the drawer in

- Insert the drawer into the chamber as shown, in the fully retracted position. Its important that it be in the right orientation.
  - The adjustment bolts should be lowered so that the roller guides are below the rails.

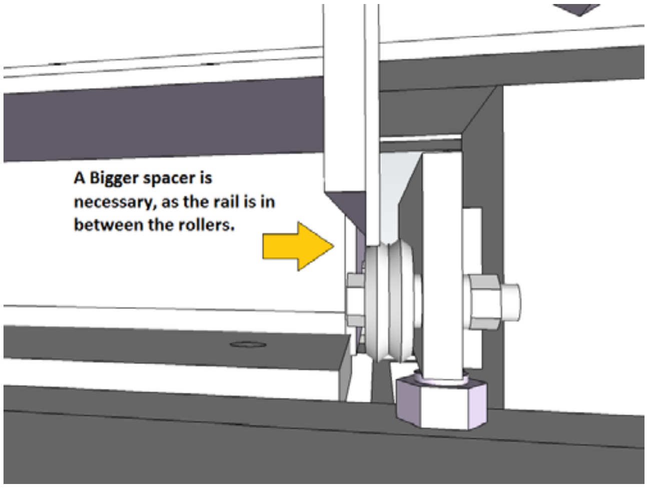




Step 2 — Align the rails with the center of the v's in the rollers.

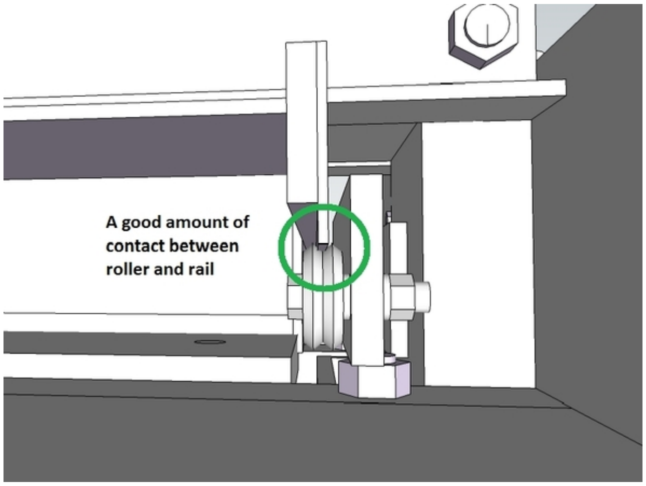


- If for some reason the rails and the rollers aren't spaced properly (the guides need to be closer or further apart) remove one of the guides and switch out the spacer on it to one that will space them properly.
- If only one roller of the four is off, the guide is not parallel with the drawer.
  - Try tightening the nut that attaches the rollers to the frame.
  - If that doesn't work, you might have welding spatter or something between the guide and the frame. Remove it and check.
- If none of the above steps make all the rollers align, your drawer is likely flawed.
  - The rails are probably not parallel. Take the drawer out and double check by measuring the separation of the rails. If they aren't parallel, see [this page.]



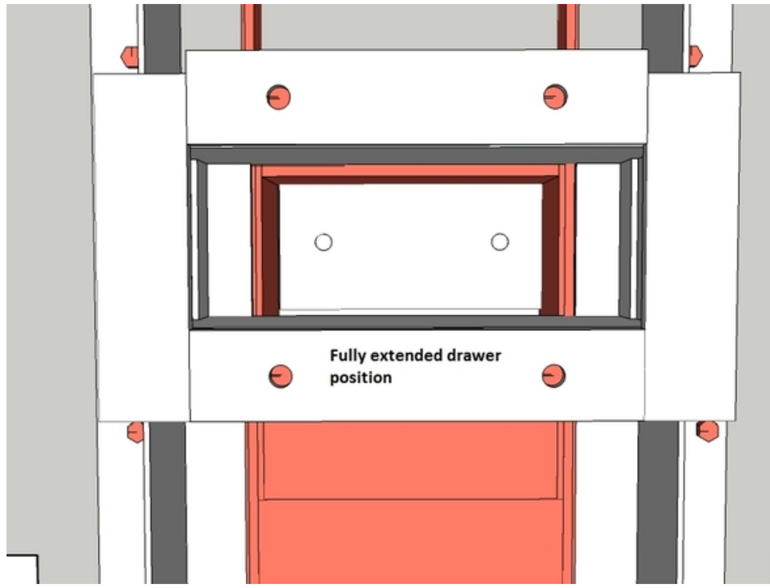
Step 3 — Tighten the rollers against the rails

- Tighten the adjustment bolts so they push the rollers up to the rail, so all of the rollers are contacting the rails.
  - The two should be touching snugly, but not forcefully.



Step 4 — Move the drawer and re-adjust bolts

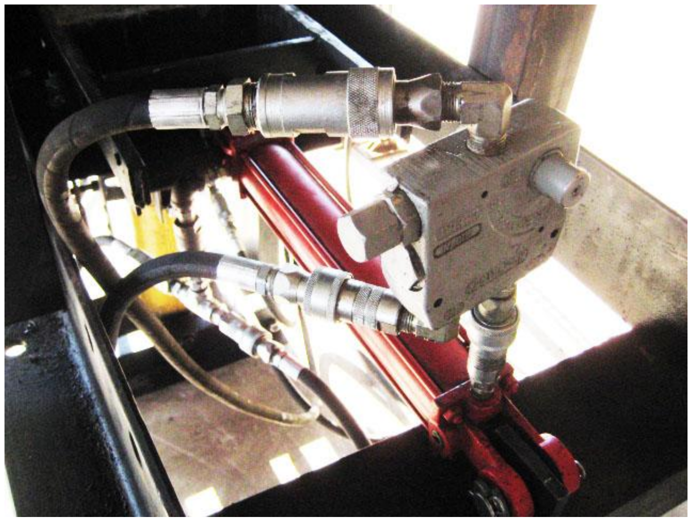
- Move the drawer to the fully extended position.
  - The drawer will likely get stuck along some points of its travel. Its OK to hit it with a hammer. Remember the secondary cylinder will be applying tons of force to move it.
  - If you need to hammer it REALLY hard, either your drawer is hitting something, or the rollers are too tight on the rails. Investigate the cause.
- When the drawer is in position, check the rollers again. They should all still be touching the rails.
  - If one is below the rail, tighten the bolt so the rail and roller are touching.



Step 5 — Slide the drawer in and out

- You will likely need to try sliding it in and out a few times before you can find the perfect amount of adjustment.
- Keep checking the contact as you slide it out.
- Your work is done when you can slide the drawer in and out and the rails stay on the roller the whole time.
  - Using a hammer is OK, but if you have to use too much force something is wrong.

CEB Assembly – Installing the Secondary Cylinder

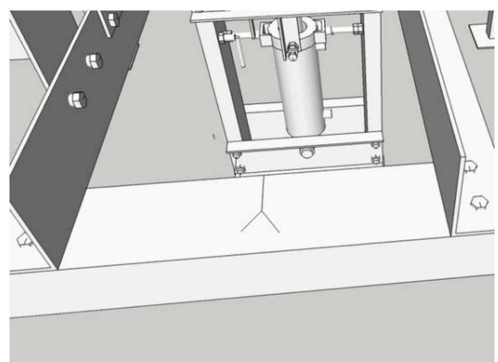


Tools Needed:

- Various Wrenches
- Welder
- Hole Puncher

Materials Needed:

- Assembled CEB
- Secondary Cylinder
- Prepared secondary cylinder hydraulics
- ½"x3" Flat – 3"(1)

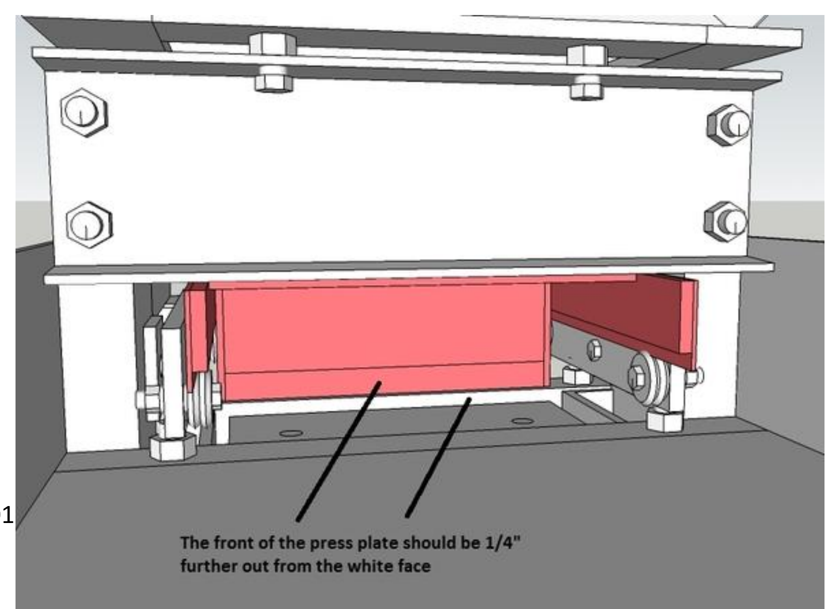


Step 1 — Mark the center between the primary arms on the secondary arm.

- This is on the opposite side of the CEB of the brickholder plate.

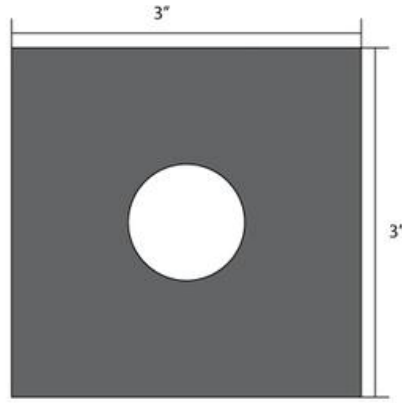
Step 2 — Position the drawer

- The drawer needs to be in the fully retracted position.
  - This is when the drawer is about to eject the brick, the press plate will be back 1/4" from the inside of the compression chamber.



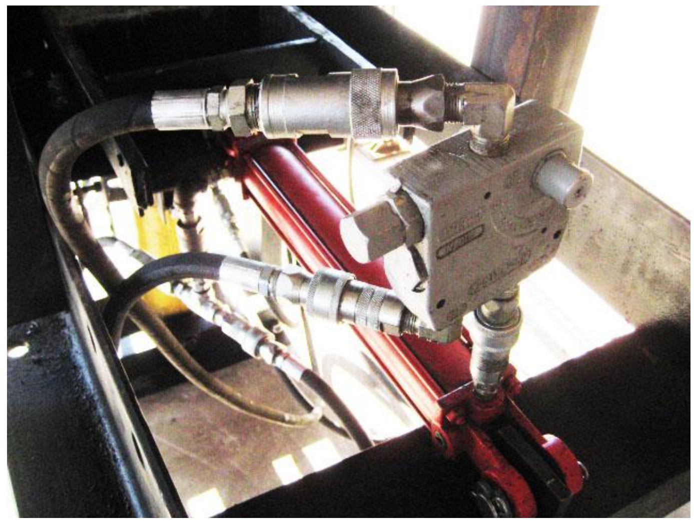
Step 3 — Prepare the cylinder mount.

- Punch a 1" hole in the center of a 3"x3" piece of 1/2" thick steel.



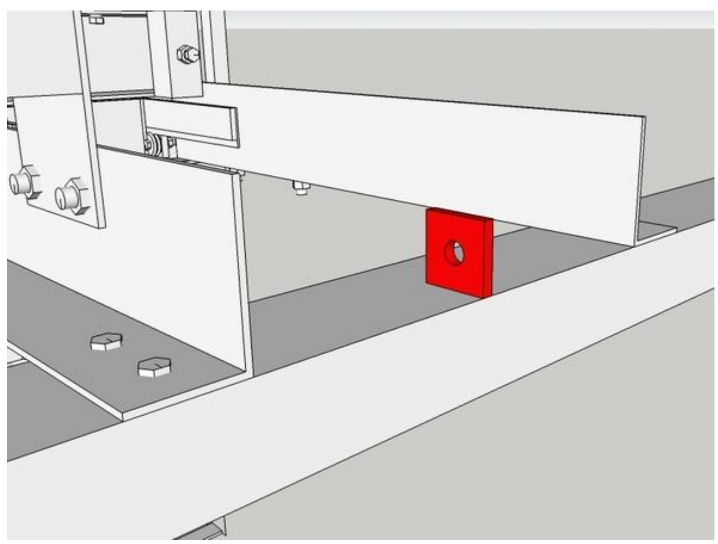
Step 4 — Place the cylinder

- The base of the cylinder attaches to the secondary cylinder. The side of the cylinder with the rod attaches to the drawer.
- On the side which attaches to the secondary arm, put the pin through the mount, a 1" washer, and the cylinder.
  - Both sides will need a 1" washer to act as a spacer so the cylinder can't slide back and forth.
- When the cylinder is attached to the drawer, place the mount on your center mark.
- Square the mount in all directions.



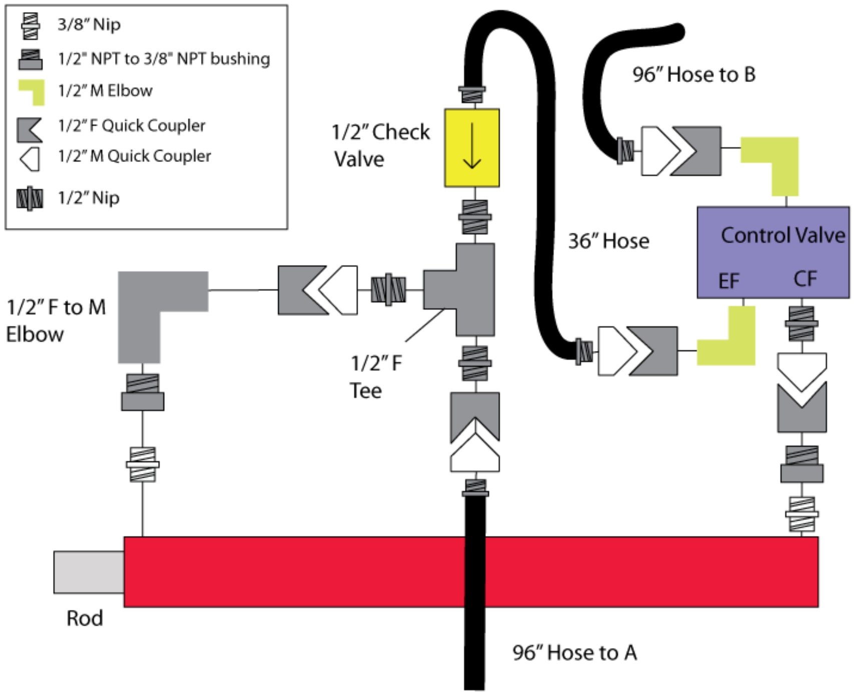
Step 5 — Weld the mount in place

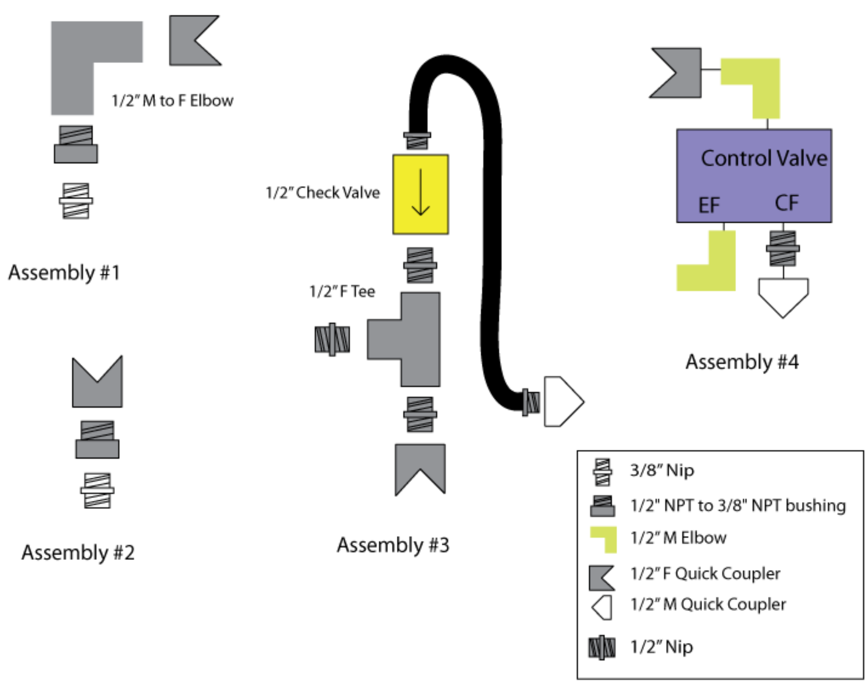
1. Tack the mount in a few places.
2. Remove the pin and move the cylinder out of the way of the mount.
   - You can slide the drawer away so you don't need to remove that side.
3. Weld the mount solid, all the way around. Make sure it stays square.



Step 6 — Install hoses

1. Return the secondary cylinder and re-mount it. Don't forget the washer.
2. Remove the plug from the port on top of the cylinder. The cylinder may have fluid in it, so keep a jar handy to catch any that spills.
3. Install Assembly #2 into this port.
4. Couple the remaining assemblies and hoses in place.





CEB Hardlining the Main Cylinder

Tools Needed:
- Various Wrenches
- Thread tape

Materials Needed:
- ½”x56” Hydraulic Hose (2)

Procedure

1. Remove the couplers and hex nipples at the elbow using a wrench.
2. Tighten the hoses (with thread tape) into the elbows.

CEB Painting the Machine

Procedure

1. Cover the hydraulics and any other place that should not be painted.
2. Check all external surfaces for sharp edges and smooth with angle grinder.
3. Remove any surface rust with wire brush and / or sandpaper.
4. Apply a thorough coating of paint to all steel surfaces.
5. Allow 24 hours to dry before handling.

CEB Electronics – Linked Extension Cord

See video first.

Tools Needed:

- Straight Pattern Tin Snips
- Wire Strippers Compatible with 16 Gauge
- Crimpers Compatible with 16 to 22 Gauge Connectors
- Measuring Tape
- Handiworks
- Compatible Set of a Soldering Iron and Solder
- Soldering Stand
- Wet Sponge or Wet Paper Towel

Materials Needed:

- Extension Cord of 50 feet (about 15 meters) having 16 Gauge Wires
- Female Insulated Electrical Connector for 16 to 22 Gauge
- Battery Alligator Clips (2)

Procedure

1. Using the tin snips, cut the extension cord such that the male cord is 6 feet in length. The cutting tolerance is 8”.
2. Using the tin snips, strip the loose sleeves of the male and female cords such that 12” of insulated wires are unsleeved. The stripping tolerance is 2”.
3. Using the tin snips, cut the green wire of the male and female cords such that none or little of the green wire is visible. The cutting tolerance is 1.25”.
4. Using the wire strippers, strip the white and black wires of the male and female cords by 0.75”. The stripping tolerance is 0.25”.
5. Using the crimpers, crimp the female connector onto the white wire of the male cord. Insure that no exposed wire lies between the wire insulation and the connector insulation.
6. Insert 1 alligator clip insulation into each of the white and black wires of the female cord.
7. Using the soldering set, solder the white and black wires of the female cord to the alligator clips.
8. Slide the inserted insulation pieces over the alligator clip handles.
9. Link the male and female cords together by their plugs.

CEB Electronics –
Sensor Unit

See video first.

Tools Needed:

- Compatible Set of Soldering Iron and Solder
- Soldering Stand
- Wet Sponge or Wet Paper Towel
- Straight Pattern Tin Snips
- Wire Strippers Compatible With 22 Gauge Wire
- Heat Gun
- Pliers
- Helping Hand
- Measuring Tape
- Wire Strippers Compatible With 8 Gauge Wire

Materials Needed:

- Hall Effect Sensor
- 1.5m of 4 Wire Underground Telephone Cable
- Silicone
- [3] 3cm lengths of Shrink Tubing
- PVC Pipe with 2.5cm Outer Diameter, 1.5cm Inner Diameter, 9cm Length

Procedure

1. Using the tin snips, cut the sleeve of the telephone wire by 5cm and 20cm at both ends. The cutting tolerance is 2cm.
2. Using the tin snips, cut the orange-white wire at both ends of the telephone wire.
3. Using the wire strippers, strip the bluewhite, blue, and orange wires of the telephone wire by 2cm at the 5cm end and by 1cm at the 20cm end. The stripping tolerance is 0.5cm.
4. Insert 3cm shrinktubing into the 5cm blue, blue-white, and orange wires.
5. Bend the sensor prongs and the exposed metal of the 5cm wires into hooks such that the 3 prong hooks can latch onto the 3 wire hooks to facilitate soldering. Use pliers to pinch the hook connections during the soldering process.
6. Using the soldering set and the helping hand, solder the hall-effect sensor prongs to the 5cm wires. The orientation of the soldering connections is such that, when you can see the sensor text and its prongs pointing downward, from left to right the colour of the wires to be soldered are: bluewhite (for 5V+), blue (for GND), and orange (for Signal).
7. Using the heat gun, cover the soldered prong-to-wire connections with the shrinktubing then apply heat to the now-covered connections. The shrinktubing should shrink, forming a tight insulating seal for each of the prong-to-wire connections.
8. Pour the silicone into the tube such that the tube is completely filled in.
9. Insert the wired hall-effect sensor into the PVC tube leaving 2cm of space at the non-insertion end of the tube.
10. Gently set the sensor unit on a flat surface and wait 24 hours for the silicone to cure.

CEB Solenoid Driver

This is a complicated step. See the wiki for troubleshooting and additional techniques or upgrades.

Tools Needed:

- Oxide Remover Solution - Ex. Isopropyl
- Masking Tape
- Etching Solution - Ex. Ferric Chloride
- Toner Removal Solution - Ex. Acetone
- Glass Bowl that fits 3" x 4.5" area dimensions with at least 1" depth
- Paper towel
- Compatible Set of Computer and Laser Printer with Glossy Paper
- Laundry Iron
- Drill Press with Number 58 Twist Drill Bit
- Compatible Set of Soldering Iron, Low-diameter Solder, Flux and Brush, Soldering Stand, and Wet Sponge or Wet Paper Towel

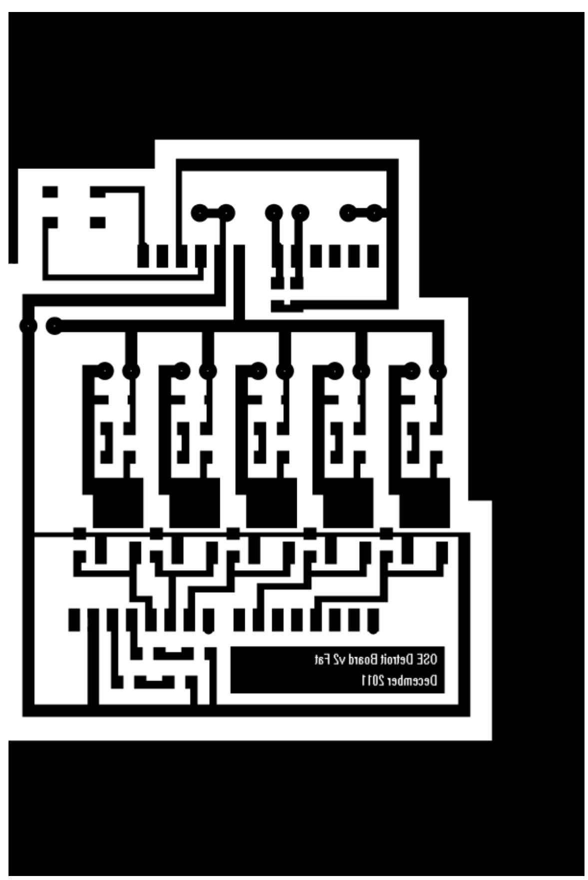
Materials Needed:

Description	Qty.
Power N MOSFET	5
Green LED	7
Diode	5
499 Resistor	5
49.9k Resistor	5
10k Resistor	2
2 Pos Terminal	9
reset switch	1
6 Pos Header	2
8 Pos Header	2
PCB	1
100 Resistor	2

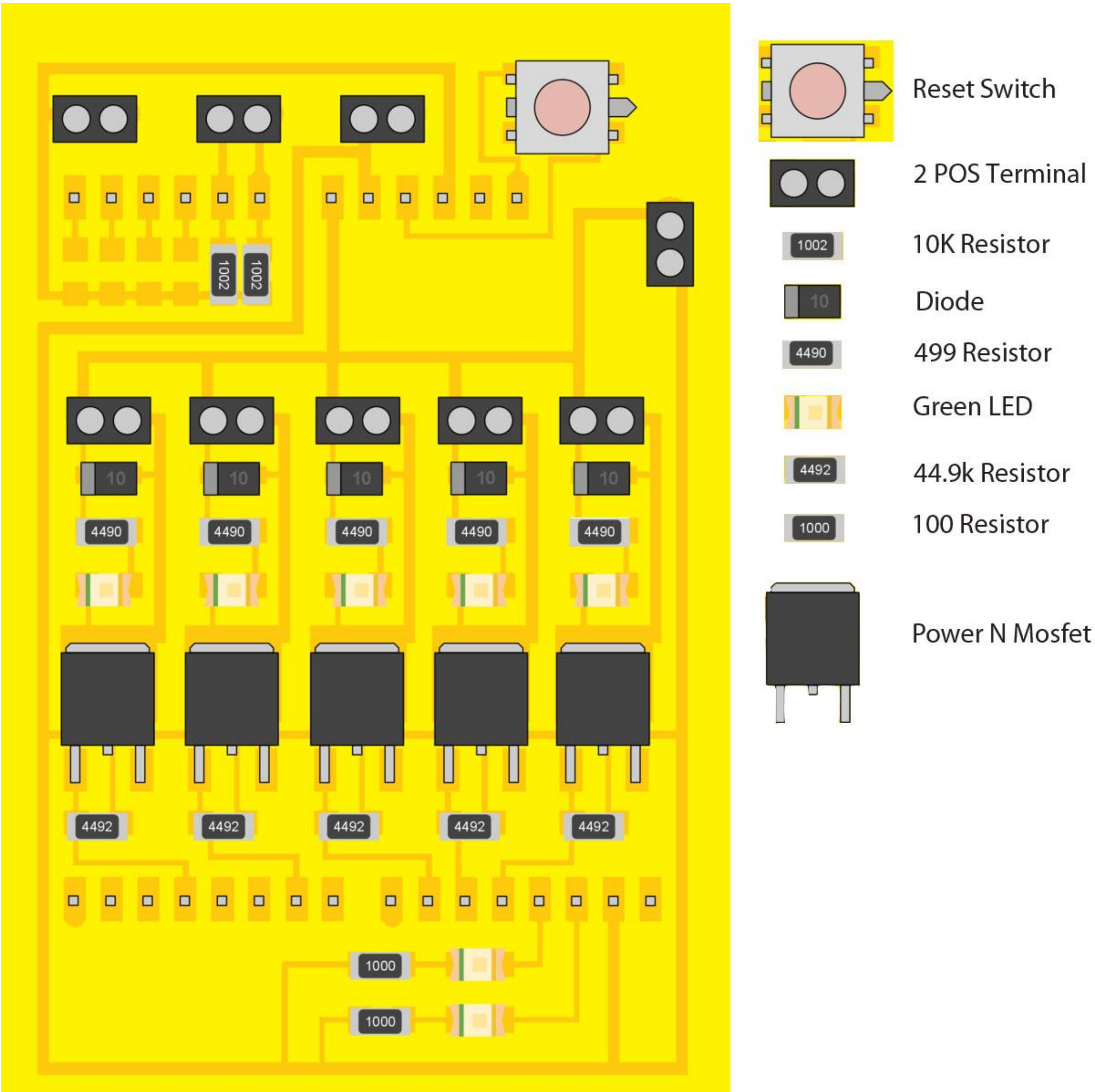
Procedure

1. **Either mill your board using this model, OR complete the remainder of this step.**

   1) Print the image on the right on laser photo paper, with dimensions of 3”x4.5.”
   2) Tape the paper onto the copper board.
   3) Using a laundry iron, heat the paper until discolored.
   4) Soak in water and peel the paper away.
   5) Agitate in pcb etchant solution for 20-30 min until copper is gone.
   6) Apply accetone to a cloth and wipe away toner.
   7) Check and fix errors.
      - Places where not enough was etched away or where too much was. Can fix by soldering or sanding.



2. **Drill** the etched board at the two rows of small grey squares where the pins would be (28 holes) and all grey circles of where the screw terminals would be (18 holes) as shown in the following diagram.



3. **Surface-mount solder** the etched and drilled copper clad board with the complete board diagram above. The 6 POS Headers go in the top drilled holes, and the 8 POS Headers go in the bottom holes.

CEB Electronics – Case

See video first.

Tools Needed:

- Screwdriver with the following bits: Quarter Inch Flathead, Half Inch Flathead, Number 1 Phillips, and Number 2 Phillips
- Hammer
- Centre Punch
- Crimper
- Cordless Drill with the following twist drill bits: 9 by 64 inch, 1 by 8 inch, 3 by 16 inch
- Needlenose Pliers
- Electrical Tape
- Tap Wrench with 8-32 Tap

Materials Needed:

- Outdoor Main Lug Box
- [2] Wire Clamps
- Toggle Switch
- [2] 3.2cm OD, 1.27cm ID Washers (1/2" Washer)
- Fuse Holder
- Male Insulated Connector for 10-12 Gauge Wire
- Ring Insulated Connecter with Small Hole for 10-12 Gauge Wire
- 10 Amp Buss Fuse
- Ring Insulated Connector for 10-12 Gauge Wire
- [2] 12cm by 7.5cm by 0.4cm high density polyethylene plate
- [4] M3 machine screws of 20mm length
- [4] M3 nylon-threaded lock nuts
- [4] 8-32 machine screws of 3/4 inch length
- [7] 8-32 machine screws of 3/8 inch length
- Arduino Uno Microcontroller
- Arduino Uno Serial Issue Solution, Replies 2 and 4 Note: for Arduino Uno Version R2, the contact point for entering DFU mode is the top-left male pin instead of the top-left pad. You'll need to perform this solution method if initial serial communication tests prove buggy. You cannot perform this after mounting the microcontroller inside the case.
- Linked Extension Cord (from prior guide)

Procedure

1. Open the lug box
2. Using the screwdriver and the half inch flathead bit, unscrew and remove the terminal components inside the lug box
3. Using the safety glasses, hammer and the centre punch, remove the inner lids at the bottom-left, bottom-middle, bottom-right, and right-bottom of the lug box
4. Mount the two wire clamps onto the bottom-left and right-bottom holes of the lug box
5. Mount the toggle switch onto the bottom-right hole of the lug box; in the process, put the 3.2cm OD washers on both sides of the lug wall.
6. Using the crimper, crimp the small ring connector and the male connector onto the two ends of the fuse holder; then insert the buss fuse.
7. Using the crimper, crimp the ring connector to the black wire of the male end of the linked extension cord.

8. Using the safety glasses, cordless drill and the 9 by 64 inch drill bit, drill holes on the first plastic plate such that 5 terminal holes are approximately evenly spaced along an axis near the top edge, and such that 2 terminal holes are located near the bottom corners.
9. Using the safety glasses, cordless drill and the 1 by 8 inch drill bit, position the Arduino microcontroller board on a second plastic plate then drill through the board mounting holes through the plastic such that the holes of the board and those of the plastic align. Use M3 Machine Screws to help align the drilled holes during the process. Be careful not to excessively ream the Arduino board.
10. Using the safety glasses, cordless drill, and the 3 by 16 inch drill bit, drill 2 mounting holes near the far edges of the first and second plastic plates.
11. Using the safety glasses, cordless drill, and the 9 by 64 inch drill bit, drill holes on the back of the lug box such that they align with the mounting holes of the first and second plastic platforms. The Arduino platform should be positioned closer to the top than the terminal platform. Leave enough room surrounding the edges of the platforms to facilitate assembly, disassembly, and wiring.
12. Using the metal file, deburr the lug box's platform mounting holes.
13. Using the tap wrench and the 8-32 tap, tap the 7 terminal holes of the terminal platform and the 4 platform mounting holes of the lug box.
14. Using the screwdriver with the number 1 phillips bit and pliers, mount the Arduino microcontroller board onto the Arduino platform through the 4 mounting holes with the 20mm M3 machine screws and the 4 M3 nylon-threaded lock nuts.
15. Using the screwdriver with the number 2 phillips bit, mount the Arduino platform and the terminal platform onto the back of the lug box by screwing the 3 by 4 inch length 8-32 machine screws through the 4 mounting holes. Use 1/2-13 nuts to act as spacers between the platforms and the back of the lug box. The arduino platform should be mounted closer to the top of the lug box than the terminal platform.
16. Insert the non-clip end of the linked extension cord into the lug box through the bottom-left hole, then connect the black wire's female connector to the fuse holder's male connector. Wrap electrical tape around the exposed male-female connection and put a small fold at the end of the tape piece for ease of disassembly.
17. Using the screwdriver with the number 2 phillips bit, connect the fuse holder's ring connector to one terminal of the toggle switch. Then connect the linked extension cord's black wire ring connector to the bottom-right screw terminal on the terminal platform.
18. Using the screwdriver with the number 2 phillips bit, tighten the screws of the wire clamp at the bottom-left of the lug box.

CEB Electronics- Controller Box

See Video

Tools Needed:

- Straight Pattern Tin Snips
- Wire Strippers Compatible with 18 and 22 Gauge
- Crimpers
- 2.3mm Flathead Screwdriver
- Screwdriver with Number 2 Philips Bit
- Needlenose Pliers
- Measuring Tape

Materials Needed:

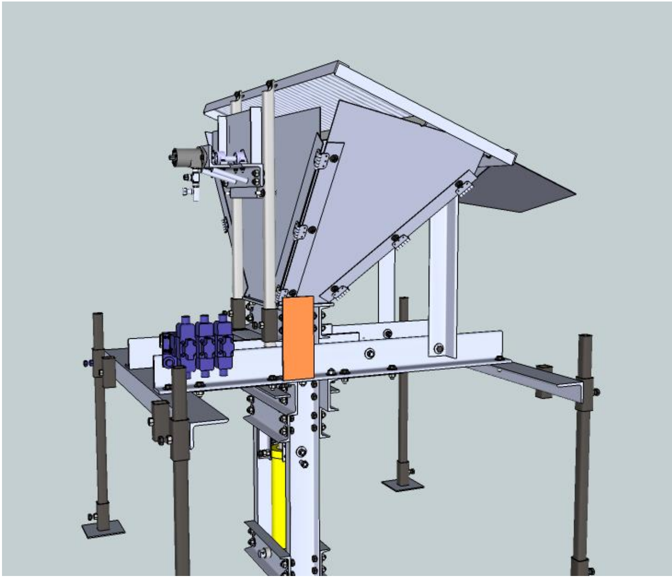
- Case
- [2] Sensor Units
- Solenoid Driver v2
- 18 Gauge Red Wire
- 18 Gauge Black Wire
- Ring Insulated Connector with Small Hole for 10-12 Gauge
- [14] Ring Insulated Connectors for 10-12 Gauge
- [6] Ring Insulated Connectors for 14-16 Gauge

Procedure

1. Mount the solenoid driver on top of the Arduino microcontroller.
2. Using the tin snips, cut 6 pieces of 20cm black wire, 2 pieces of 20cm red wire, 5 pieces of 1.5m black wire, and 1 piece of 1.5m red wire.
3. Using the wire strippers at 22 gauge, strip half a centimetre at one end of the 6 pieces of 20cm black wire and 1 piece of 20cm red wire.
4. Using the wire strippers at 18 gauge, strip a centimetre at the other ends of the 6 pieces of 20cm black wire and the 1 piece of 20cm red wire, as well as both ends of the other 1 piece of 20cm red wire, the 5 pieces of 1.5m black wire, and the 1 piece of 1.5m red wire.
5. Using the crimper, crimp the 10 to 12 gauge ring insulated connector at one of the 1 centimetre stripped ends of the 6 pieces of 20cm black wire, the 2 pieces of 20cm red wire, the 5 pieces of 1.5m black wire, and the 1 piece of 1.5m red wire.
6. Also crimp the 10 to 12 gauge small hole ring insulated connector at the remaining 1cm end of the 20cm red wire and crimp the 14 to 16 gauge ring connector to the remaining 1cm ends of the 5 pieces of 1.5m black wire and 1 piece of 1.5m red wire.
7. Using the screwdriver with the number 2 philips bit, connect the small ring end of the 20cm red wire to the remaining power switch terminal.
8. Insert the large ring end of the 6 1.5m wires through the bottom-middle hole of the lug box.
9. Using the screwdriver with the number 2 philips bit, connect the large ring end of the 1.5m red wire, the remaining ring end of the switch-connected 20cm red wire, and the ring end of the other 20cm red wire to the bottom-left screw of the terminal platform.
10. Connect the large ring end of the 5 1.5m black wires and the ring end of 5 20cm black wires to the top 5 screws of the terminal platform. Then connect the ring end of the remaining 20cm black wire to the bottom-right screw of the terminal platform.
11. Using the flathead screwdriver, connect the half centimetre ends of the 6 pieces of 20cm black wire to the lower terminal of the 5 mosfet terminal blocks, and the left terminal of the power terminal block. Note that the mosfet connections from left to right on the terminal platform should go from bottom to top on the solenoid driver. Also connect the half centimetre end of the 1 piece of 20cm red wire to the right terminal of the power terminal block.

12. Insert the 2 sensor units by their wire end into the right-bottom hole of the lug box.
13. Using the flathead screwdriver, connect the bluewhite wires, orange wires, and blue wires into the top, middle, and bottom terminal blocks, respectively, on the right side of the solenoid driver.
14. Using the screwdriver with the number 2 philips bit, screw-tighten the wire clamp at the right-bottom hole of the lug box.

CEB Mount Solenoid Valve Set and Controller Box



The CEB Assembly video also shows how to do this step. Note that the video is different than the written instructions in that they use quick couplers whereas the written instructions do not.

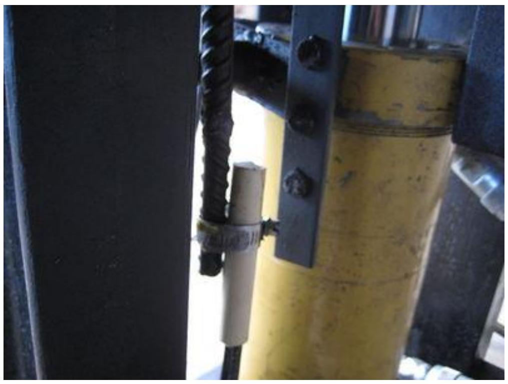
Tools Needed:

- Various Wrenches

Materials Needed:

- 3/4" Quick Coupler Set (1)
- SAE 12M to 3/4" Swivel (2)
- SAE 6M to 1/2" Swivel (6)
- Bolts and nuts for mounting on valve mount and controller
- 3/4"x1.5" Bolts (4)
- 3/4" Nuts (4)
- Power Clamps (4)
- Rare Earth Magnets (6)
- Prepared Controller Box
- Prepared Controller Mount

Install Controller



1. Bolt Controller Box to Controller Mount
2. Bolt controller mount to CEB.
3. Power clamp the sensor that has its orange (signal) wire in Arduino pin A0 (aka pin 14) next to the primary cylinder bar.
    - Attach 3 magnets to the primary cylinder bar such that they are vertically aligned and their terminals are reversing ex. NSN or SNS.
    - Space the magnets approximately 5cm apart. Change the magnet positions during testing to achieve the

desired soil loading position, maximum compression position, and press foot ejection position.

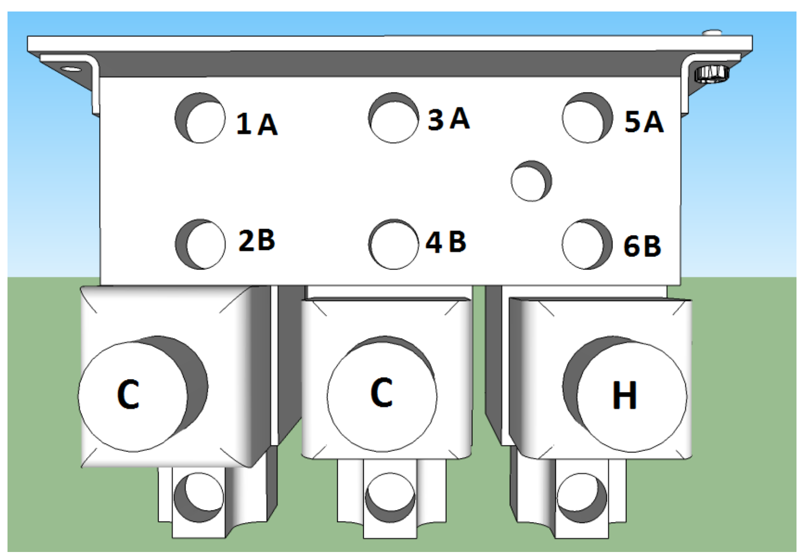
4. Power clamp the sensor that has its orange (signal) wire in Arduino pin A1 (aka pin 15) next to the secondary cylinder and soil loading drawer.
    - Attach 3 magnets to the soil loading drawer such that they are vertically aligned and their terminals are reversing ex. NSN or SNS.
    - Space the magnets approximately 5cm apart. Change the magnet positions during testing to achieve the desired soil loading position, compression position, and maximum ejection position.

Prepare Solenoid

1. Install the solenoid valves on the manifold in the order C-C-H, going from left to right, with the ports at the top.
2. Install the quick connect inlet and outlet in the side ports on the manifold. DON'T use thread tape for any connections to the manifold.
3. Onto the top of the manifold, install the 6 swivel fittings into the ports.

Install Solenoid on Machine

1. Bolt the solenoid to the valve mount.
2. Bolt the solenoid and valve mount to the primary arms on the assembled CEB.
3. Attach hoses from cylinders and shaker to manifold. See illustration for number locations.
    - 1=Main Cylinder Top
    - 2=Main Cylinder Bottom
    - 3=Secondary Cylinder Tee
    - 4=Secondary Cylinder Control Valve
    - 5=Shaker Non Return Line
    - 6=Shaker Return Line (Side with Needle Valve and Tee)



CEB Electrohydraulic Integration

See video first. Note that this process should occur only if the solenoid valve set and controller box are already mounted on the CEB press. The process is shown separately from the CEB press for clarity.

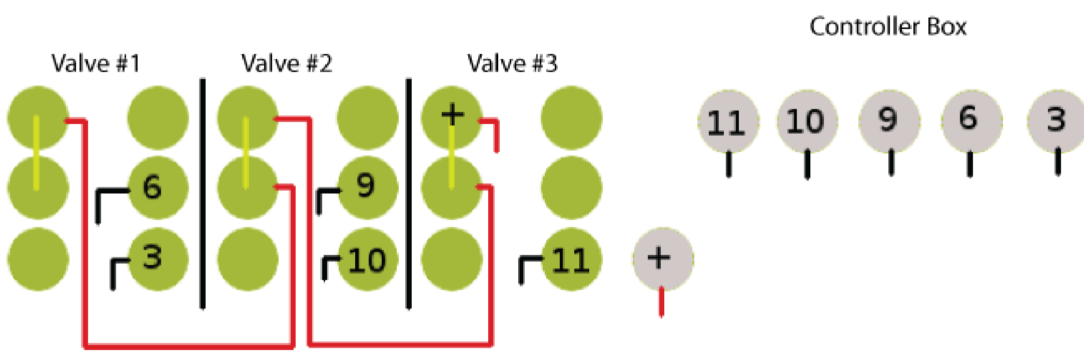
Tools Needed:

- Screwdriver with Number 2 Philips Bit
- Straight Pattern Tin Snips
- Wire Strippers compatible with 18 gauge
- Crimper
- 10mm Hex Key
- Measuring Tape

Materials Needed:

- Controller Box
  - Ensure that the connections between the top 5 terminals of the terminal platform and the left 5 (MOSFET) terminals of the solenoid driver are such that left to right (terminal platform) corresponds with bottom to top (solenoid driver), respectively. In this case, from left to right the top terminals of the terminal platform are indirectly connected to Arduino pins 11, 10, 9, 6, and 3, respectively.
- Solenoid Valve Set
  - Ensure that the solenoid valves are mounted to the subplate such that, when the work ports open away from you, from left to right the solenoid valve types are C, C, and H, respectively.
- 18 Gauge Red Wire
- [4] Ring Insulated 14-16 Gauge Connectors

Wiring Diagram



Procedure

1. Using the tin snips, cut 2 pieces of 30cm red wire.
2. Using the wire strippers, strip 1cm at all ends of the 2 pieces of red wire.
3. Using the crimpers, crimp the ring connectors at all ends of the 2 pieces of red wire.

4. Orient the solenoid valve set such that its work ports open away from you.
5. Using the hex key, unscrew the 3 hex caps closer to you.
6. Using the screwdriver with the number 2 philips bit, unscrew and remove the lids of the solenoid valve electronics.
7. Ensure and relocate if necessary the solenoid valve jumpers such that each solenoid valve has its left-middle and left-top terminals linked.
8. Screw the small ring end of the long red 1.5m wire to the left-top terminal of the rightmost solenoid valve.
9. Screw the small ring ends of the 30cm red wire to the left-middle terminal of the rightmost solenoid valve and the left-top terminal of the middle solenoid valve.
10. Screw the small ring ends of the other 30cm red wire to the left-middle terminal of the middle solenoid valve and the left-top terminal of the leftmost solenoid valve.
11. Screw the small ring end of the long black wire of pin 11 to the right-bottom terminal of the rightmost solenoid valve, pin 10 to the right-bottom terminal of the middle solenoid valve, pin 9 to the right-middle terminal of the middle solenoid valve, pin 6 to the right-middle terminal of the leftmost solenoid valve, and pin 3 to the right-bottom terminal of the leftmost solenoid valve.
12. Screw on the lids of the solenoid valve electronics.

CEB Code Upload

Tools Needed:

- Computer
- USB Cable
- CEB Press
- Arduino Integrated Development Environment Software

http://www.arduino.cc/en/Main/software

- CEB Control Code V5 Annotated

Procedure

Note that you may have to rotate the sensors about their position for the CEB Press to function properly. The hall effect sensors within the sensor units must have the correct orientation with respect to the magnets. Use the CEB Testing Code, python GUI, and Arduino serial monitor to ensure that the sensor is picking up the magnetic field from movement of the magnets.

1. Using the computer, open the Arduino Integrated Development Environment.
2. Within the Arduino IDE, click File > Open (a search box should pop up).
3. Within the Arduino IDE Search Box, navigate to and click on the .ino file in which the desired CEB code exists, then click Open.
4. Within the Arduino IDE, click Compile (if compiling failed, fix the code).
5. Connect the computer to the Arduino microcontroller via the USB cable.
6. Within the Arduino IDE, click Tools then check Serial Port for a connection and check Board for the correct microcontroller type selection.
7. Within the Arduino IDE, click Upload and wait for upload completion.
8. Disconnect the USB cable from the Arduino microcontroller.

Operation, Safety, and Maintenance

The User should acknowledge first that the Machine is a heavy piece of powered equipment, and poses inherent risks of injury or death that may result from improper usage or accidents. If all operating, safety, and maintenance procedures are followed, these risks are minimized or nonexistent.

Inherent risks for the Machine arise from several sources. First, this is a machine powered by hydraulic fluid pressure, as produced by an external power source. Second, there are risks associated with moving parts. Third, there are risks associated with the heavy weight of the machine. Fourth, there are risks associated with the electrical power delivery to the machine electronics. Fifth, there may be risks associated with the power unit used with the machine. Sixth, the machine is typically used under a workflow involving other heavy machinery used for ancillary purposes such as soil preparation and loading. All these risks, while insignificant under normal operating conditions, can be injurious or deadly when proper procedures are not followed.

Hydraulic Fluid Power - General Safety Considerations

Hydraulic fluid power is used to power the machine. The machine is plugged into a power source via hydraulic hoses. The hydraulic power is generated by an external power unit, wherein a gas, diesel, electric, or other engine drives a hydraulic pump - which in turn pumps hydraulic fluid at high pressure through the hydraulic circuit. Depending on the power unit used, the fluid going into the machine may be anywhere from 2000 to 5000 PSI. This is extremely high pressure, and may be a danger to the user in case of direct contact. For example, death or injury may result from a hose rupturing and hot, hydraulic fluid hitting a person directly. It should be noted that hydraulic fluid under normal working conditions reaches 180F (82C) in temperature, which can produce a burn on the body, and will cause serious human body damage if delivered under pressure. Moreover, loose hoses may spring back and forth as pressure is applied and released within them, so there is some danger of being hit by a flexing hose.

For safety, one should take several steps. First, hydraulic hoses, and especially exposed hydraulic hoses, should be inspected for their integrity. When a hose is damaged or worn out, it should be replaced immediately. Second, all hoses should be secured such that they move as little as possible upon pressure being cycled. Moreover, hoses should be secured in such a fashion that they do not rub against each other or against other metal parts. This prevents them from wearing out - as the rubber covering will be abraded readily, and the metal braids inside will be damaged subsequently, placing the hose at a risk of rupture. Fourth, one should stay away from the hydraulic hoses as far as possible during machine operation and one should wear safety glasses when near the machine in case of hose rupture. Hose rupture is the only risk that the machine presents to the user even when the user is not touching the machine in any way.

Moving Parts Safety Issues

The Machine has 3 moving parts: the main cylinder and its assembly; the secondary cylinder with the soil-loading drawer; the soil shaker. Any user should stay behind the Safety Rope at all times when the machine is in operation. Users with long hair should make sure that they do not catch their hair in the grate shaker motor. If the user puts their hand in the way of any pinch point, the user runs a serious risk of losing a limb immediately, and death in the worst case. The force of the main cylinder is about 40,000 lb., and the force of the secondary cylinder is about 10,000 lb. Also, note that the hoses flex like a stiff muscle when pressurized, so make sure that you are aware of this motion.

Heavy Weight Issues

The machine weighs about 1600 lb. total. The user should avoid any situation in which there is a risk of the machine toppling on top of the user, as injury or death by crushing may occur. This is especially true if the machine is being moved. The machine is designed to be moved by forklift, with forklift arms placed under the machine arms closest to the main cylinder frame. Whenever moving the machine, the User should secure the Machine to the forks with chains. When placing the machine on the ground, one should select a site with the floor as level as possible, to minimize the possibility of the machine moving. The ground directly under the 10”x10” feet of the machine should be leveled so that the feet lie flat on the ground.

Electronics Safety

The Machine electronics are powered by 12 volts via the battery clamps. Typically, the battery that comes with the power unit is tapped. One should be aware of the standard dangers of electric shock when working with 12V batteries.

Power Unit Safety

The power unit may emit loud noise, in which case any user in close proximity should wear ear protection. Standard safety procedures should be taken when dealing with engines - such as staying away from moving parts, not using indoors for risk or gaseous poisoning, and considering the risk of flammability and explosion associated with liquid or other fuels. Since the power unit connects to the Machine via hydraulic hoses, care should be taken not to step on or trip over them. Care should be taken not to damage the hoses, and to make sure that hose quick connections are securely coupled when starting the machine. There is a risk of damaging the power unit in case of hoses being disconnected if the power unit does not have an internal pressure relief bypass. If there is no internal pressure relief and a hose is not connected, hoses on the power unit run a risk of rupture due to high pressure buildup upon startup of the power unit. Moreover, users with long hair should take precautions to make sure that their hair does not get caught in any moving parts of the power unit.

Workflow Safety Issues

The workflow of a CEB production operation may involve a number of people and heavy equipment. The User should stay away from the working path of tractors or other heavy equipment, and wear protective eyewear and a hardhat.

The general workflow immediately surrounding the machine may consist of: (1), one or more tractors loading the Machine hopper from the front of the machine; (2) one or more people unloading the machine from the opposite side. The workflow should include a set of rollers or some table surface, such that the people unloading the machine are 20 feet or farther away from the hopper of the machine. This helps to prevent any accidents related to the loader-tractor operator losing control of the tractor and ramming into the Machine, and the machine hitting people on the opposite side.

The Machine soil-loader-tractor operator should attend to coming to a full stop prior to releasing the bucket to assure a controlled soil drop, and to avoid bumping the machine.

The hopper shaker will go on and off automatically according to the programming of the Machine, so the User should be aware of this so as not to be startled by the vigorous shaking.

Weather Issues

There are inherent risks associated with operating the machine in foul weather. One should never operate the machine when there is lightning in the area, and one should avoid pressing operations when it is raining or wet. Slippery ground may be dangerous when one falls and trips onto the machine and slipping may be dangerous when one is carrying a load of blocks. Each block weighs 10-20 lb., so one should wear solid boots to prevent injuries related to bricks falling. During extremely hot weather, one should pay attention to the temperature of the power unit and the hydraulic fluid, and discontinue operations if the hydraulic fluid gets too hot. In extremely cold weather, one should first warm the machine up by running on idle, or undue stress result in premature hydraulic hose rupture.

Safety Features

The Machine is built with a number of safety features:

Pressure Reliefs - The Machine features 2 pressure relief valves to release hydraulic system pressure above 2200 PSI, in order to prevent pressure buildup that could potentially rupture hydraulic hoses. The pressure reliefs may be activated upon: (1), jamming or other unforeseen machine condition; (2), end of the compression stroke of the main cylinder; (3) cylinders reaching their limits. The pressure reliefs are essential to the safe and efficient operation of the Machine, and they are activated on a continuous basis. The main pressure relief is located on the main hydraulic hoses, and the second pressure relief is located on the solenoid valve.

Kill Switch - the safety rope around the machine, which also serves as the power cord for the automatic controls, serves as a kill switch. When this rope is pulled from any of the 3 sides other than the control panel side, power is shut off to the machine. Another power switch is located on the bottom of the controller box.

Hopper Orientation - The hopper is oriented in such a fashion that the tractor-loader approaches the machine from one side, and bricks are ejected from the other side. The machine is designed for use with brick rollers, such that brick rollers should be attached to ejection side of the Machine. With brick rollers in place, people are removed away from the machine by a recommended distance of 20 feet or more.

Moving Part Covers - All moving parts are inaccessible to the user when the user remains behind the safety rope. The main cylinder is within the main pressing frame, shielded on 4 sides from the user. The hopper shaker eccentric is located behind a safety shield, away from users.

Machine Testing Code - cylinder, bypass valve, and shaker motor functions may be tested independently with supporting control code to determine proper functioning of these components

Indicator Light on the Power Switch - Machine on-condition may be determined visually by observing whether the power switch is lit.

Indicator Lights on Control Circuit - For troubleshooting purposes, indicator lights on the solenoid driver board light up to indicate which solenoid sections are activated. Wear protection - There are 4 adjustment bolts to keep the press foot positioned away from the walls of the compression chamber. This minimizes and at best eliminates metal-on-metal contact in the compression chamber, to extend machine life. The hopper loading drawer rides on v-groove rollers above the table surface, so wear is minimized on the drawer surfaces.

Operation and Maintenance Procedures

For safe operation of the machine, all the points in the above Operation, Safety, and Maintenance section must be kept in mind and followed. In addition, here are further, specific operation and maintenance points:

Assembly

Follow the CEB Assembly Video to put the machine together.

Complete the Machine assembly prior to testing and running the machine.

First Run and Setup

Follow the Initial Setup and Testing Procedure on the wiki, and verify that the relief valve, 2 cylinders, and hopper shaker are in working order.

Inspect all hoses and hose connections.

Tighten any bolts on the main frame section and any other bolts that may have loosened during shipping.

Follow all points relevant to every machine run in the next section.

Set the brick thickness and machine speed as needed, by following the Machine Adjustments section.

Every Run

Stay behind the safety rope at all times during operation, and remain 20 feet away from the machine unless you need to be closer.

Inspect all hydraulic hoses for wear prior to beginning of brick production, and replace any defective hoses.

If the machine locks up for any reason, turn the power off immediately, identify and correct the problem, and restart machine.

Do not touch the machine while it is in operation.

If you have long hair, make sure that it is kept away from the hopper shaker motor. Your hair may get wrapped up in the motor and pull you in, potentially killing you.

Do not loosen the leg bolts when the machine is standing. Machine level adjustment should be performed only when a set of tractor forks or other jack is in used to prevent the machine from falling down when the machine leveling is being adjusted.

Wear safety goggles and a hard hat during machine operation, and ear protection in case the power unit makes a lot of noise.

Listen to the relief valve system to make sure that it is working properly. You should hear a hiss every time the bypass condition happens.

If you hear that the power source is bogged down or if it stops, disable the Machine immediately and identify the issue.

Check all accessible bolts by hand or visually to make sure than they have not loosened during operation.

Maintenance and Repair

There is little maintenance that needs to be done to the machine. This is due primarily to the absence of a power unit on the machine. For storage, take off the hopper grate and clean soil from the machine. Store the machine indoors to prevent rusting. Cap the hose ends so that dirt does not get into the hoses.

If any parts become damaged structurally for any reason, assess the damage and replace the part if needed. All parts are either stock steel or off-shelf components. Most of the machine features bolt-together, design-for-disassembly, and most parts may be replaced readily. The entire machine can be taken apart in about 5 hours for study or refurbishing, and as long as the machine is kept free from rust, it should last from generation to generation. We recommend a new paint job every 10 years, including the inside the main frame. The inside of the compression chamber is the only part that may wear out in time. Replacement of the front and back u-channel pieces involves approximately a 2 hour job involving the drilling of holes and minor welding, and replacement of the side wear plates involves torching off the old ones and welding on new ones, which is about a 2 hour job if the machine frame is already taken apart. Material costs for these repairs involve a total of about US $40.

Troubleshooting

For the machine to operate properly:

- Hydraulic power must be available by a power source.
- Hydraulic power must be delivered to the actuator.
- Electrical power must be available from an electrical source.
- Electrical power must be delivered to the power usage points.
- The logic system must be providing control logic.
- Control logic must receive position feedback from sensors.

To troubleshoot the hydraulic system - see ***Appendix: Hydraulic System Troubleshooting***

Electric System Troubleshooting:

- Is the power turned on?
- Is there a master power switch that is turned off?
- Is there an indicator light that tells that power is on?
- Check that an electric source has electric power
- Check polarity of connection to power source.
- Check the connection from the electric power source to wires.
- Check the integrity of wires.
- Check the connection of wires to the component that uses power
- Check for loose connections on the device receiving power
- Check that a device is grounded properly
- Check for frayed or broken insulation
- Check whether a fuse is burned out
- Check if any safety component or breaker is tripped
- Check whether voltage is being delivered to a device

Mechanical System Troubleshooting:

- Check that bearings are rolling smoothly
- After tightening bearings and shafts, make sure that shaft is aligned and it spins freely

- Check for obstruction on any moving parts, such as rocks, metal, or wood branches
- Check that bolts are secured and not loose
- Check for any broken parts by visual inspection
- Check for signs of wear or rubbing of mechanical parts
- Check that parts are greased as needed

User Responsibilities

The User takes on the full responsibility of using the plans to build a CEB machine, by ensuring that the User follows all CEB build, safety, maintenance, and operation procedures. It is the duty of the User to accept that accidents and unforeseen circumstances may occur by using, and that such happenings may place the User in danger of injury or even death. The User agrees to not hold OSE liable for any accidents or deaths, and the User agrees to not pursue any legal action against OSE and his or her agents and collaborators in the case of harm, injury, or death resulting from use of the Machine, regardless of the cause or reason for the accident. It is the duty of the User and his/her collaborators or work crew to read and understand the Assembly, Setup and Testing Procedure, Machine Adjustment, Troubleshooting, and all of the above safety, maintenance, and operation procedures. Furthermore, the User agrees to not solicit the services of any agents, assigns, or other third parties to pursue legal action against the Producer in the case of accidents or death related to use of the Machine. If the User allows any other person or group to use the machine or participate in brick production, the User likewise agrees to take on the full responsibility and liability associated with any harm or injury that may happen to anyone involved in using the Machine, and shall hold the Producer in indemnity.

Therefore, the User hereby agrees to release and forever discharge OSE from any and all liability, claims, and demands of whatever kind either in law or in equity, which arise or may hereafter arise from the building or use of the Machine by: (1), the User, (2), others involved with the User in the build or use of the Machine, and (3), others to whom the User grants use of the Machine. The User furthermore agrees and understands that this contract discharges OSE from any liability or claim that the User may have against OSE with respect to bodily injury, personal injury, or property damages that may result from the User's and Beneficiary's production or use of the machine, wherever the Machine may be used. The User also understands that the Producer does not assume any responsibility for or obligations to provide financial or other assistance, including but not limited to medical, health, or disability insurance in the event of injury or loss – unless OSE agrees to help the User or Beneficiary out of voluntary, good faith and honor.

Tractor

LifeTrac

Design Rationale

Definition: LifeTrac is a low-cost, multipurpose open source tractor. LifeTrac is a versatile, 4-wheel drive, full-sized, hydraulically-driven, skid-steering tractor of 18-75 hp with optional steel tracks. LifeTrac is intended to be a minimalist but high-performance, lifetime design, design-for-disassembly workhorse and power unit of any land stewardship operation. It features featuring easy serviceability by the user. Its modular nature allows for quick attachment of implements; interchangeability/stackability of multiple power units (Power Cubes) for adopting power level to the task at hand; quick attachment of all hydraulic components via quick-coupling hoses; including quick interchangeability of hydraulic motors for use in other applications. It can be fitted with up to two sets of loader arms. LifeTrac is intended to be used with modern steam engine Power Cube module for fuel flexibility, such that locally-harvested, pelletized biomass crop, such as hay, may be used for fuel. Regarding safety features, LifeTrac replaced the traditional power take-off (PTO) shaft for driving other implements with a detachable hydraulic motor for the same purpose, where this motor may be mounted on the tractor, on the implement, or wherever it is required.

Problem Statement – Industrial tractors are being designed increasingly for planned obsolescence with 10 year lifespans, and the user typically cannot service their own tractor due to complexity of design. Power transmission and engine systems are the dominant failure modes of tractors. Fuel costs are a significant expense of operating a tractor. Capital costs of purchasing tractors typically place their users in debt.

Solution – LifeTrac is designed to be the peoples' tractor. The user is able to service, modify, and produce fuel for the tractor. Gear transmission is replaced with a hydraulic drive train, where quick-connect, flexible hoses are the means of transferring power. Lifetime design (bolt-together construction, modularity) with general purpose parts allows the tractor to be passed down from generation to generation, before its life-cycle is completed as feedstock for the induction furnace. The absolute simplest design facilitates creation of small-scale enterprise for manufacturing these tractors in as little as 3 days of time using a RepLab1 facility. This allows communities to be entirely self-sufficient in their mechanical power infrastructures, while reducing lifetime costs of tractors by a factor of at least 10.

Development Status and Needs – We have completed Prototype I-III, and we are currently on Prototype IV. Prototype I (ref) was an articulated version of the tractor without roll cage, and Prototype II (ref) was an enclosed version with tracks and skid steering. Prototype II has demonstrated quick-attachment and stackability of power units (ref), as well as interchangeability of wheel motors and control valves via quick-couplers for repurposing in other applications. Prototype III was a shortened version of Prototype II with only one set of loader arms, and it featured CNC Torch Table assist in its fabrication. Prototype IV (Current as of Dec. 2011) introduces Quick Connect Wheels. Moreover, minor redesign (thicker wheel shafts and bearings (2.5" instead of 1-7/8") of LifeTrac lend themselves to adaptation as a tracked bulldozer – via addition of chain gear reduction to the direct-coupled wheel drive.

LifeTrac satisfies many of the OSE Core Values

Open Source: The LifeTrac was designed from the ground up with the intention of making freely available not only the design, but also the education necessary to understand, use, and improve the design.

Low Cost: As compared to its commercial equivalent, the LifeTrac is 1/5 of the cost to acquire. There are even more dramatic reductions in the cost to own.

Do-It-Yourself: Most of the components and sub-assemblies are held together with bolts. If you've got a wrench you've got a tractor.

Closed-Loop Manufacturing: Because the materials the LifeTrac is made out of require so little machining, they can be produced by future GVCS machines. No need for exotic materials or fancy injection molding.

Industrial Efficiency: The LifeTrac's performance is designed to be comparable to industry standards, and we are approaching that point quickly.

Lifetime Design: Unlike what is available commercially, the LifeTrac is designed to function indefinitely. Design for obsolescence is avoided, as maximum service to the user is part of the design.

Robustness: It ugly, but it works.

Technological Recursion: LifeTrac is part of technological recursion at the deepest level, in that it is responsible in part for extracting raw resources from which all things are made.

Local Resources: What good are the resources under your feet if you can't use them? The LifeTrac opens up new avenues for self-sourcing.

Replicability: With full documentation of how to source the materials, build the tractor, and use it in the field, the LifeTrac eradicates barriers to entry.

LifeTrac

Fabrication Report

Disclaimer:

When building this tractor you are explicitly assuming full responsibility for the safety of yourself, anyone who helps you, anyone who wanders past, and anyone who uses the tractor or is nearby while it is being used. OSE accepts no responsibility for the quality of your work.

Warning:

This tractor is a heavy piece of equipment and carries with it significant operating risks inherent to heavy, mobile machinery. OSE recommends that you obtain experience in construction, agriculture, engines and heavy equipment operation prior to building this tractor.

Warning:

The current design does not include a seat belt, safety bar, or operator cage. However, it does not prohibit them either.

Warning:

Do not use on hillsides or uneven terrain which may cause the tractor to tip.

Warning:

Neither axle should support more than 70% of the combined weight of the tractor and load. Do not lift objects more than 1,000 lbs without ballasting the rear of the tractor to maintain at least this 70/30 distribution. The maximum load the tractor can handle is 4,000 lbs, with proper ballast, or 8,000 lbs if the rear of the tractor is fastened down.

Note:

This tractor is currently in the beta release stage. If you build the tractor you are a developer. It is strongly suggested that you contact OSE prior to building and remain in contact throughout the process.

Note:

This report is the last step in a distributed collaboration process. It is recommended that you obtain the digital OpenProj file and a copy of OpenProj (free and open source). You will be able to organize your fabrication project with only a few mouse clicks. Track your progress with the digital tool, then send your final file back and it can be used to improve the machine and the documentation.

Editor: Matthew Maier

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Frame Jig: Matt Griffing

Cover tractor image: Isaiah Saxon

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Published by: Open Source Ecology

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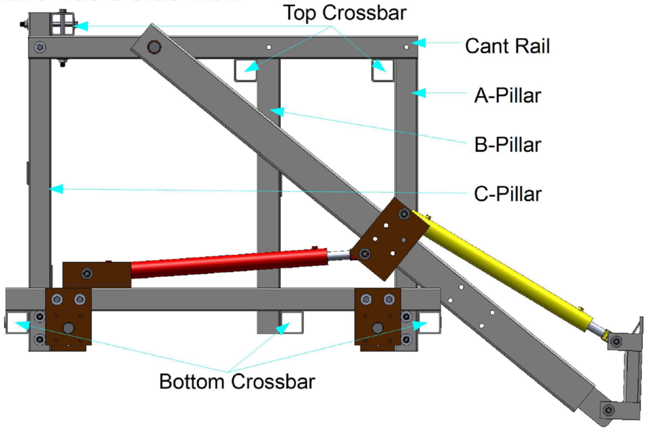
Introduction

This guide will walk you through the entire process of fabricating LifeTrac, Open Source Ecology's general purpose tractor.

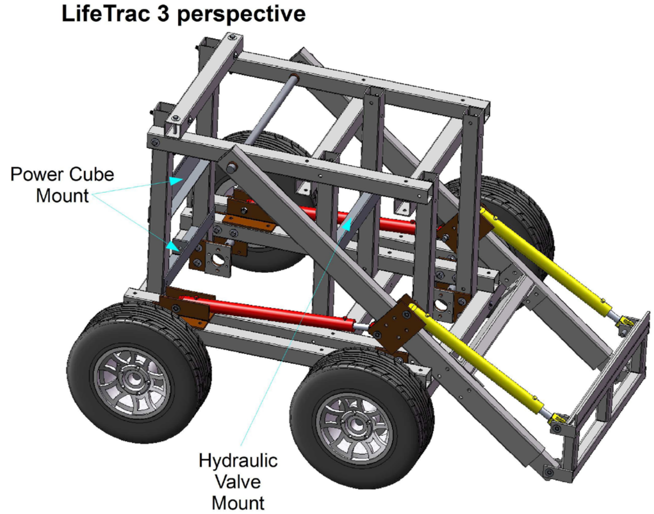
This guide documents Prototype III. Prototype IV has bent loader arms and quick attach wheels. Prototype IV has about 20 hours of run time as of 7 February 2012. The upgrades are recommended, however, documentation is not complete.

There are two primary sections: Definitions & Project Steps. Definitions are sufficient for an experienced fabricator to replicate the LifeTrac. Project Steps are an addition that makes organizing the effort easier and provides a standardized format to guide discussion and feedback.

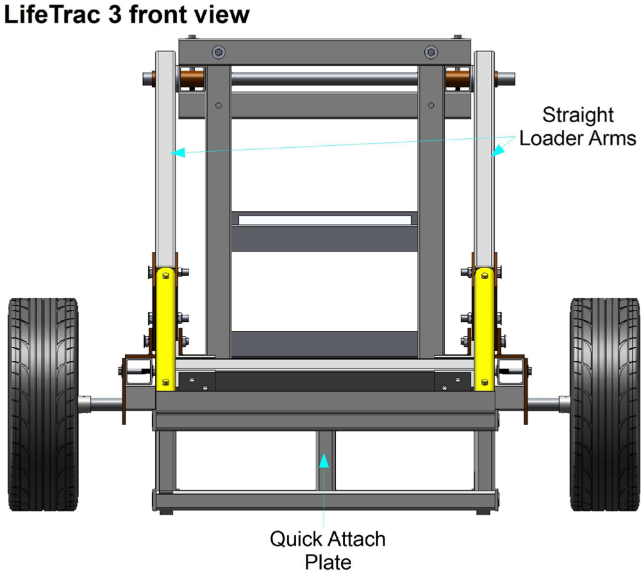
LifeTrac 3 side view



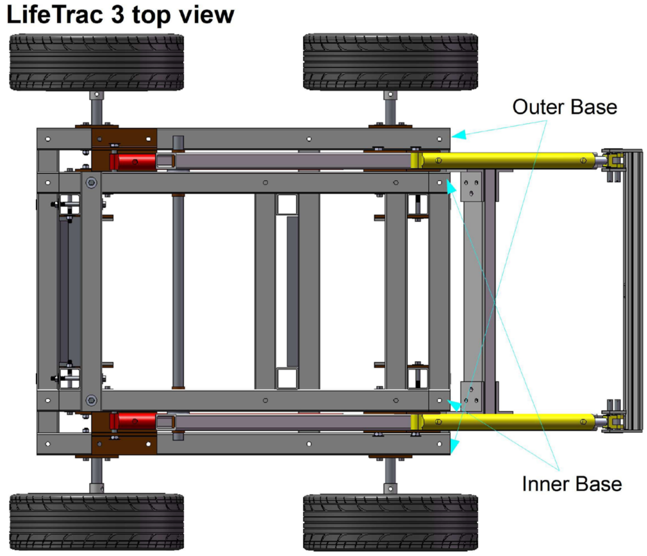
LifeTrac 3 perspective



LifeTrac 3 front view



LifeTrac 3 top view



Bill of Materials

Tools		
	Metal Saw	
	Drill	
	Cutting Torch	
	welding torch	
	Tape Measure	
	hand-held grinder	
	pipe wrench	
	Lathe	
	Center Punch	
	5/16" hex wrench	
	9/16" wrench	
	3/4" wrench	
	cinder block	
	Frame Hole Jig	
Consumables		
	grease	
	Teflon tape	~15 feet
	1/8" drill bit	
	1/4" drill bit	
	1/2" drill bit	
	5/8" drill bit	
	3/4" drill bit	
	13/16" drill bit	
	1" drill bit	
Bar		
	1" dia by 6" bar	x10
	1 3/8" dia by 6" splined shaft	x4
	1 7/8" dia by 26" bar	x4
	1 7/8" dia by 56" bar	

Tube		
	1 7/8" inner dia by 3 1/2" tube	x2
	1 7/8" inner dia by 4 1/2" tube	x2
	1 7/8" inner dia by 6" tube	x4
	3" x 3" by 9" square tube	x3
	3" x 3" by 51" square tube	x2
	3" x 6" x 3/8" by 45" rectangle tube	x1
	3" x 6" x 3/8" by 100" rectangle tube	x2
	4" x 4" x 1/4" by 44" square tube	x3
	4" x 4" x 1/4" by 52" square tube	x2
	4" x 4" x 1/4" by 55" square tube	x2
	4" x 4" x 1/4" by 59" square tube	x2
	4" x 4" x 1/4" by 60" square tube	x3
	4" x 4" x 1/4" by 68" square tube	x2
	4" x 4" x 1/4" by 76" square tube	x4
Flat		
	2" x 1/2" by 51" flat	
	3" x 1/2" by 3" flat	x4
	3" by 1/2" by 6" flat	x4
	3" x 1/2" by 51" flat	
	4" x 1/4" by 26" flat	
	4" x 1/4" by 44" flat	
	4" x 1/4" by 76" flat	
	4" x 1/2" by 4" flat	x17
	4 1/2" x 2" by 8" flat	x2
	8" x 3/8" by 12 1/2" flat	x4
	8" x 1/2" by 6" flat	x4
	8" x 1/2" by 10" flat	x12
	12" x 1/2" by 4" flat	x4
	12" x 1/2" by 12" flat	x6
Angle		
	4" x 6" x 1/2" by 6" angle	x4
	4" x 4" x 1/4" by 36” angle	x3
Hardware		

Nuts		
	9/16" locknut	x32
	3/4" locknut	x114
	1" nut	x12
Washers		
	9/16" washer	x64
	3/4" washer	x238
	1 7/8" washer	x20
Bolts		
	9/16" by 2" bolt	x32
	3/4" by 2" bolt	x8
	3/4" by 4 1/2" bolt	x18
	3/4" by 5 1/2" bolt	x46
	3/4" by 9 1/2" bolt	x42
Misc		
	1/8" cotter pin	x10
	1 7/8" lock collar	x18
Hydraulics		
1/4” Hex		
	1/4" NPT female quick coupler	x4
	1/4" NPT male quick coupler	x5
	1/4" NPTF 90 elbow	
	1/4" NPTF tee	x3
	SAE 4 to 1/4" NPT nipple	x4
	1/4" NPTM hex nipple	x4
1/2” Hex		
	1/2" NPT female quick coupler	x9
	1/2" NPT male quick coupler	x9
	1/2" NPTF tee	x8
	SAE 10 to 1/2" NPT nipple	x10
	1/2" NTPM hex nipple	x4

	SAE 10 to 1/2" NPT swivel	x8
	1/2" NPT swivel	
	3/8" to 1/2" NPT swivel	x6
	3/8" to 1/2" NPT 90 elbow swivel	x2
3/4" Hex		
	3/4" NPT female quick coupler	x8
	3/4" NPT male quick coupler	x8
	3/4" NPTF 90 elbow	
	3/4" NPTF tee	x2
	3/4" hex nipple	x10
	3/4" power beyond sleeve	x2
Hoses		
	1/4" by 36" hose	
	1/4" by 60" hose	x2
	1/4" by 72" hose	
	1/2" by 12" hose	x2
	1/2" by 36" hose	x10
	1/2" by 48" hose	x7
	1/2" by 60" hose	
	1/2" by 120" hose	
	1/2" by 144" hose	
	3/4" by 96" hose	x4
Valves		
	1/2" cushion valve	
	3/4" NPT check valve	x2
	2-spool valve	
	3-spool valve	
Actuators		
	30" cylinder	x2
	36" cylinder	x2
	31.88 cubic inch motor	x4

Frame Hole Jig

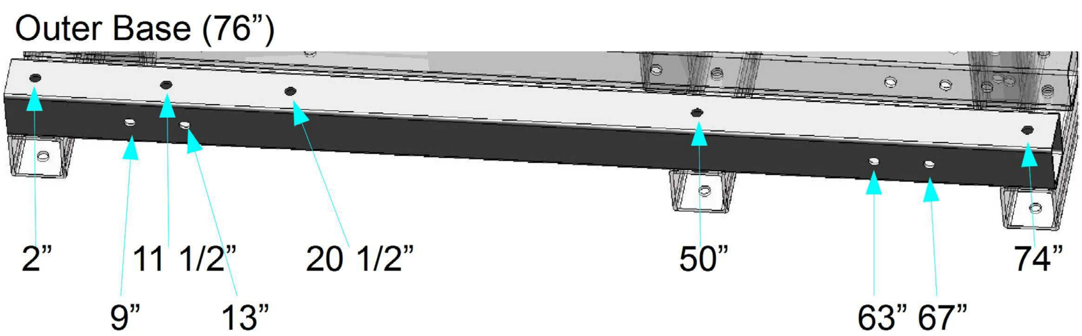
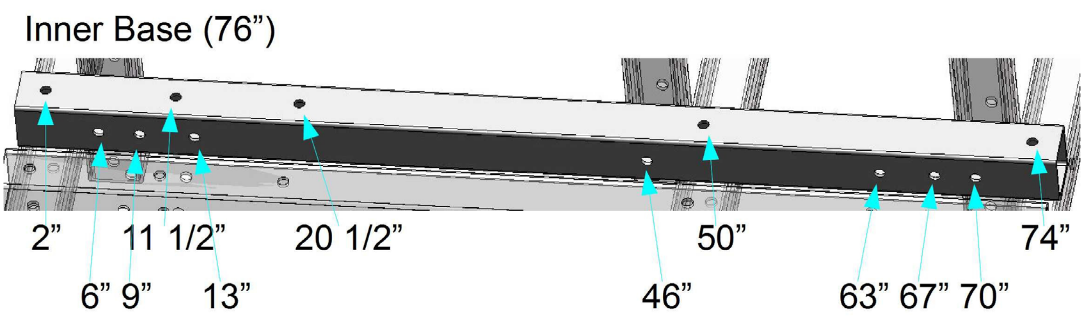
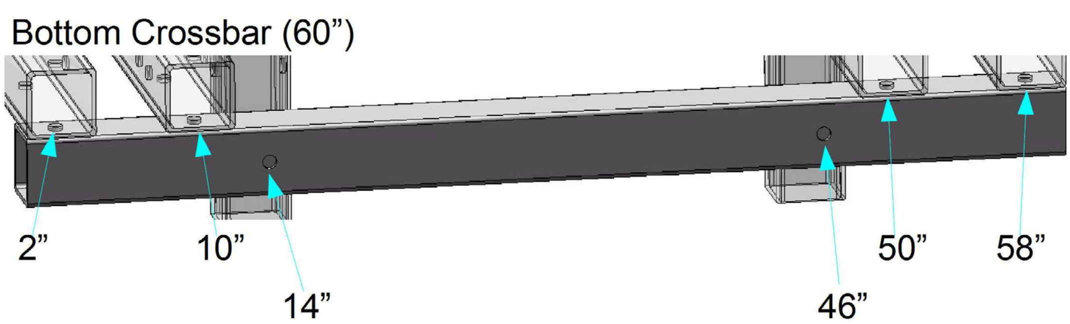
Cut a piece of 4” wide flat stock to 76” long. Starting at one end, mark (centered) and drill 1/4” holes at the following distances:

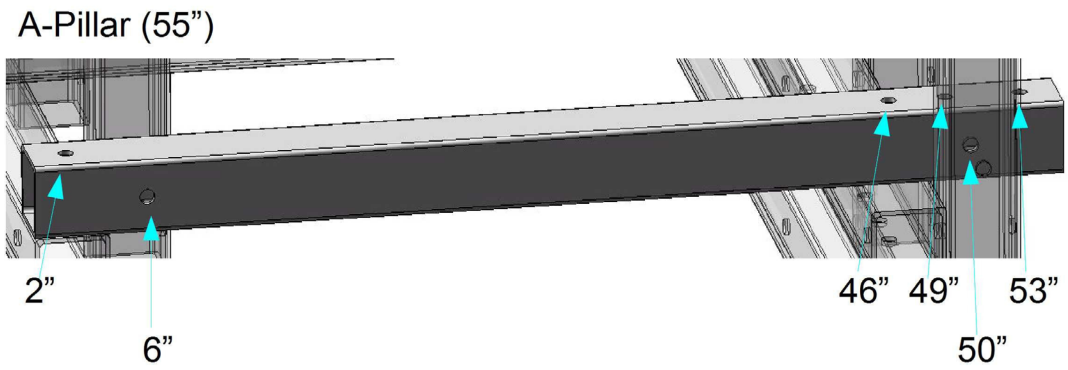
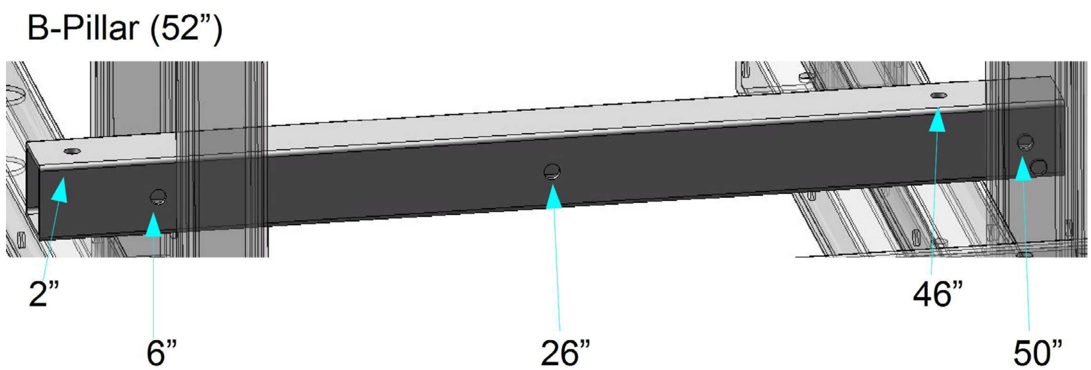
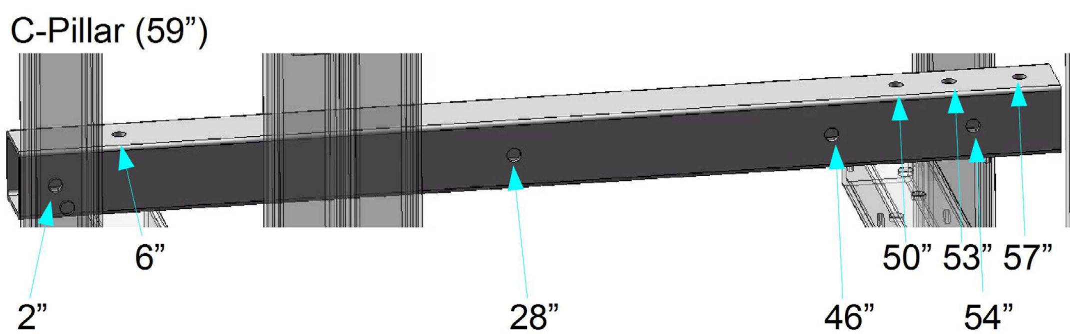
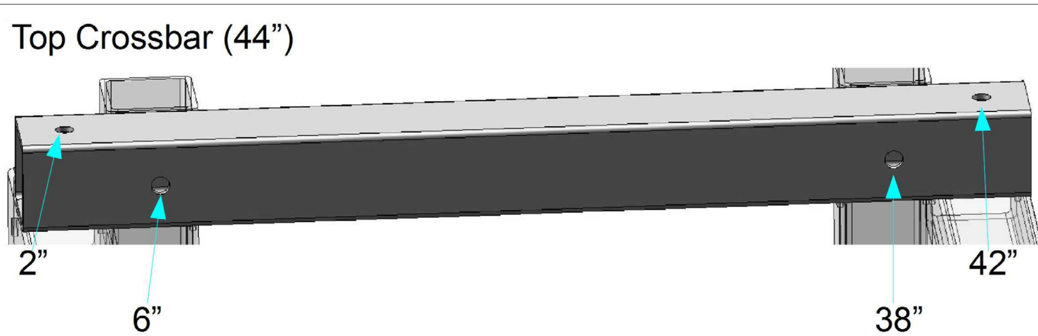
- 2”
- 6”
- 9”
- 10”
- 11 1/2”
- 13”
- 14”
- 20 1/2”
- 26”
- 28”
- 30”
- 38”
- 42”
- 46”
- 49”
- 50”
- 53”
- 54”
- 57”
- 58”
- 62”
- 63”
- 66”
- 67”
- 70”
- 74”

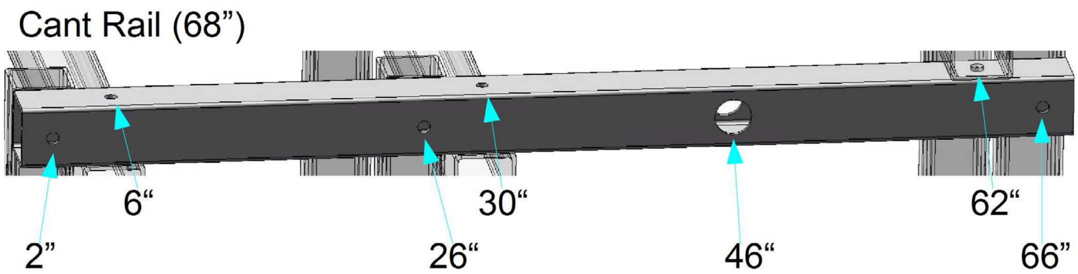
Definitions

Frame Tube Lengths & Hole Positions

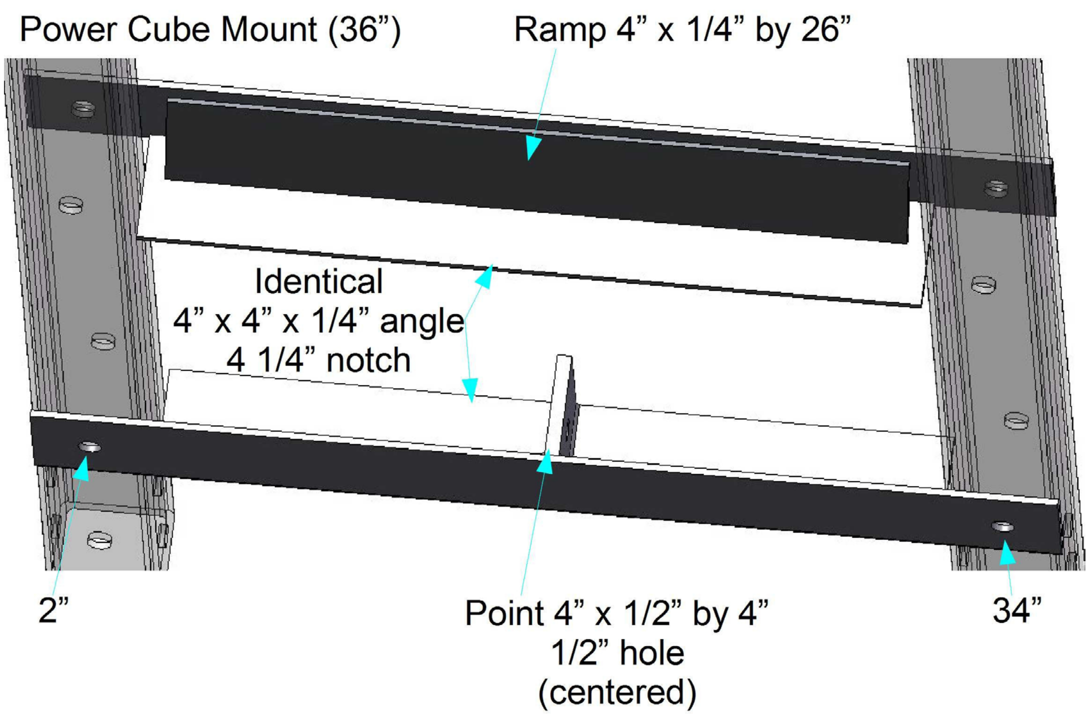
- All frame members are 4” x 4” x 1/4” steel tube.
- Use the Frame Jig to mark matching holes on opposite sides of the tube.
- Drill each mark 13/16” (unless otherwise specified).
- Do not drill all the way through the tube from one side unless using a drill press.

Part	Illustration
Outer Base	
Inner Base	
Bottom Crossbar	

A-Pillar	
B-Pillar	
C-Pillar	
Top Crossbar	

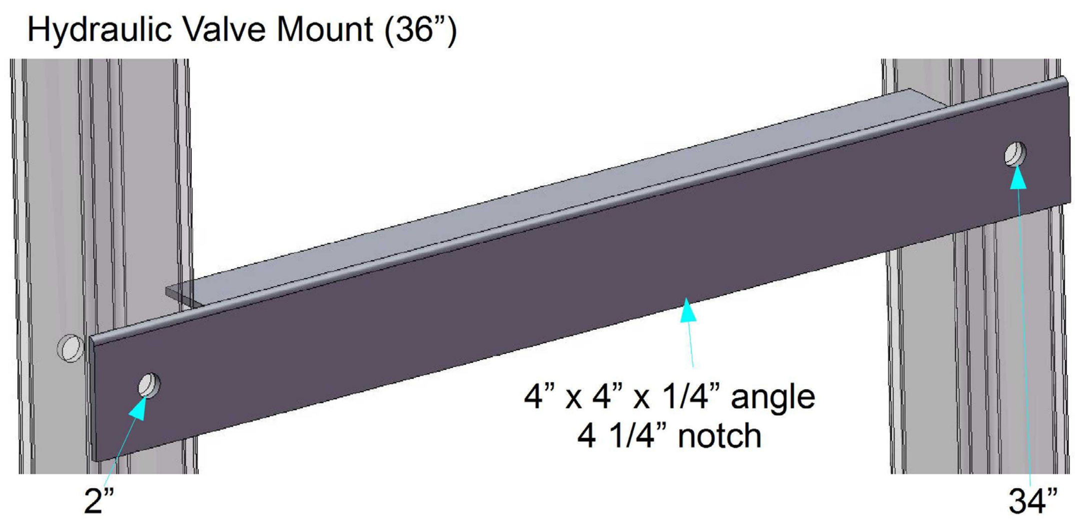
Cant Rail The big hole at 46" should be 2 3/8". Use a cutting torch.	

Power Cube Mount

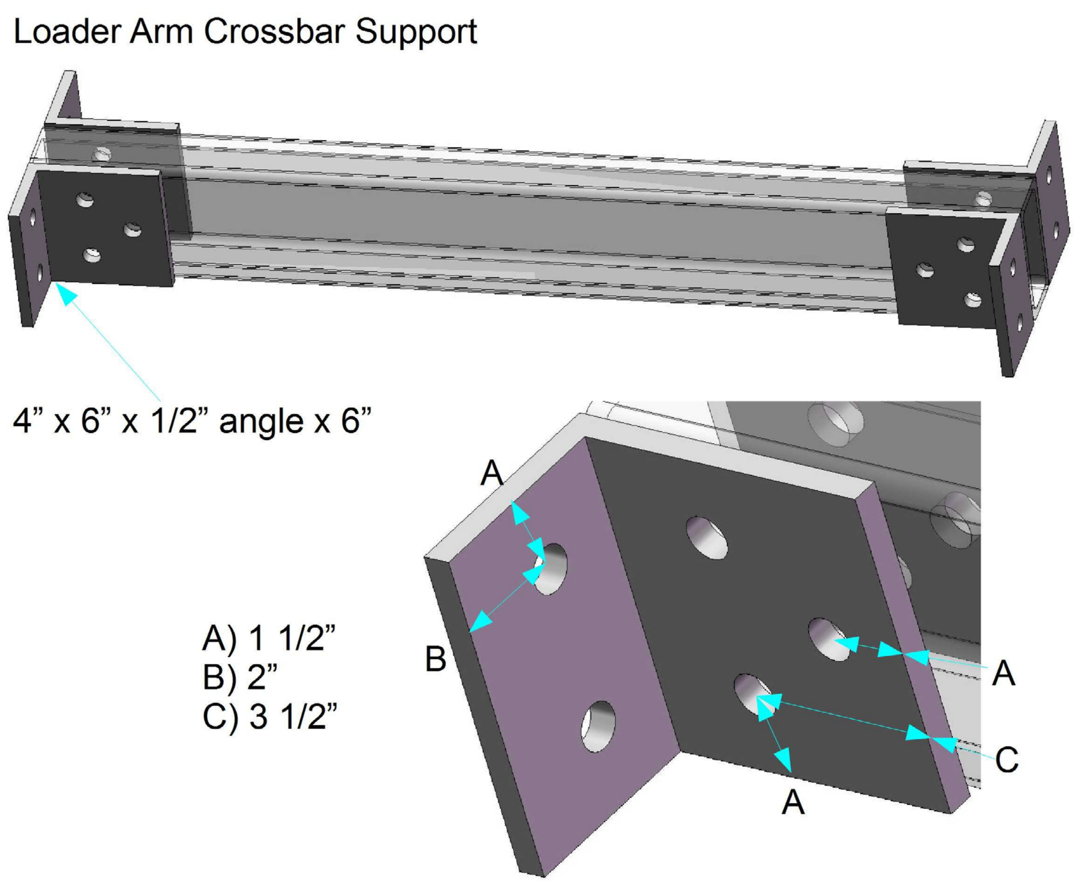
Part	Illustration
Power Cube Mount Holes 13/16 unless otherwise noted. The angle of the ramp needs to match the Power Cube. A good estimate is to leave a 3/4" gap between the top edge of the ramp and the top edge of the angle.	

Hydraulic Valve Mount

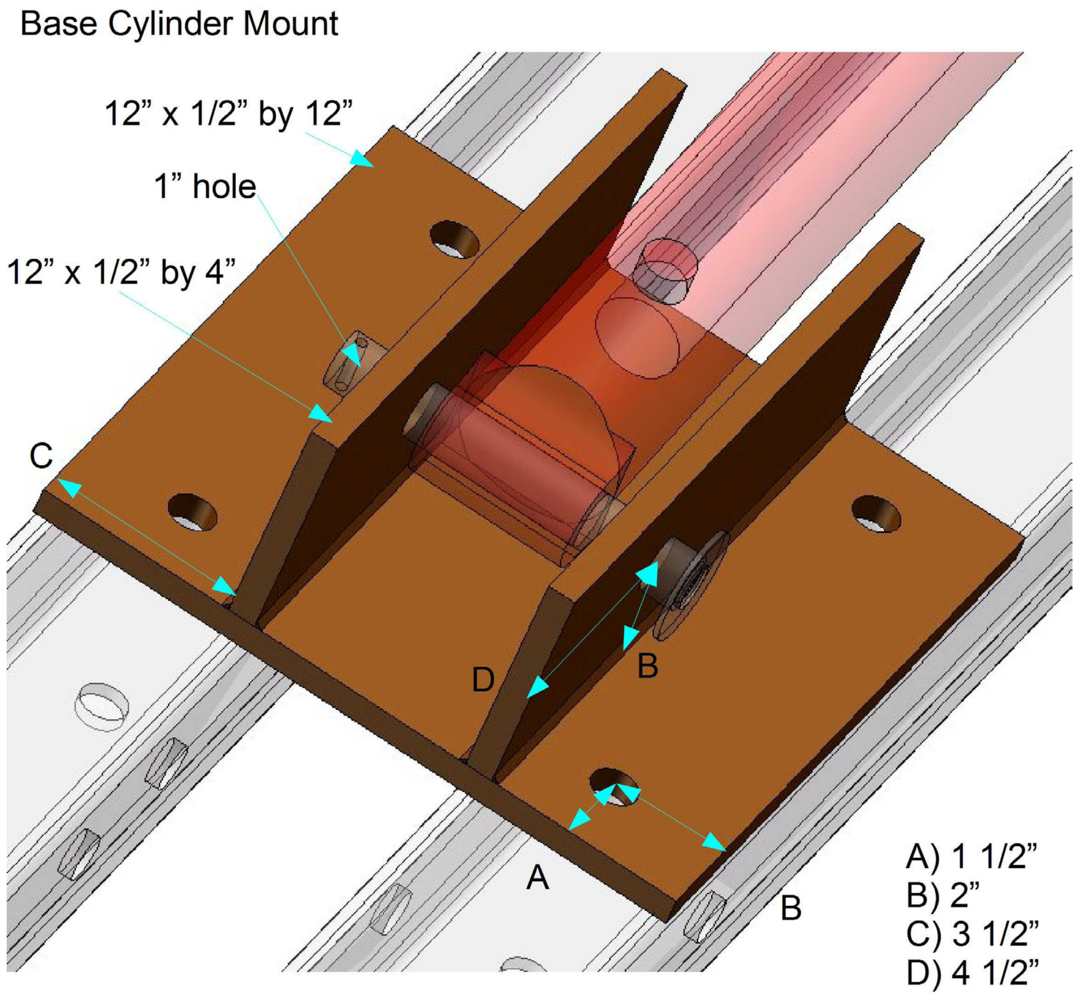
Part	Illustration

Hydraulic Valve Mount Additional holes for the hydraulic valves will be necessary. Use your specific hardware to mark the holes.	

Loader Arm Crossbar Support

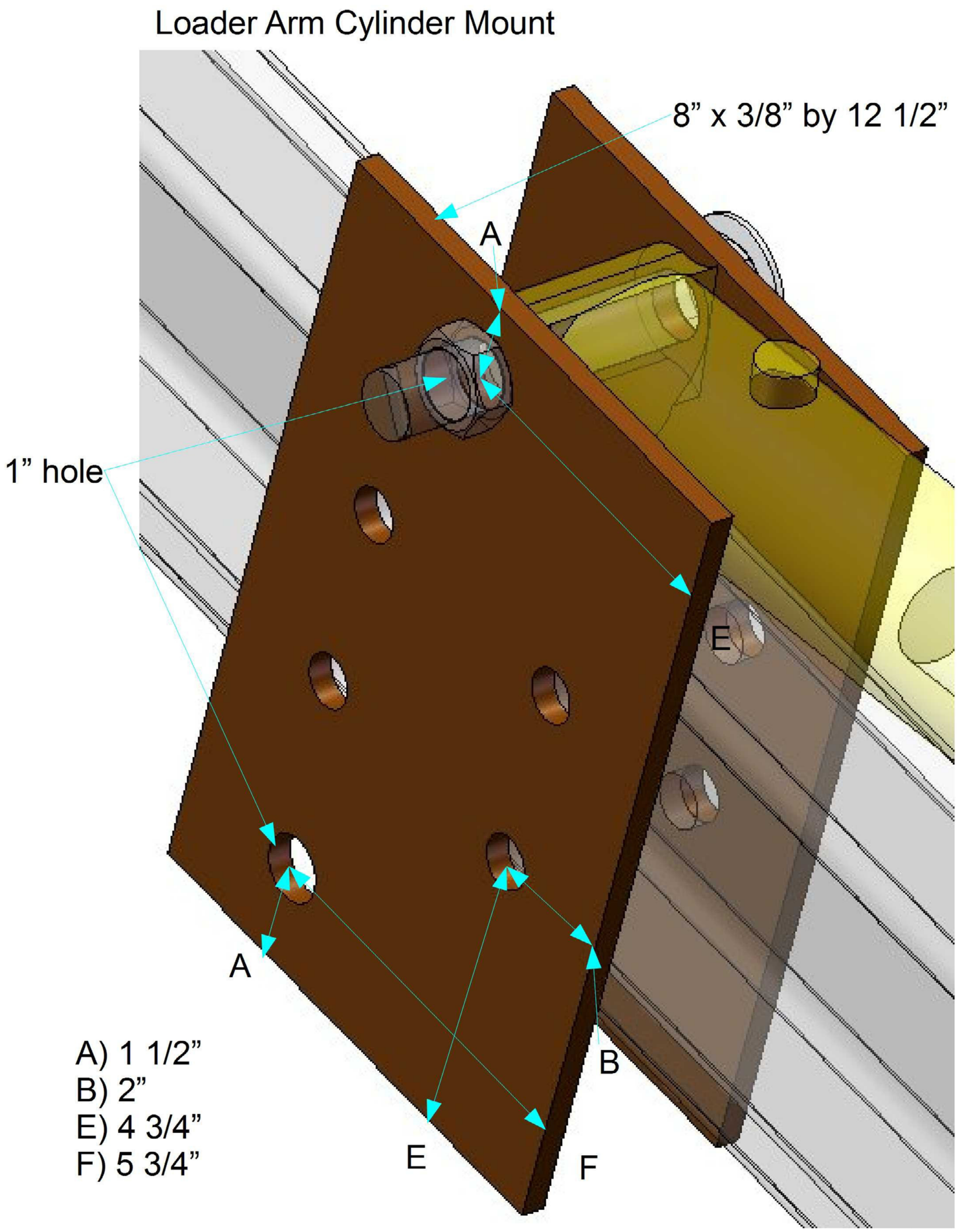
Part	Illustration
Loader Arm Crossbar Support	

Base Cylinder Mount

Part	Illustration
Base Cylinder Mount	

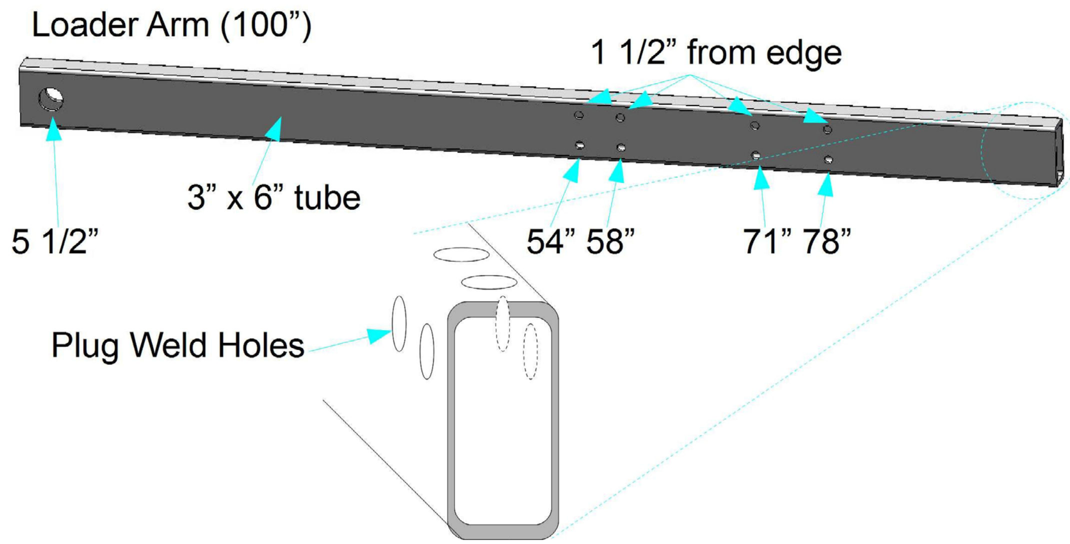
Loader Arm Cylinder Mount

Part	Illustration

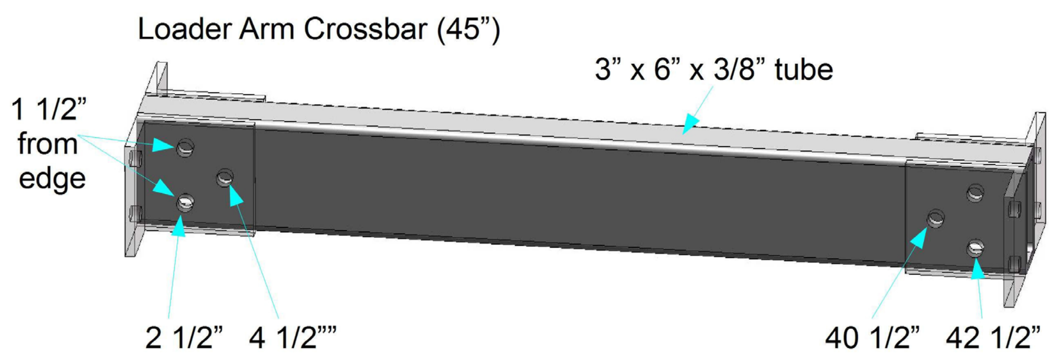
Loader Arm Cylinder Mount Drill out two nuts to 1" inner diameter and weld onto the 1" holes.	

Loader Arm

Part	Illustration

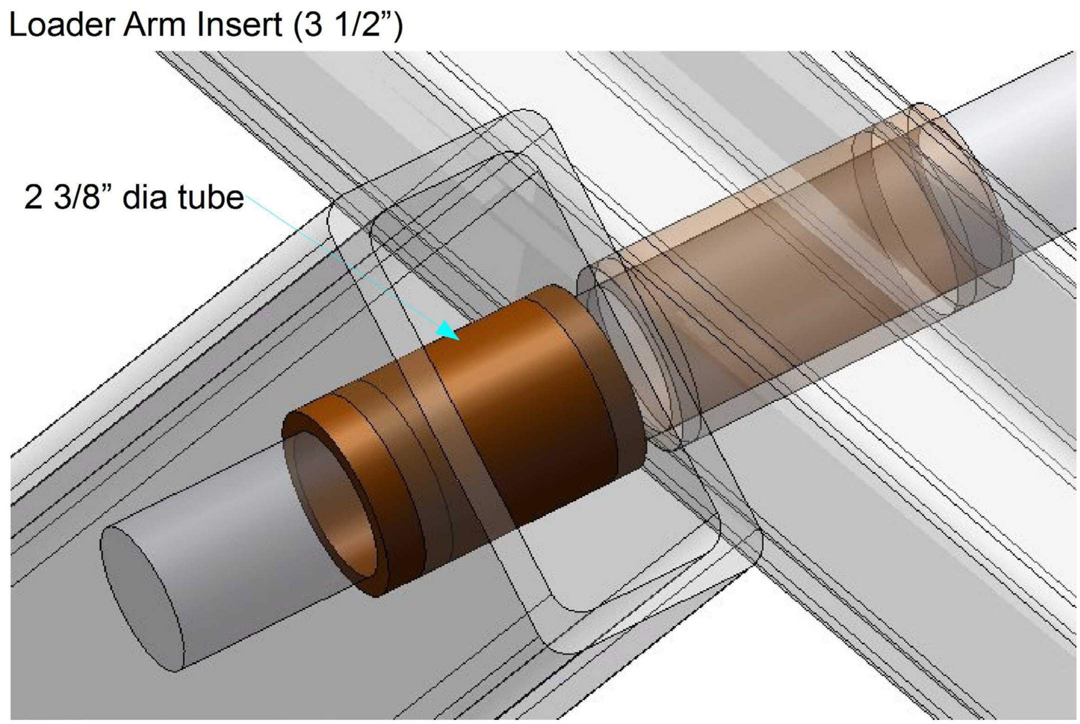
Loader Arm The big hole should be 2 3/8". Use a cutting torch. The plug weld holes should overlap the lump when it is inserted into the end of the arm. Weld through the holes to secure the lump.	

Loader Arm Crossbar

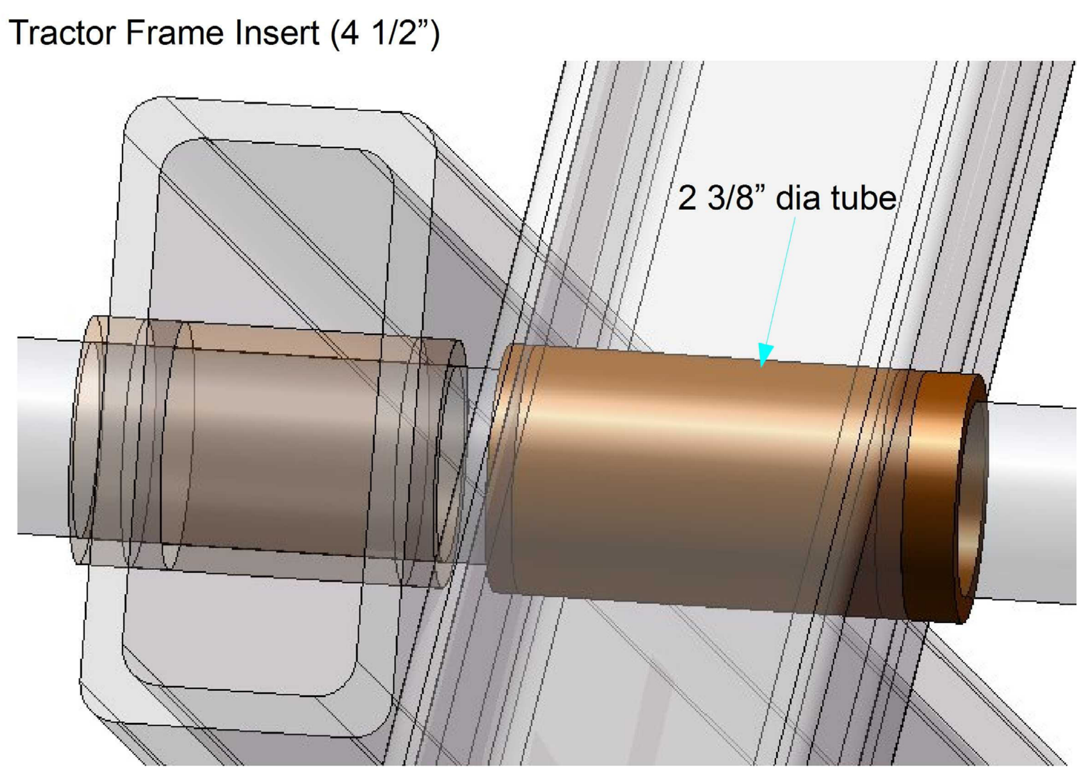
Part	Illustration
Loader Arm Crossbar	

Loader Arm Insert

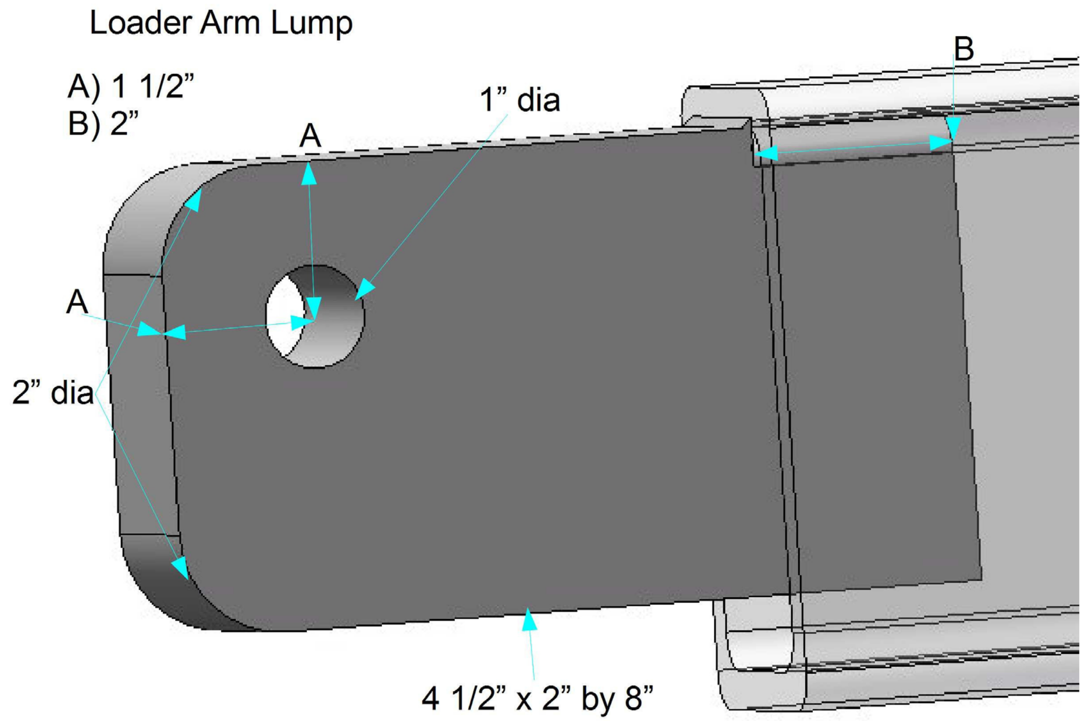
Part	Illustration

Loader Arm Insert	

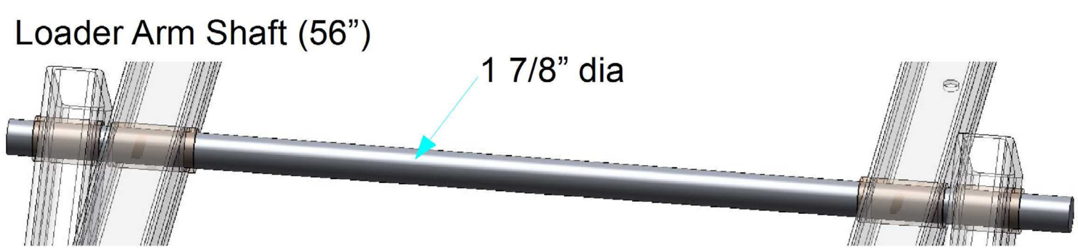
Tractor Frame Insert

Part	Illustration
Tractor Frame Insert	

Loader Arm Lump

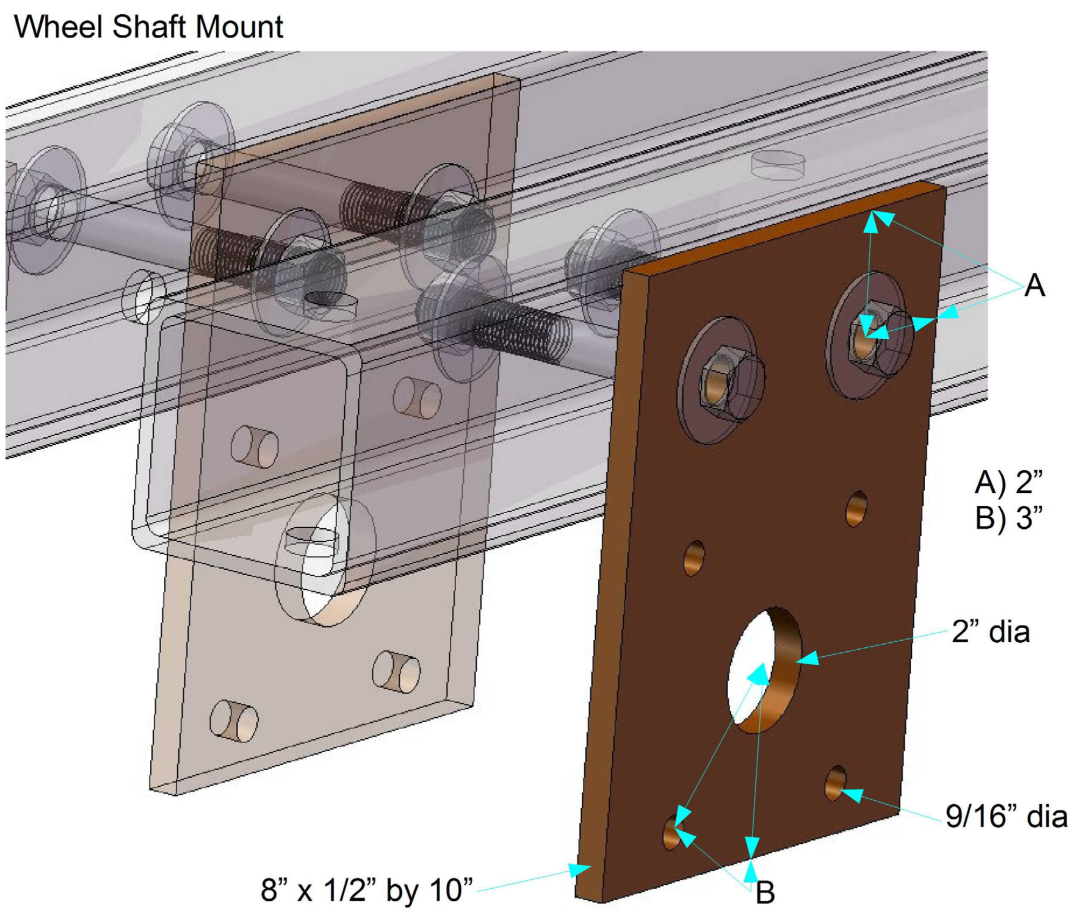
Part	Illustration
Loader Arm Lump The top edges of the lump can be notched and rounded to better fit inside the loader arm tube.	

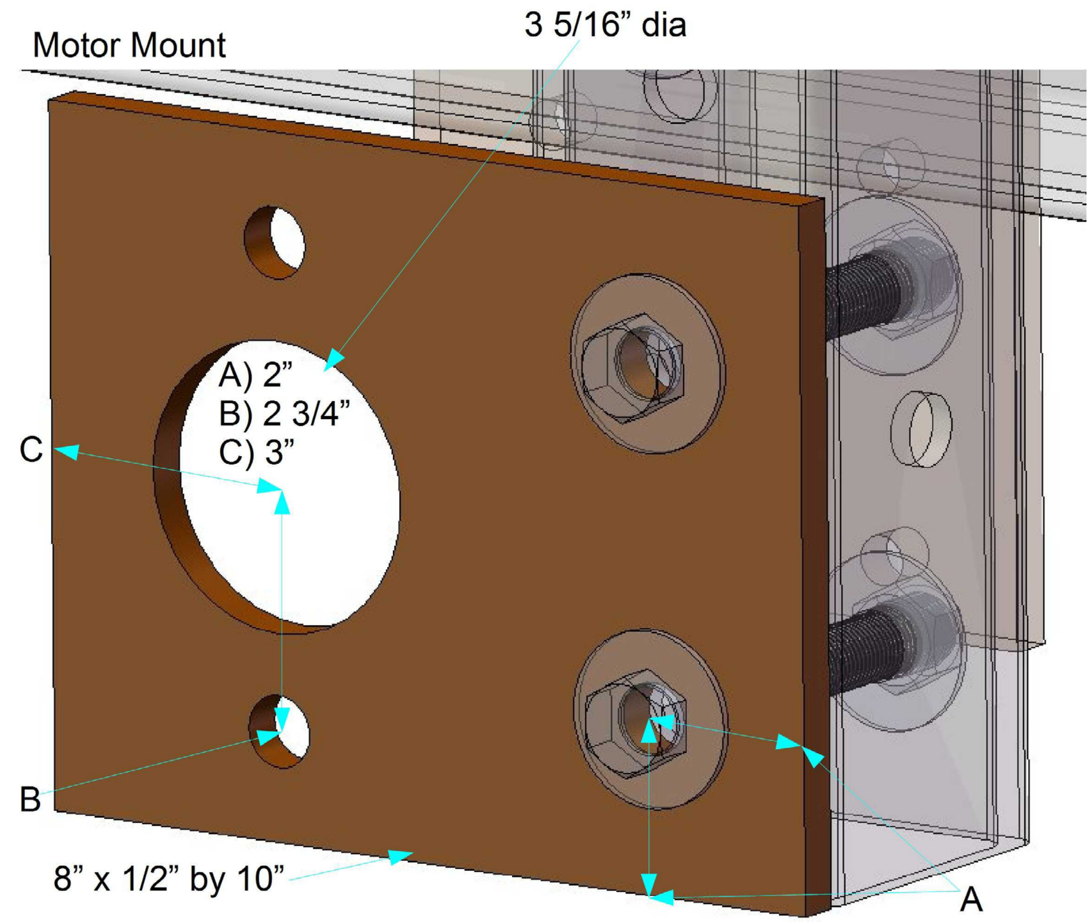
Loader Arm Shaft

Part	Illustration
Loader Arm Shaft	

Wheel Shaft Mount

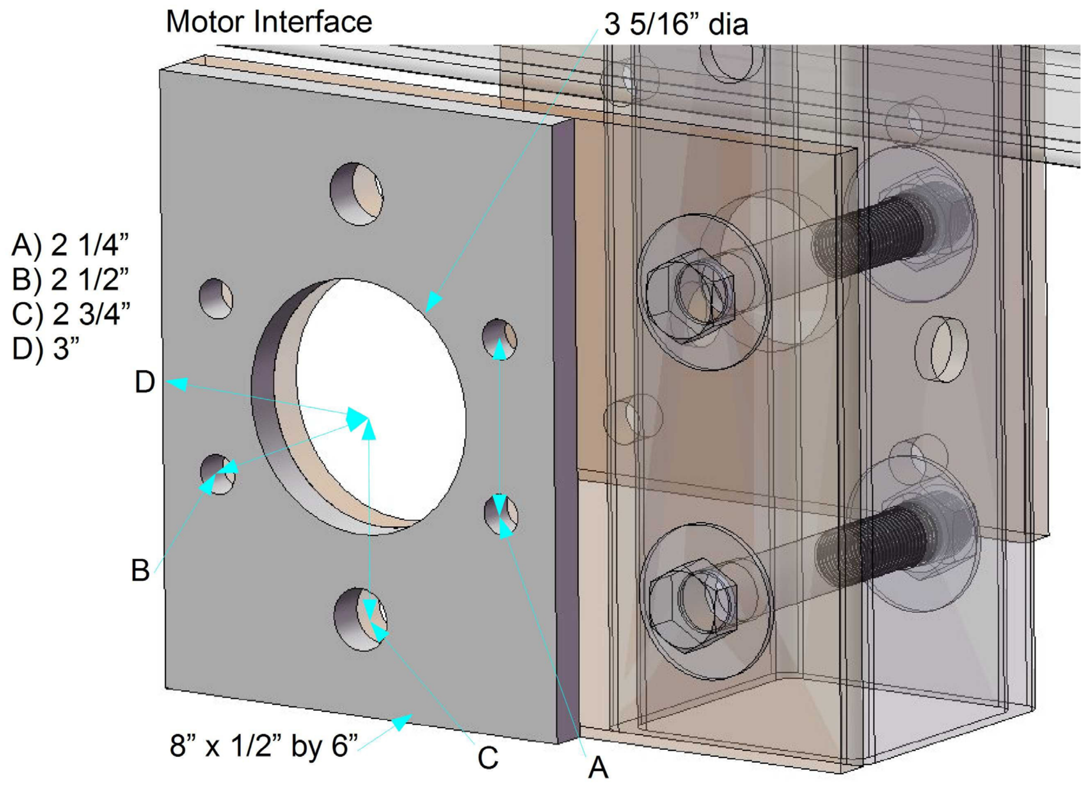
Part	Illustration

<table>
<tr><td>Wheel Shaft Mount
The position and diameter of the four bearing mounting holes depends on the bearing block you end up using. Pictured is an example. Use a cutting torch for the 2” shaft hole.</td><td>
</td></tr>
<tr><td colspan="2">Motor Mount</td></tr>
<tr><td>Part</td><td>Illustration</td></tr>
</table>

Motor Mount Use a cutting torch to make the large shaft hole. The motor mounting holes will depend on the particular hardware you end up using. This picture is just an example.	

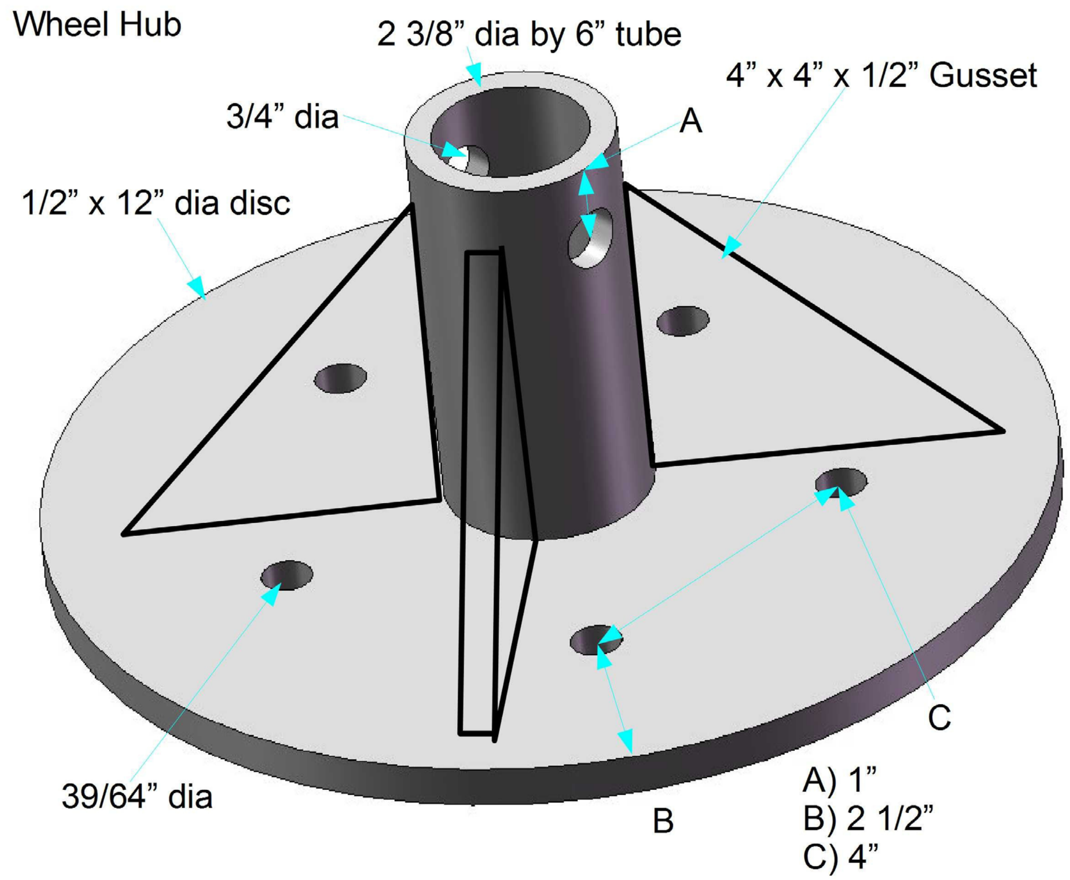
Motor Interface

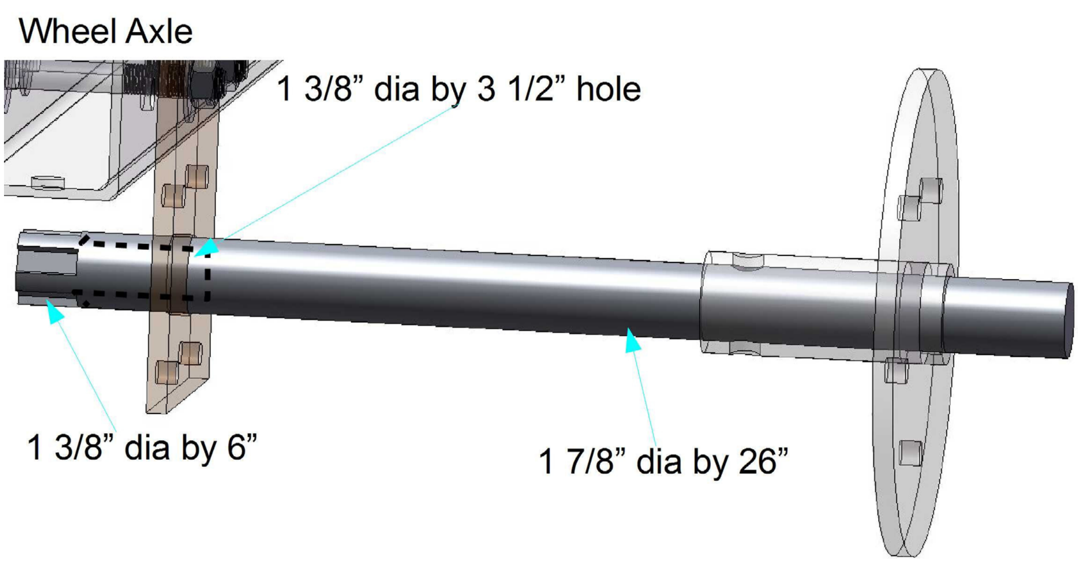
Part	Illustration

Motor Interface Use a cutting torch to make the large shaft hole. The motor mounting holes, if used, will depend on the particular hardware you end up using. The motor will probably be welded to this plate. This picture is just an example.	

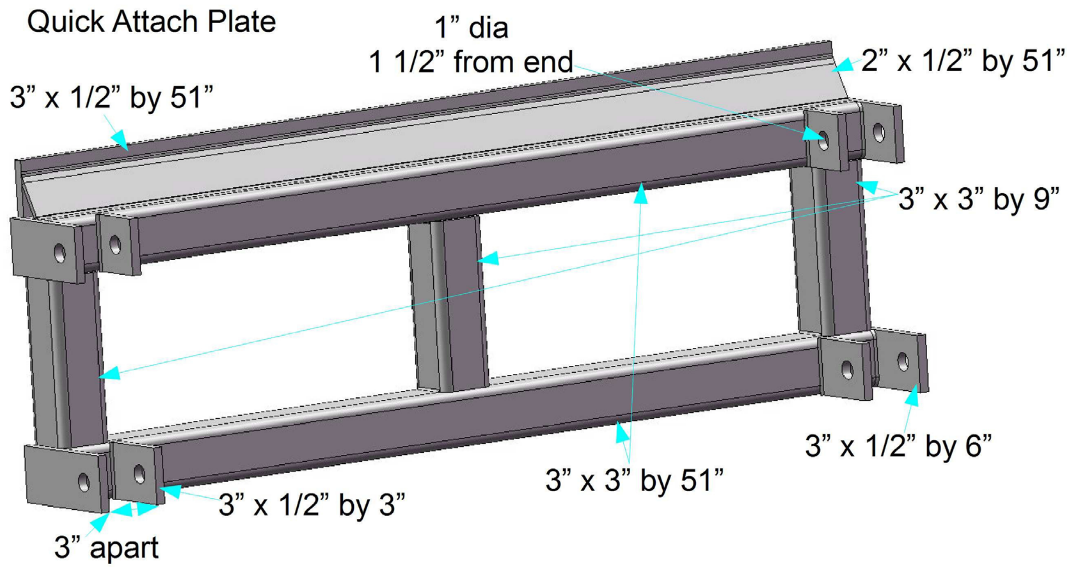
Wheel Hub

Part	Illustration

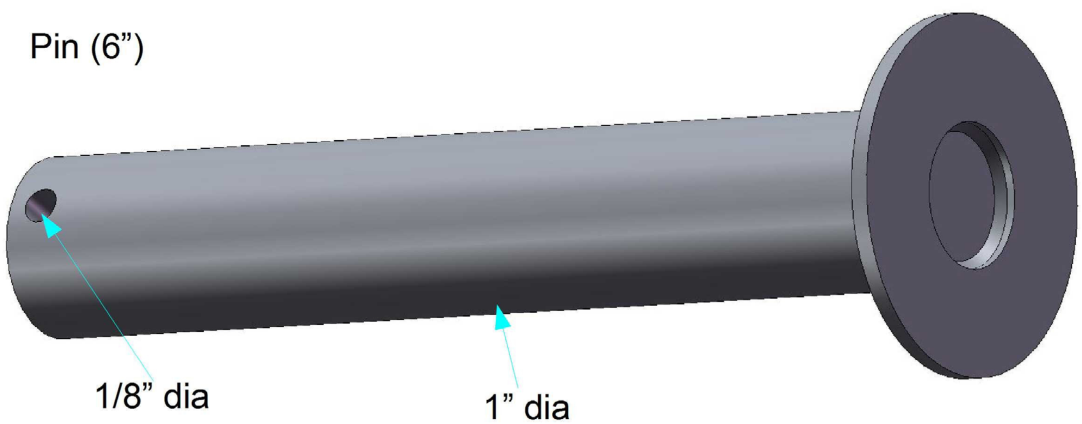
Wheel Hub Use a cutting torch to make the shaft hole in the middle of the disc. The layout of the tire rim mounting holes will depend on the hardware you end up using. Pictured is just an example. Gussets should be as close to 90* apart as possible.	

Wheel Axle	
Part	Illustration
Wheel Axle Using a lathe, drill into the end of the axle shaft. Cut two slits on either side of the hole. Insert the smaller splined shaft and weld in place. Use the wheel hub to locate and drill a bolt hole through the other end of the shaft.	

Quick Attach Plate	
Part	Illustration

Quick Attach Plate	

Pin

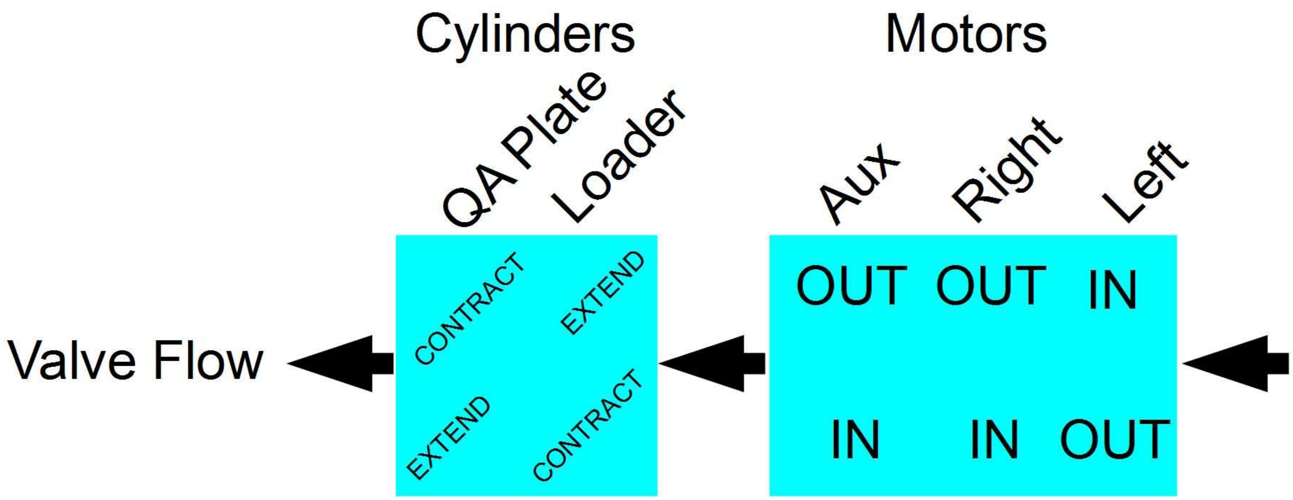
Part	Illustration
Pin Weld a washer onto the end opposite the cotter pin hole.	

Hardware

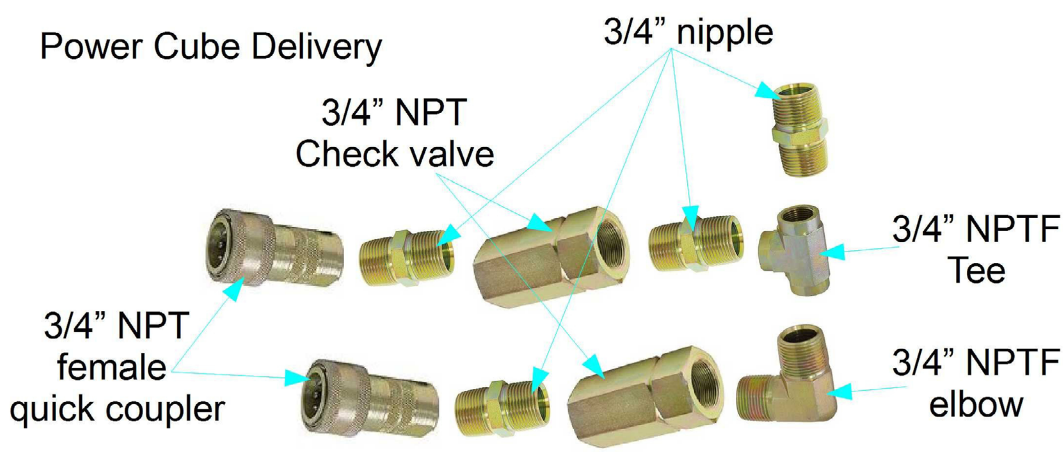
Power Transmission

Part	Illustration
Lock Collar 1 7/8" Double Split https://www.surpluscenter.com/item.asp?item=1-2768-	

187&catname=powerTrans	
Flange Bearing 1 7/8” 9/16” bolt holes https://www.surpluscenter.com/item.asp?item=1-210-30-4&catname=powerTrans	
Shaft Coupler 1 1/4” bore 5/16” keyway https://www.surpluscenter.com/item.asp?item=1-1563-J&catname=	
Splined Shaft 1 3/8” 6 teeth https://www.surpluscenter.com/item.asp?item=1-2938-6&catname=	
Female Splined Coupling 1 3/8” 6 teeth https://www.surpluscenter.com/item.asp?item=1-1562&catname=	
Hydraulics	
Valves	

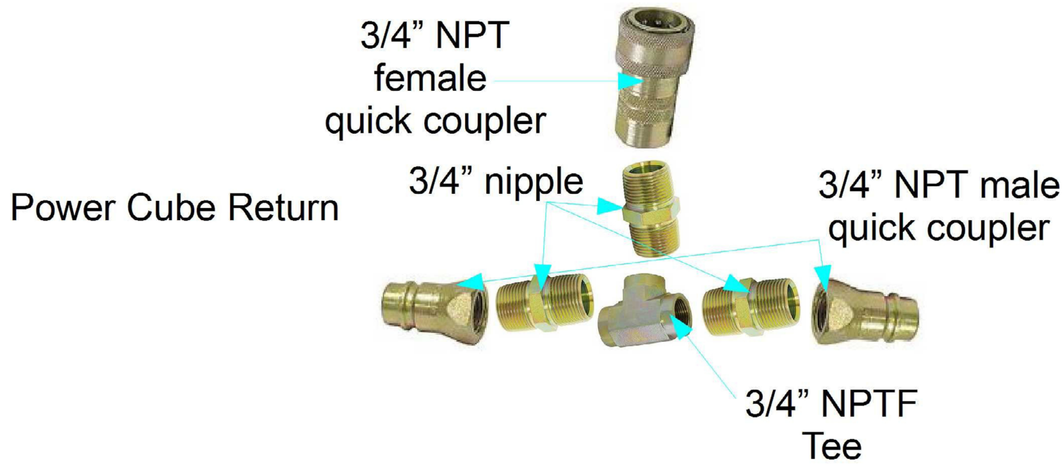


Power Cube Delivery

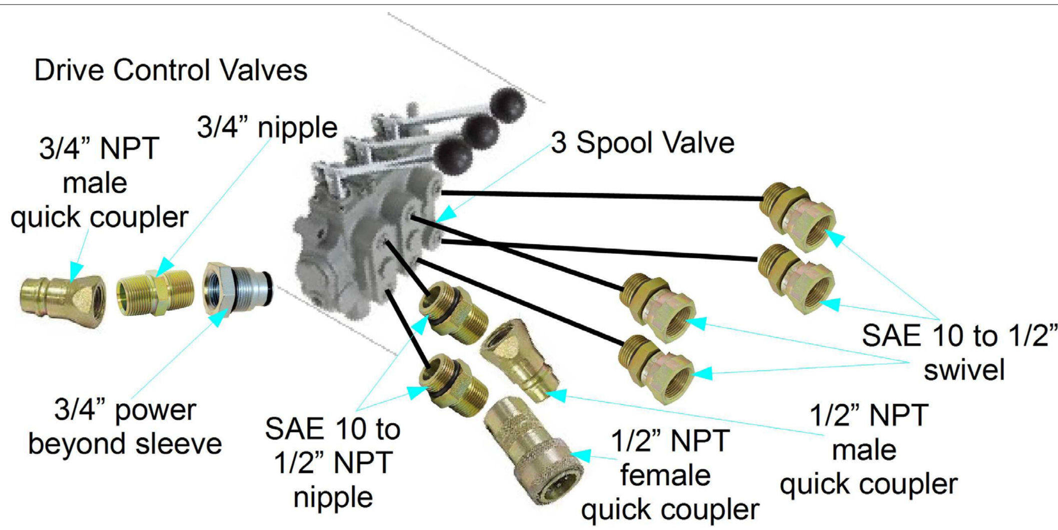
Part	Illustration
Power Cube Delivery Wrap all threads with teflon tape.	

Power Cube Return

Part	Illustration

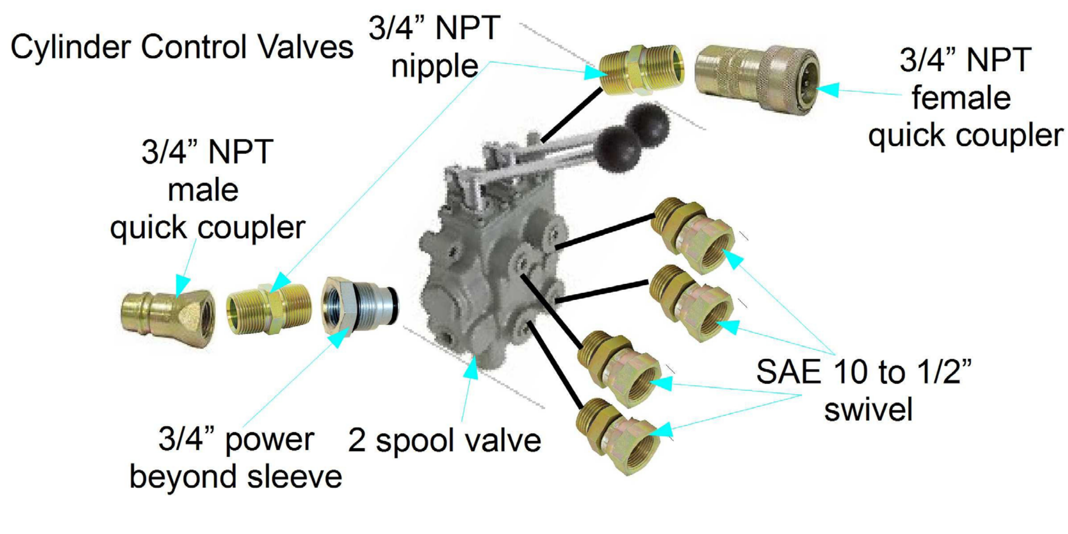
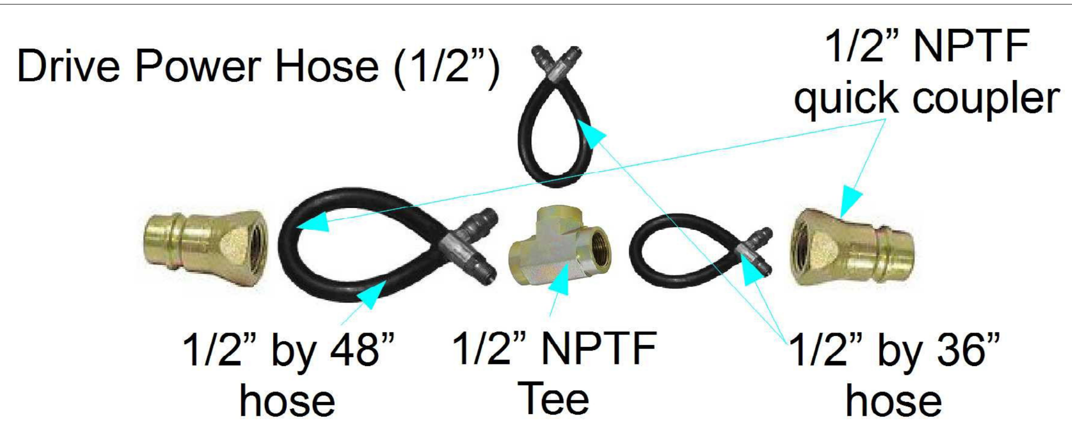
Power Cube Return Wrap all threads with teflon tape.	

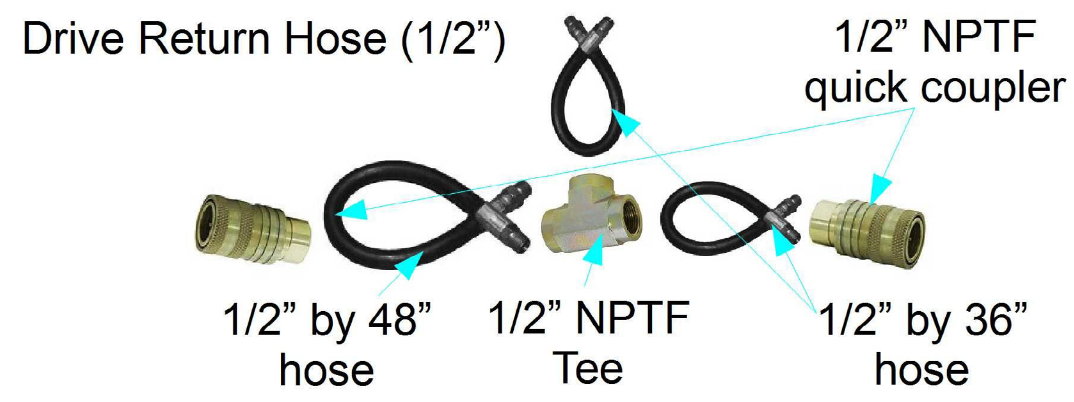
Drive Control Valves

Part	Illustration
Drive Control Valves Wrap all threads with teflon tape. Cut off the tip of the power beyond sleeve just below the threads.	

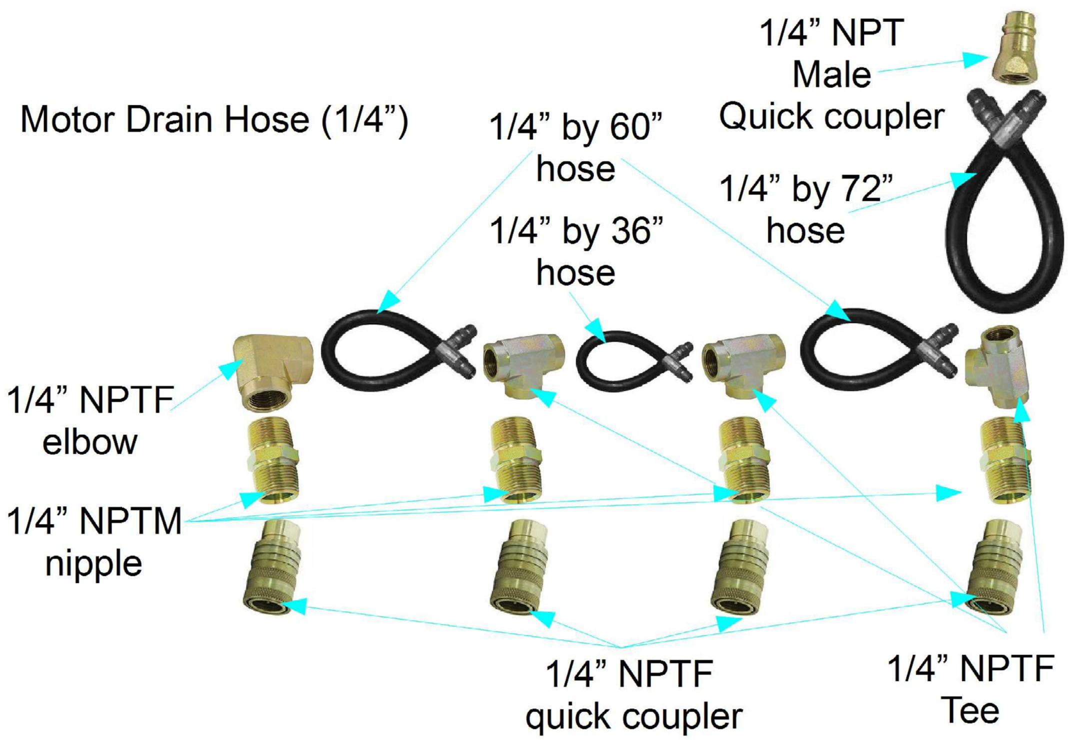
Cylinder Control Valves

Part	Illustration

Cylinder Control Valves Wrap all threads with teflon tape.	
Hoses	
Part	Illustration
1/4”, 1/2” and 3/4” NPTM	
Drive Power Hose	
Part	Illustration
Drive Power Hose Wrap all threads with teflon tape.	
Drive Return Hose	
Part	Illustration

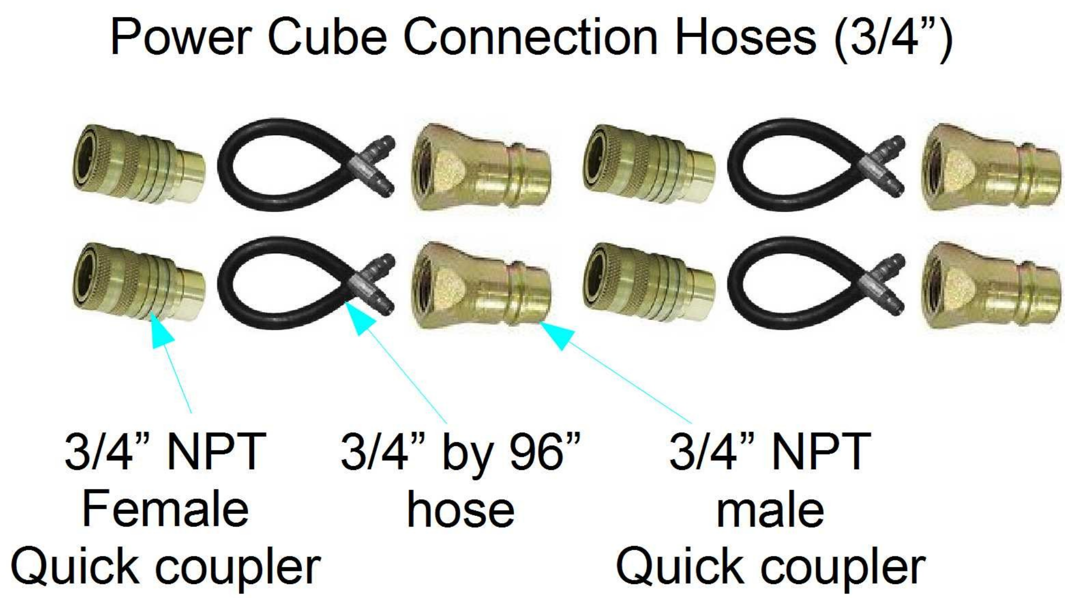
Drive Return Hose Wrap all threads with teflon tape.	

Motor Drain Hose

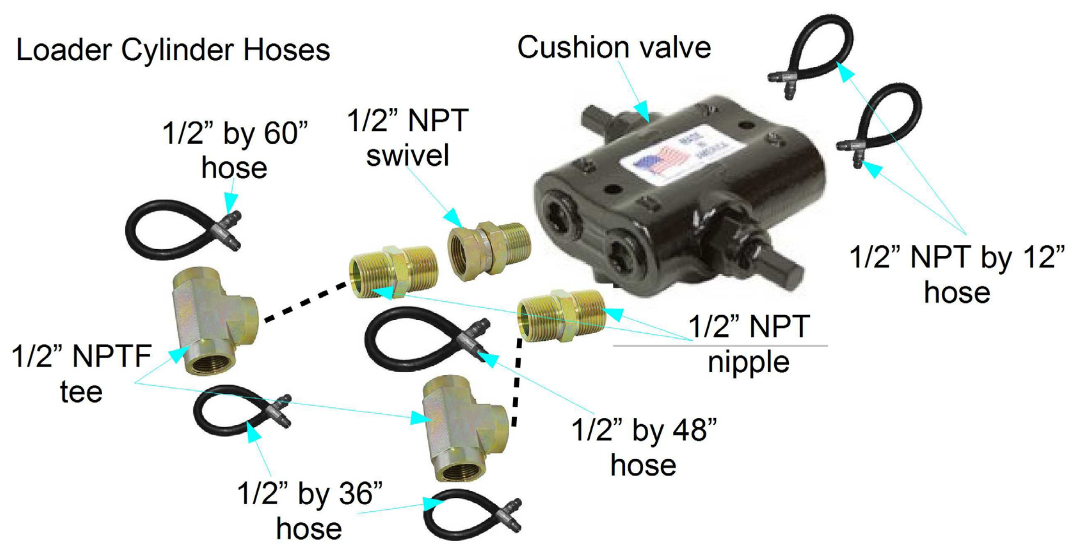
Part	Illustration
Motor Drain Hose Wrap all threads with teflon tape.	

Power Cube Connection Hoses

Part	Illustration

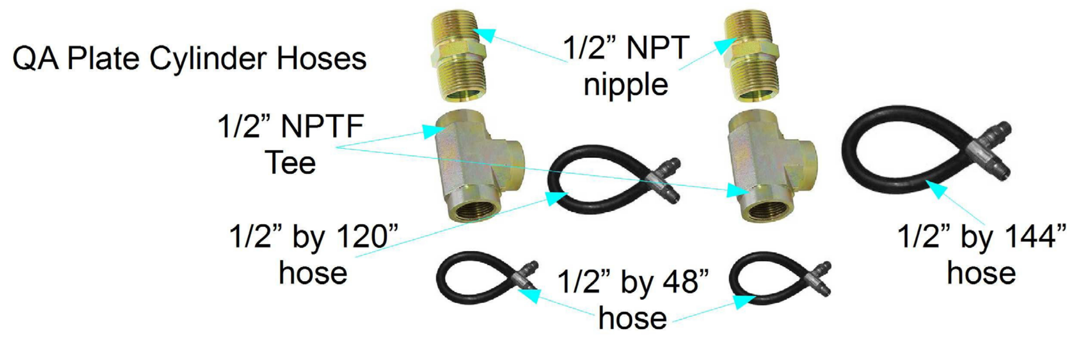
Power Cube Connection Hoses Wrap all threads with teflon tape.	

Loader Cylinder Hoses

Part	Illustration
Loader Cylinder Hoses Wrap all threads with teflon tape.	

QA Plate Cylinder Hoses

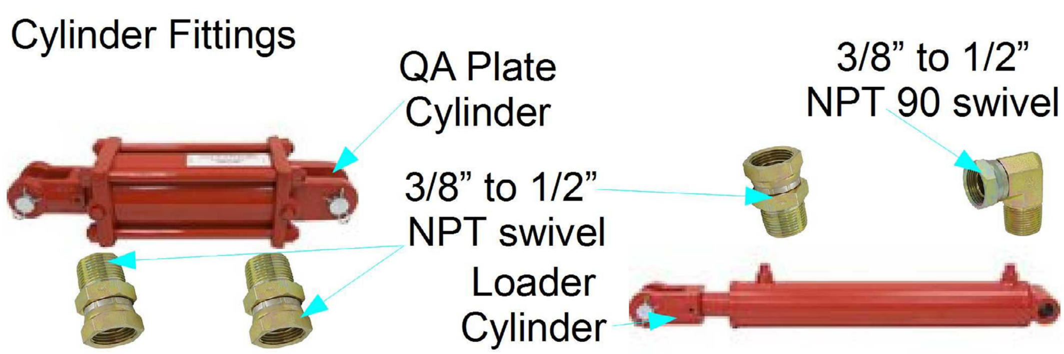
Part	Illustration

QA Plate Cylinder Hoses Wrap all threads with teflon tape.	

Cylinders

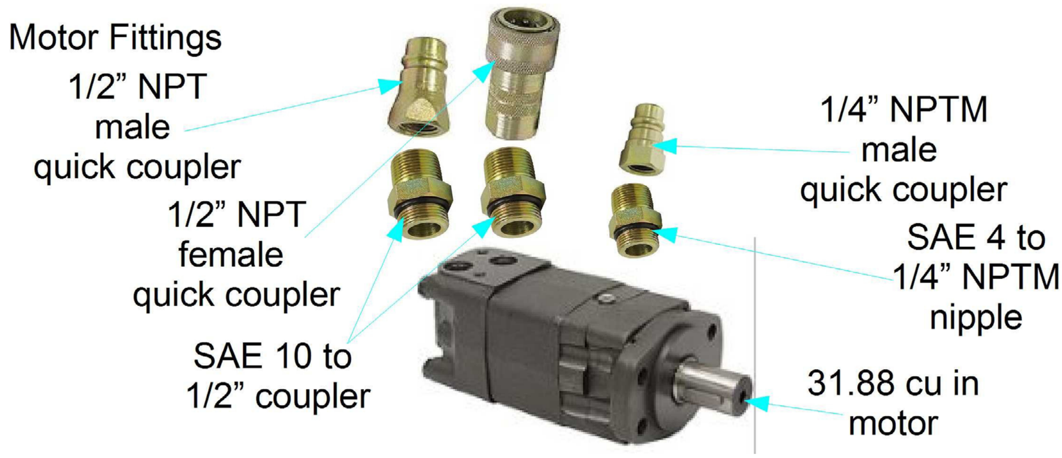
Part	Illustration
Loader Cylinder 2.5X36X1.5" double acting 3/8" NPT ports https://www.surpluscenter.com/item.asp?item=9-6775&catname=hydraulic	
QA Plate Cylinder 2.5X30X1.25" double acting 3/8" NPT ports https://www.surpluscenter.com/item.asp?item=9-7619-30&catname=hydraulic	

Cylinder Fittings

Part	Illustration
Cylinder Fittings	

Motor

Part	Illustration

Wheel Motor 31.88 cubic inch SAE 10 ports SAE 4 case drain https://www.surpluscenter.com/item.asp?item=9-7469&catname=	
Motor Fittings	
Part	Illustration
Motor Connections Wrap all threads with teflon tape.	
Valves	
Part	Illustration
3-spool spring centered 3/4" NPT ports 1/2" NPT ports https://www.surpluscenter.com/item.asp?catname=hydraulic&qty=1&item=9-6761	

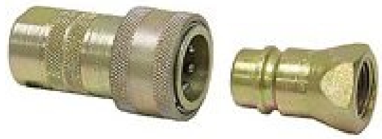
2-spool spring centered 3/4" NPT ports 1/2" NPT ports https://www.surpluscenter.com/item.asp?item=9-6702&catname=hydraulic	

Cushion Valve 1/2" NPT https://www.surpluscenter.com/item.asp?item=9-4019-50-H&catname=hydraulic	
3/4" NPT check valve	

Fittings

Part	Illustration
SAE 10M to 1/2" NPT nipple	
SAE 10M to 1/2" NPTM swivel coupler	
3/4" NPT nipple	
3/4" NPTM 90 degree elbow	

3/4" NPTF tee	

3/4" female quick coupler	
1/2" NPT quick coupler Male and Female in one package	
3/4" NPT power beyond sleeve Cut off the tip of the sleeve just below the threads.	 
SAE 4M to 1/4" NPTM nipple	
1/4" NPTM quick coupler Male and female in one package.	
1/2" NPT nipple	
1/2" NPTF Tee	
1/2" NPT swivel	

1/2" NPT 90 elbow swivel	
3/8" NPTM to 1/2" NPTF swivel	
3/8" NPTM to 1/2" NPTF 90 swivel	
1/4" NPT nipple	
1/4" NPTF Tee	
1/4" NPTF 90 elbow	
3/4" to 1/4" NPT bushing	

Project Steps

Cut Stock Material		
Jig		
	Frame Hole Jig: Cut To Length	
	Frame Hole Jig: Drill Holes	
Bar		
	Loader Arm Shaft: Cut To Length	
	Wheel Axle: Cut To Length	x4
	Wheel Axle: Drill Holes	x4
	Wheel Axle Splined Shaft: Cut To Length	x4
	Pin: Cut To Length	x10
	Pin: Drill Hole	x10
Tube		
	Frame	
	Outer Base: Cut To Length	x2
	Outer Base: Drill Holes	x2
	Inner Base: Cut To Length	x2
	Inner Base: Drill Holes	x2
	Bottom Crossbar: Cut To Length	x3
	Bottom Crossbar: Drill Holes	x3
	A-pillar: Cut To Length	x2
	A-pillar: Drill Holes	x2
	B-pillar: Cut To Length	x2
	B-pillar: Drill Holes	x2
	C-pillar: Cut To Length	x2
	C-pillar: Drill Holes	x2
	Top Crossbar: Cut To Length	x3
	Top Crossbar: Drill Holes	x3
	Cant Rail: Cut To Length	x2
	Cant Rail: Drill Holes	x2
	Cant Rail: Torch Holes	x2

	Loader Arm	
	Loader Arm: Cut To Length	x2
	Loader Arm: Drill Holes	x2
	Loader Arm: Torch Holes	x2
	Loader Arm Crossbar: Cut To Length	
	Loader Arm Crossbar: Drill Holes	
	Loader Arm Insert: Cut To Length	x2
	Tractor Frame Insert: Cut To Length	x2
	Wheel Hub	
	Wheel Hub Tube: Cut To Length	x4
	Wheel Hub Tube: Drill Holes	x4
	Quick Attach Plate	
	Quick Attach Plate Horizontal: Cut To Length	x2
	Quick Attach Plate Vertical: Cut To Length	x3
Flat		
	Cylinder Mounts	
	Base Cylinder Mount: Cut To Length	x2
	Base Cylinder Mount: Drill Holes	x2
	Loader Arm Cylinder Mount: Cut To Length	x4
	Loader Arm Cylinder Mount: Drill Holes	x4
	Power Cube Mount	
	Power Cube Mount Ramp: Cut To Length	
	Power Cube Mount Point: Cut To Length	
	Power Cube Mount Point: Drill Hole	
	Loader Arm Lump	
	Loader Arm Lump: Cut To Length	x2
	Loader Arm Lump: Drill Hole	x2
	Wheel Mount	
	Wheel Shaft Mount: Cut To Length	x8
	Wheel Shaft Mount: Drill Holes	x8
	Wheel Shaft Mount: Torch Hole	x8

	Motor Mount	
	Motor Mount: Cut To Length	x4
	Motor Mount: Drill Holes	x4
	Motor Mount: Torch Hole	x4
	Motor Interface: Cut To Length	x4
	Motor Interface: Drill Holes	x4
	Motor Interface: Torch Hole	x4
	Wheel Hub	
	Wheel Hub Disc: Cut To Diameter	x4
	Wheel Hub Disc: Drill Holes	x4
	Wheel Hub Disc: Torch Hole	x4
	Wheel Hub Gusset: Cut To Triangle	x16
	Quick Attach Plate	
	Quick Attach Plate Ramp Face: Cut To Length	
	Quick Attach Plate Ramp Slope: Cut To Length	
	Quick Attach Plate Small Hinge: Cut To Length	x4
	Quick Attach Plate Small Hinge: Drill Hole	x4
	Quick Attach Plate Large Hinge: Cut To Length	x4
	Quick Attach Plate Large Hinge: Drill Hole	x4
	Seat Mount	
	Seat Mount: Cut To Length	
	Seat Mount: Drill Holes	
Angle		
	Loader Arm Crossbar Support: Cut To Length	x4
	Loader Arm Crossbar Support: Drill Holes	x4
	Power Cube Mount: Cut To Length	x2
	Power Cube Mount: Drill Holes	x2
	Hydraulic Valve Mount: Cut To Length	
	Hydraulic Valve Mount: Drill Holes	
Build Components		
Hardware		
	Position Bottom Crossbars	

Attach Inner and Outer Base

Attach Pillars to Inner Base and Bottom Crossbars

Attach front two Top Crossbars to A & B Pillars

	Attach Cant Rail to Pillars and Top Crossbars
	
	Attach last Top Crossbar to Cant Rail and C-pillars
	
	Tighten All Frame Bolts
	Get them as tight as possible without deforming the square tubes.
	Weld Base Cylinder Mounts
	Use a jig, magnet or clamp to hold all the pieces in place. Insert a pin through the pin holes to maintain alignment.
	Weld Loader Arm Cylinder Mounts
	Weld Motor Interfaces

Weld Axle Shafts

After the 3" hole is drilled into the end of the shaft, torch or cut two channels on either side. When the splined shaft is inserted into the hole, it should be visible through the two channels. Plug weld through the channels to permanently attach the splined shaft.

Weld Pins

Stand the 1" bar upright and weld a washer with roughly a 2" outer diameter on the end.

Weld Quick Attach Plate

Use a bar or a bolt to keep the hinges aligned while welding.

Weld Power Cube Mount

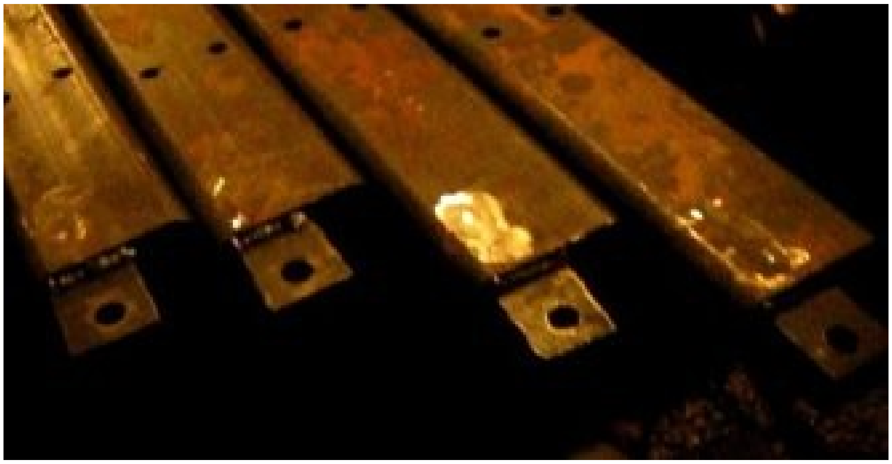
Attach Flange Bearings to Wheel Shaft Mounts

Weld Together Wheel Hubs

Attach Wheel Hubs to Wheels

Plug Weld Lumps into Loader Arms

Run a piece of bar, or a bolt, through one or more holes in the loader arm to maintain alignment. Use a similar method on the lumps. Insert the lumps and weld through the plug weld holes to permanently attach the lumps to the loader arm.



Hydraulics

	Remember to keep the open ends of hydraulic components covered up. Use plastic caps, or rags, or tape. Be particularly careful around grinding/welding operations. The inside of the hydraulic components must remain free of contamination.	
	Assemble Power Cube Delivery	
	Assemble Power Cube Return	
	Assemble Drive Control Valves	
	Assemble Cylinder Control Valves	
	Assemble Drive Power Hose	x2
	Assemble Drive Return Hose	x2
	Assemble Motor Drain Hose	
	Assemble Power Cube Connection Hose	x4
	Assemble Loader Cylinder Hoses	
	Assemble Quick Attach Plate Cylinder Hoses	
	Assemble Loader Cylinder	x2
	Assemble Quick Attach Plate Cylinder	x2
	Assemble Motor	x4

Assemble Tractor

Prepare Loader Arm

Position Frame Inserts and Loader Arm Shaft

The insert goes into the 2 3/8” holes in the Cant Rails. The shaft goes through the two inserts, aligning them.

Weld Frame Inserts

Weld the aligned inserts to the Cant Rail. Grind the outside smooth.

	Position Loader Arm Inserts and Arms on Shaft
	The inserts go into the 2 3/8” holes in the Loader Arms. Then the Loader Arms go on the shaft sticking out of the Cant Rails. It helps to use one or two bolts to attach the Loader Arm Crossbrace, or use pins and the Quick Attach plate to align the Loader Arms.
	Weld Loader Arm Inserts
	Attach Loader Arm Cylinder Mount to Loader Arm
	Remove the Crossbrace or Quick Attach Plate. Take the Loader Arms off the tractor and attach the Cylinder Mounts.
	Mount Loader Arm
	Position Loader Arms on Shaft
	Put a large washer on the shaft before the Loader Arm. This will keep the Arm from rubbing against the Cant Rail. Then put a lock collar on after the Loader Arm. This will keep the Arm from moving sideways.
	Attach Loader Arm Crossbar
	Tighten and Grease Lock Collars
	Attach Base Cylinder Mounts to Base
	Attach Quick Attach Plate to Loader Arm
	Attach Cylinders to Loader Arm
	Mount Wheels
	Attach Wheel Shaft Mounts and Motor Mounts to Frame
	Attach Motors to Motor Mounts
	Insert Axle Shafts
	After the shaft is through the outer bearing, but before it goes through the inner bearing, put a large washer, two lock collars, and another large washer on the shaft. Continue pushing it through the inner bearing. Push the male splined shaft into the female coupler so there is no more than 1/8” gap.
	Weld Motor Mounts to Pillars
	This is important to keep the Motor Mounts from shifting. Don't spare the welding.
	Tack Weld Wheel Shaft Mounts to Base
	Just a dab along the top. Keep it small so it can be easily removed with a grinder.
	Tighten and Grease Lock Collars
	Attach Wheel Hubs to Axles
	Attach Power Cube and Valve Mounts
	Install Hydraulic System

	Attach Power Cube Delivery to Drive Control Valves
	Attach Power Cube Return to Cylinder Control Valves
	Attach Drive & Cylinder Control Valves
	Either mount the Valves directly to the Valve Mount in the middle of the tractor, or use custom interface plates.
	Attach Cylinder Hoses
	Attach Drive Hoses
	Attach Motor Drain Hose
	Attach Power Cube Connection Hoses

Soil Pulverizer

Design Rationale

The basic design for the soil pulverizer is to provide soil digging, pulverizing, loading into the tractor bucket, and dumping into the CEB press in one step. Otherwise, one must use a tractor to dig, followed by pulverizing with a stationary pulverizer, and followed by a conveyor belt into the machine.

The Soil Pulverizer Satisfies Many of the OSE Core Values

1. ***Open Source*** - the design is simple and freely available. Additionally, the manufacturing process is fully documented.

2. ***Distributive Economics*** - the Soil Pulverizer is a bit more specialized than some of the other machines. With the full economic pros/cons documented you can decide for yourself if it's worth building.

3. ***Low Cost*** - the GVCS Soil Pulverizer design is significantly cheaper than its commercial equivalents.

4. ***User Friendly*** - It's easy to make, easy to use, and easy to modify.

5. ***Do-It-Yourself*** - The tools required to make the Soil Pulverizer can be learned in an afternoon, or you can use whatever tools you are already familiar with.

6. ***Lifetime Design*** - The Soil Pulverizer is over-built so that, with a minimum of care, it will last forever.

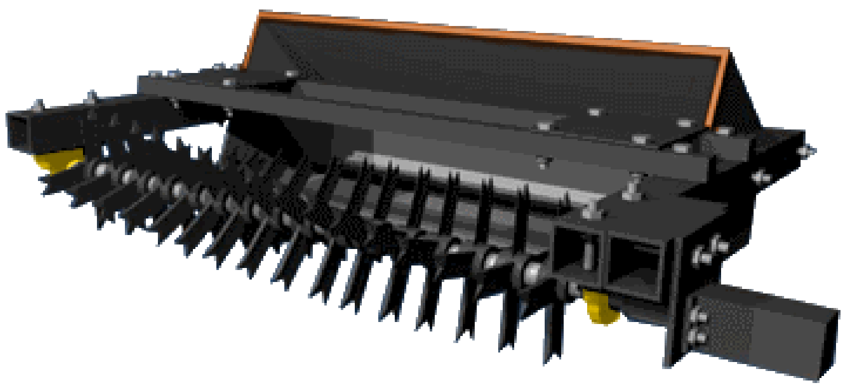
7. ***Substitutability*** - The Soil Pulverizer is just one of many tools that can be attached to the LifeTrac quickly and easily.

8. ***Complete Economy*** - Sometimes the local dirt is just not pulverized enough on its own. The Soil Pulverizer ensures you process enough dirt to keep everything else going.

9. ***Division of Labor*** - One person can break up the soil while another person uses it for something. Together they get more done then they would on their own.

10. ***Realistic Immediacy*** - The bricks that the Soil Pulverizer helped produce are currently providing shelter for real people.

Soil Pulverizer



Complete Fabrication Instructions, 2011
Open Source Ecology

Introduction

The purpose of this guide is to provide all information to make the 2011 version Soil Pulverizer from stock steel and parts. More information and a constantly updated procedure can be found on the OSE wiki Soil Pulverizer Manufacturing Page.

This guide is broken into 2 main fabrication steps: Parts Fabrication, and Parts Assembly. After these two have been completed, the machine can be painted. After it's painted, the remaining hydraulics must be installed. After that, it should be ready to go! See the User Manual for how to adjust the height of the tines to your soil cutting needs.

Parts fabrication begins with the cutting of all stock steel as listed in the cut list. It focuses on cutting, drilling, punching, bolting and welding the steel into parts pieces and then assembling the parts pieces into individual parts. Each part (IE Bucket, Arm Rest…) listed in this section is independent of all others, therefore the parts can be fabricated in any order.

Parts assembly joins all of the parts into the whole machine. It mostly involves bolting, but some parts must still be welded upon assembly.

Bill of Materials

Steel

Type	Stock Size (Inches)	Length (inches)
Sheet	0.125 X 48	40
Plate	0.25 X 16	29
	0.25 X 24	48
	0.25 x 16	48
Beveled Flat	0.5 X 6	49
Flat	0.25 X 2	5.5
	0.25 X 2.5	48.5
	0.25 X 5.5	48.5
	0.375 X 3	324
	0.5 X 2	16.5
	0.5 X 3	39
	0.5 X 4	12
	0.5 X 6	8
	0.5 X 8	36
	0.75 X 2	6
	0.75 X 4	35.75
Pipe	2" SCH 80 Pipe	44.5
	2” SCH 40 Pipe	1
Round Tubing	0.5ID X 0.75OD	16
Round	0.5	58
	1.875	52
Square Tubing	0.1875 X 2.5X2.5	36
	0.25 X 2X2	75
	0.25 X 2X4	56

Hardware

Type	Size (Inches)	QTY
Nut, Hex	0.375"-16	1
Nut, Hex	0.5"-13	2
Nut, Hex	0.5625-11	8
Nut, Hex, Steel	0.75"x10	18
Nut, Hex, Galv.	0.75”x10	4
Nut, Nylon Lock	1"-8	2
Bolt, Hex	0.3750-16x3x3	1
Bolt, Hex	0.5000-13x2.5x2.5	2
Bolt, Hex	0.5625-11x2x2	8
Bolt, Hex	0.7500-10x1.25x1.25	14
Bolt, Hex	0.75"-10x1.5"x1.5"	4
Bolt, Hex	0.75"-10x2"x2"	2
Bolt, Hex	0.75"-10x5.5"x1.75"	2
Bolt, Hex	1.0"-8x3"x2.25"	2
Washer, Wide	0.5625"	8
Washer, Wide	0.5"	2
Washer, Wide	0.75"	6
Washer, Wide	1.0"	4
Misc.	COUPLER, 1-3/8" 6T SPLINED	1
Misc.	BEARING WITH LOCK COLLAR, FS210, 1-7/8"	2
Misc.	COTTER PIN, 1/8” X 2 ½”	6

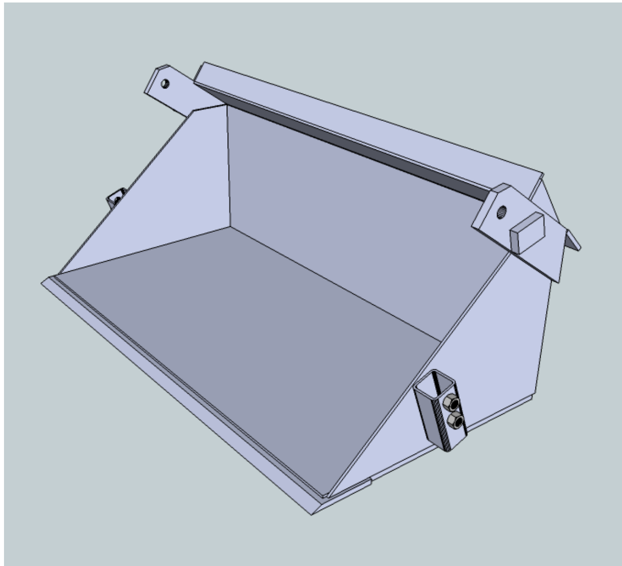
Hydraulics

Description	Quantity	Source
Hydraulic Motor	1	https://www.surpluscenter.com/item.asp?item=9-7368-125&catname=hydraulic
SAE 10 to 1/2 NPT swivel	2	https://www.surpluscenter.com/item.asp?item=9-6900-10-8&catname=hydraulic
SAE 4 to 1/4 NPT swivel	1	https://www.surpluscenter.com/item.asp?item=9-6900-4-4&catname=hydraulic
1/2 NPTM x 12' Hose	2	https://www.surpluscenter.com/item.asp?item=905-12144&catname=hydraulic
1/4 NPTM x 12' Hose	1	https://www.surpluscenter.com/item.asp?item=916-14144&catname=hydraulic
30 gpm Quick Coupler set, Body Size: 1/2, Thread Size: 3/4-14 NPT	3	Dalton Hydraulics
¼" Quick Coupler Set	1	https://www.surpluscenter.com/item.asp?item=9-6314&catname=hydraulic
¼" Male Quick Coupler	1	https://www.surpluscenter.com/item.asp?item=9-5924&catname=hydraulic

Cut List

Type	Stock Size (Inches)	Length (inches)	QTY	Primary Part Name	Secondary Part Name
Sheet	0.125 X 48	40	1	PIECE PARTS	TOP PLATE
Plate	0.25 X 16	29	1	BUCKET	SIDE PLATES
	0.25 X 24	48	1	BUCKET	BOTTOM PLATE
	0.25 x 16	48	1	BUCKET	BACK PLATE
Beveled Flat	0.5 X 6	49	1	BUCKET	BLADE
Flat	0.25 X 2	5.5	1	BUCKET	TRIANGLE PLATE
	0.25 X 2.5	48.5	1	BUCKET	CROSS SUPPORT PLATE
	0.25 X 5.5	48.5	1	BUCKET	CROSS SUPPORT PLATE LOWER
	0.375 X 3	48	1	BUCKET	REAR MOUNTING PLATE
	0.375 X 3	11.5	24	TINE	TINE
	0.5 X 2	4.25	2	FRONT FRAME	END PLATE, CROSS TUBE
	0.5 X 2	4	2	ARM REST	PLATE, ARM REST
	0.5 X 3	19.5	2	BUCKET	SKID PLATE
	0.5 X 4	6	2	BUCKET	BOTTOM MOUNTING PLATES
	0.5 X 6	8	1	PIECE PARTS	PLATE, MOTOR MOUNT
	0.5 X 8	12	1	FRONT FRAME	PLATE, MOTOR END
	0.5 X 8	12	2	FRONT FRAME	PLATE, BEARING
	0.75 X 2	3	2	BUCKET	HARD STOP PLATE
	0.75 X 4	23.75	1	BUCKET	SIDE BRACE PLATE
	0.75 X 4	6	2	PIVOT	JOINT PLATE
Pipe	2" SCH 80	2.5	1	COUPLER	COUPLER, SHAFT SIDE
	2" SCH 80	3.5	12	TINE	TUBE, TINE
	2” SCH 40	1	1	COUPLER	SLEEVE
Round Tubing	0.5ID X 0.75OD	2	8	PIECE PARTS	HINGE PIPE
Round	0.5	50	1	PIECE PARTS	ROD, HINGE
	0.5	4	2	PIECE PARTS	ROD, PIN
	1.875	52	1	PIECE PARTS	SHAFT
Square Tubing	0.1875 X 2.5X2.5	6	2	BUCKET	LARGE TUBE, ANGLED
	0.1875 X 2.5X2.5	12	2	PIVOT	LARGE TUBE
	0.25 X 2X2	24	2	PIECE PARTS	SMALL TUBE
	0.25 X 2X2	13.5	2	ARM REST	SMALL TUBE, ARM
	0.25 X 2X4	56	1	FRONT FRAME	CROSS TUBE

Parts Fabrication - Bucket



Sketchup Model

Tools:

- Torch
- Welder
- Angle Grinder
- Hole Puncher
- Protractor

Materials:

- ¾" Nuts, Steel (4)

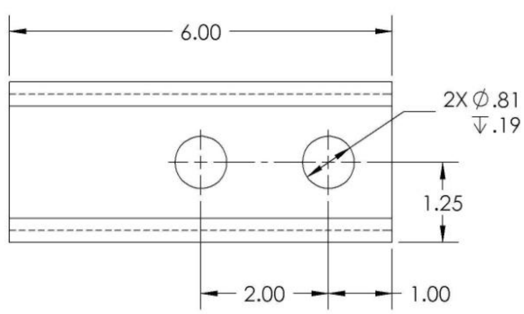
Type	Size	Length	Qty.	Part
Beveled Flat	0.5 X 6	49	1	BLADE
Flat	0.25 X 2	5.5	1	TRIANGLE PLATE
Flat	0.25 X 2.5	48.5	1	CROSS SUPPORT PLATE
Flat	0.25 X 5.5	48.5	1	CROSS SUPPORT PLATE LOWER
Flat	0.25 x 16	48	1	BACK PLATE
Flat	0.375 X 3	48	1	REAR MOUNTING PLATE
Flat	0.5 X 3	19.5	2	SKID PLATE
Flat	0.5 X 4	6	2	BOTTOM MOUNTING PLATES
Flat	0.75 X 2	3	2	HARD STOP PLATE
Flat	0.75 X 4	23.75	1	SIDE BRACE PLATE
Plate	0.25 X 16	29	1	SIDE PLATES
Plate	0.25 X 24	48	1	BOTTOM PLATE
Square Tubing	0.1875 X 2.5X2.5	6	2	LARGE TUBE

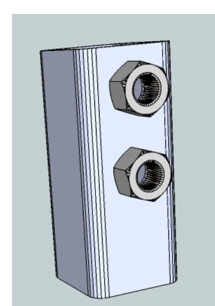
Piece Parts Preparation

Large Tube

You need to make 2 of these.

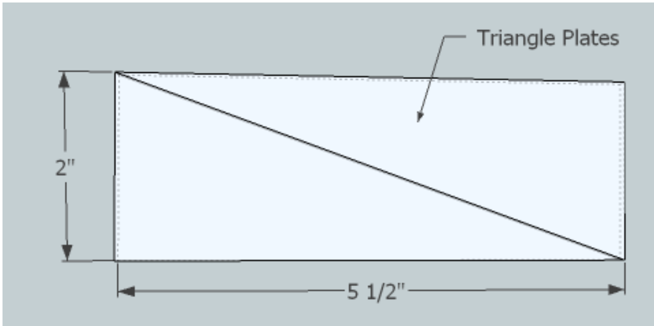
1. Torch the holes as shown. Make sure they are large enough for a ¾" bolt.
2. Grind away the slag.
3. Weld the ¾" nuts 100% over the holes, insuring the nut is level and the hole is clear.
   - Cover the top of the nut so no spatter goes inside while welding.





Triangle Plates

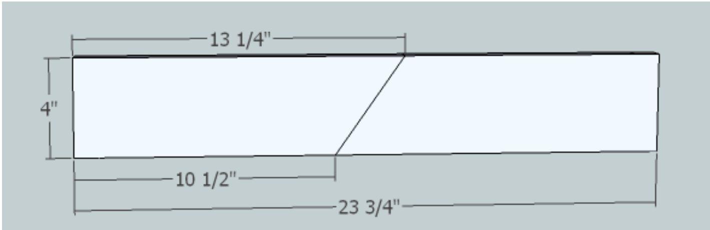
- Torch or shear the flatbar into two pieces as shown.



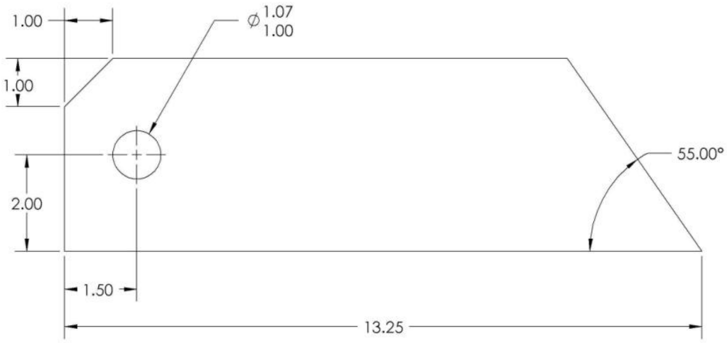
Side Brace Plates

You need 2 of these which are mirror images of eachother.

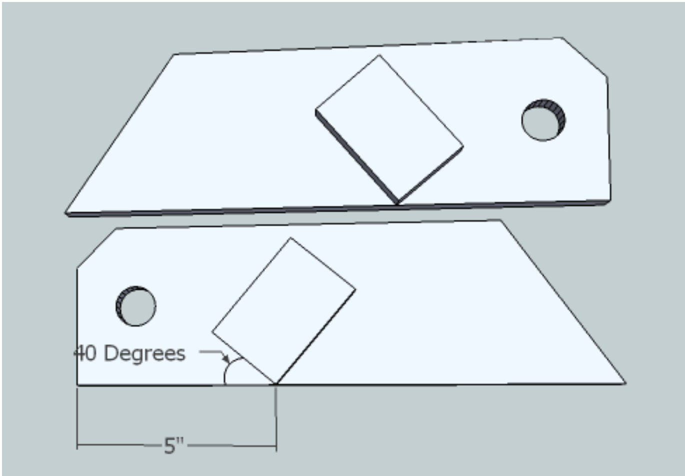
1. Torch or shear the flatbar into two pieces as shown.



2. Punch the hole as shown.
3. Torch away the corner as shown.



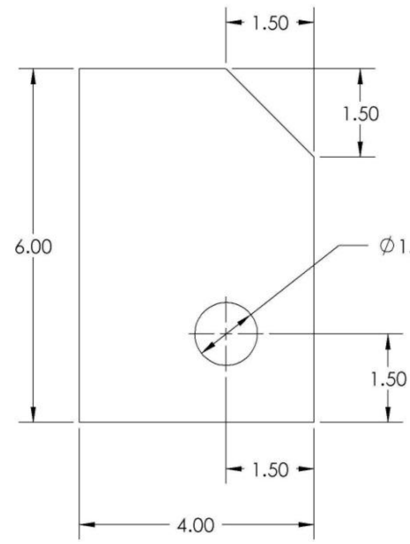
4. Weld the Hard Stop Plate to them as shown.



Bottom Mounting Plates

You need to make 2 of these.

1. Punch the hole as shown.
2. Torch or shear away the corner as shown.

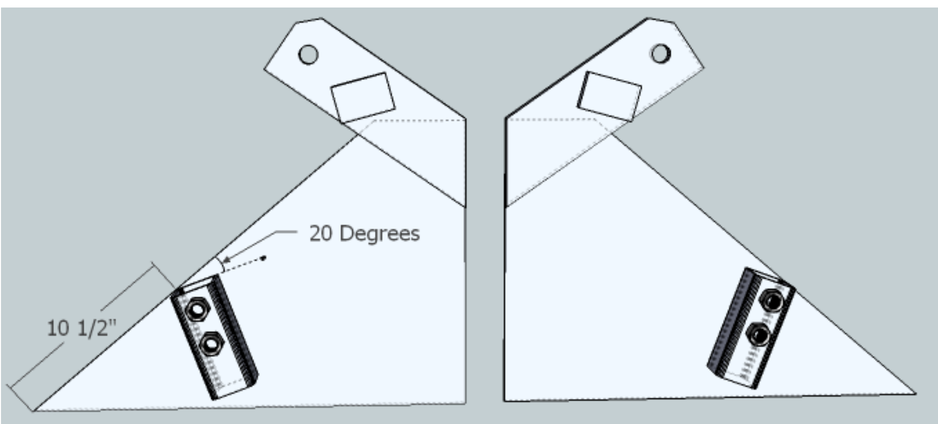


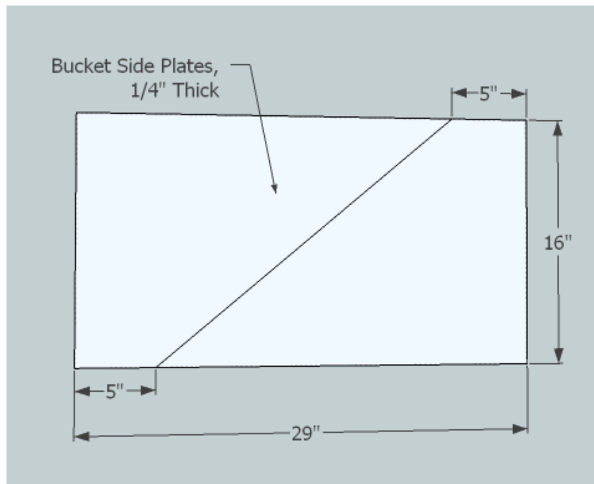
Piece Parts Assembly

Side Plates

You need 2 of these which are mirror images of eachother.

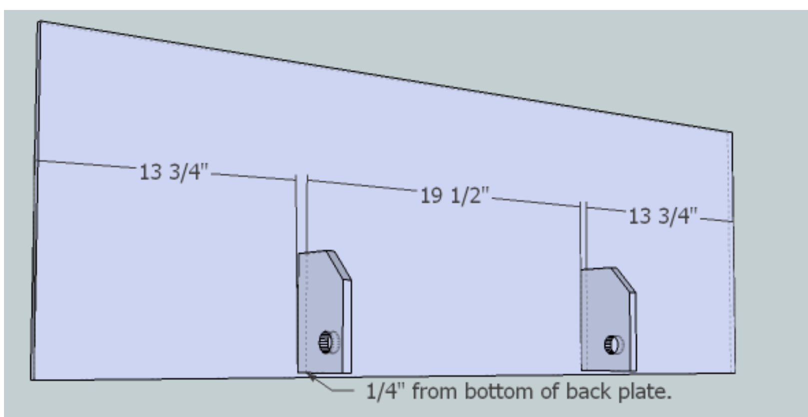
1. Torch or shear the plate as shown (right).
2. Weld the Side Brace Plates and Large Tubes as shown (below).





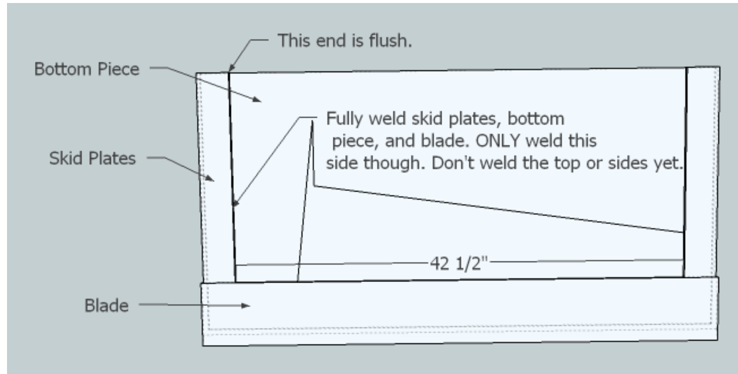
Back Plate

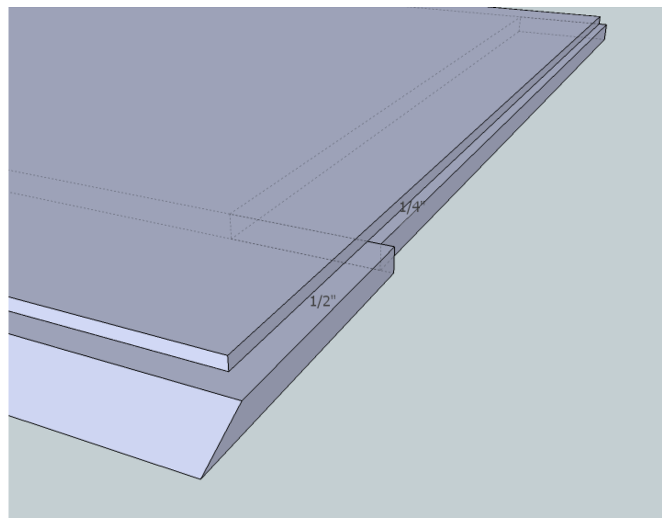
- Fully weld the bottom mounting plates to the back plate as shown.
- Insure they are square and do not warp while welding.



Bottom Plate

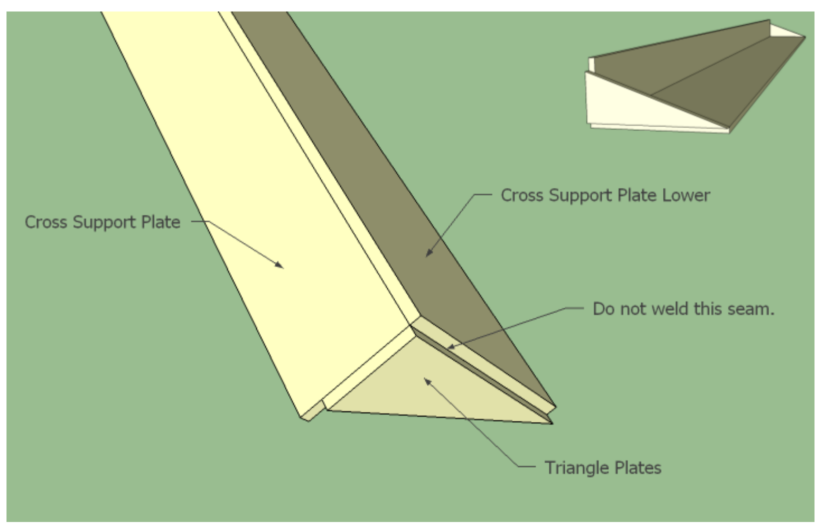
- Fully weld skid plates and blade to the bottom plate as shown.
    - Only weld them from the bottom side, NOT the top or sides yet.
    - Insure you get the right spacing on them by looking at the lower diagram.
    - The blade will stick out ½" on each side, and the skid plates will stick out 1/4" on each side.





Cross Supports

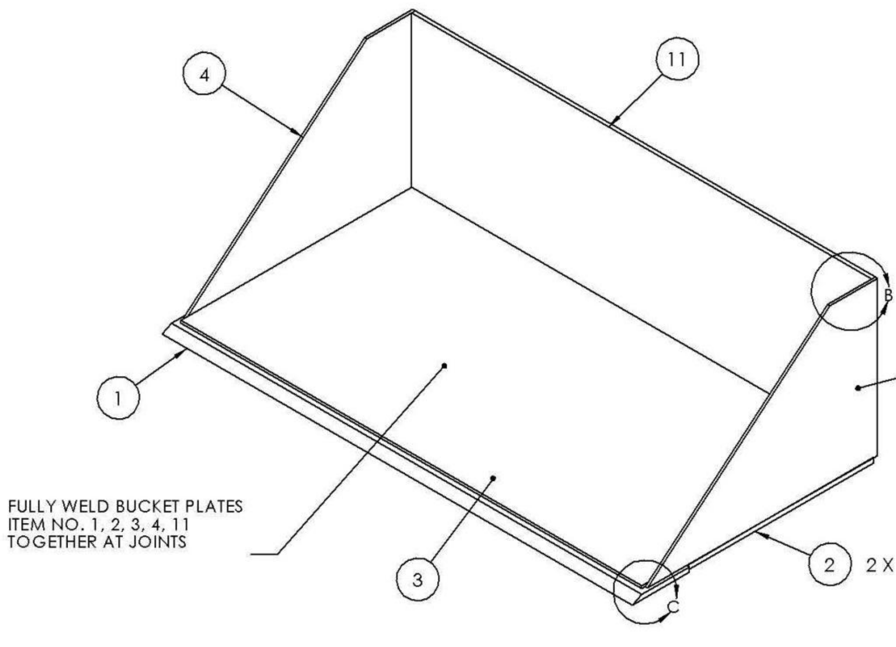
- Weld the Cross Support Plate, Cross Support Plate Lower, and Triangle Plates together as shown, with one Triangle Plate at each end of the supports.
    - Fully weld all seams except the one shown.



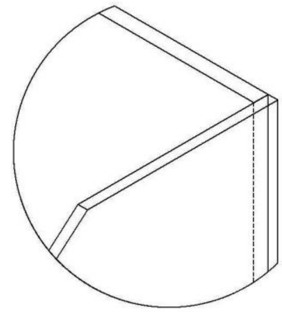
Parts Assembly

1. Weld Bucket Plates

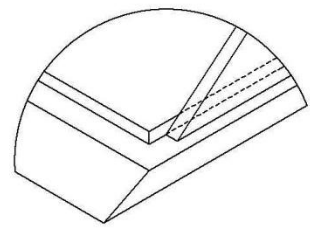
Fully weld the side pates, bottom plate, and back plate together at all joints as shown below.



ISO VIEW
(ITEMS REMOVED FOR CLARITY)



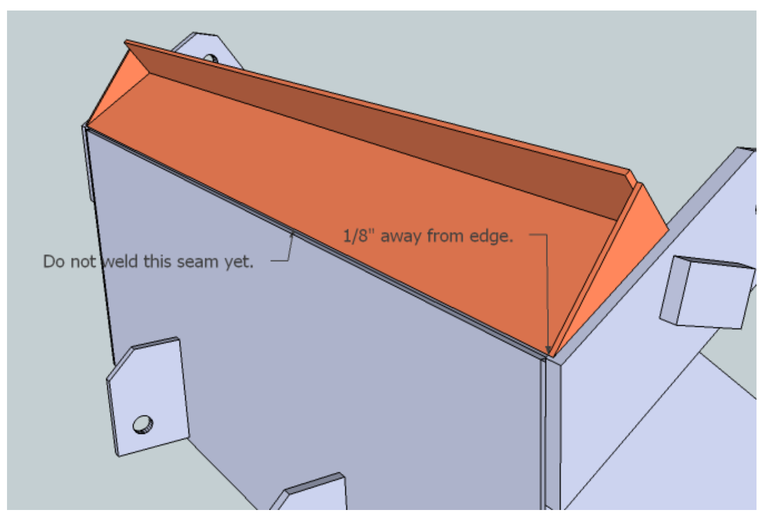
Detail B



Detail C

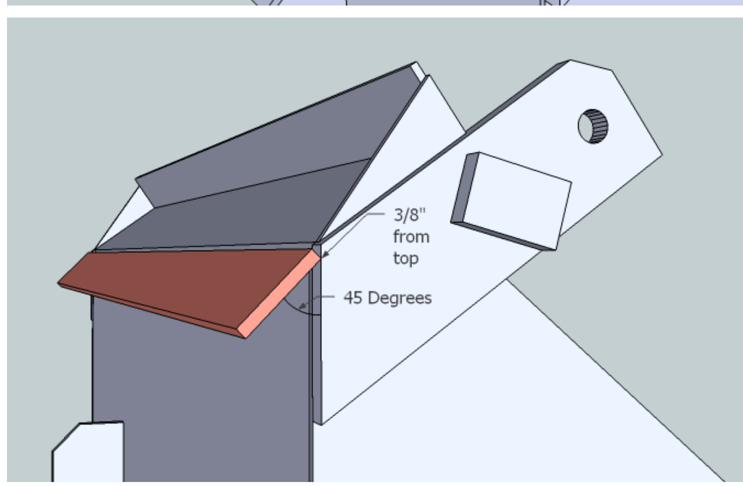
2. Weld Cross Supports

- Weld Cross Supports as shown.
  - Fully weld all seams except the one marked not to.

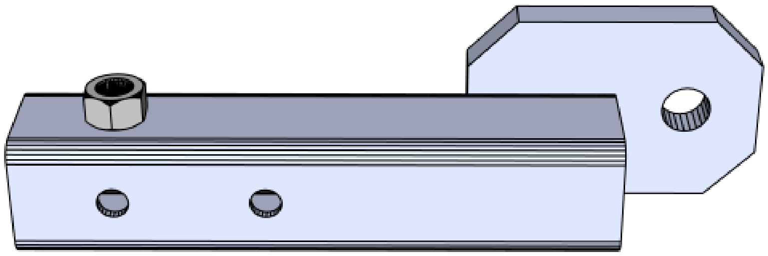


3. Weld Rear Mounting Plate

- Weld it in place, from all angles, as shown, at a 45® angle with the back plate.



Parts Fabrication - Frame Pivot Hinge



Tools:

- Torch
- Welder
- Angle Grinder
- Hole Puncher

Materials:

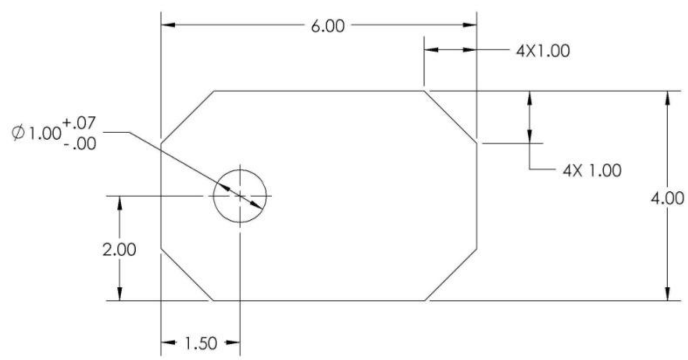
- .75"x4" Flat- 6" (2) – Joint Plate
- 2.5"x2.5"x3/16" Square Tubing- 12" (2) – Large Tube
- .75" Nut, Steel (2)

Procedure

Joint Plate

You need 2 of these.

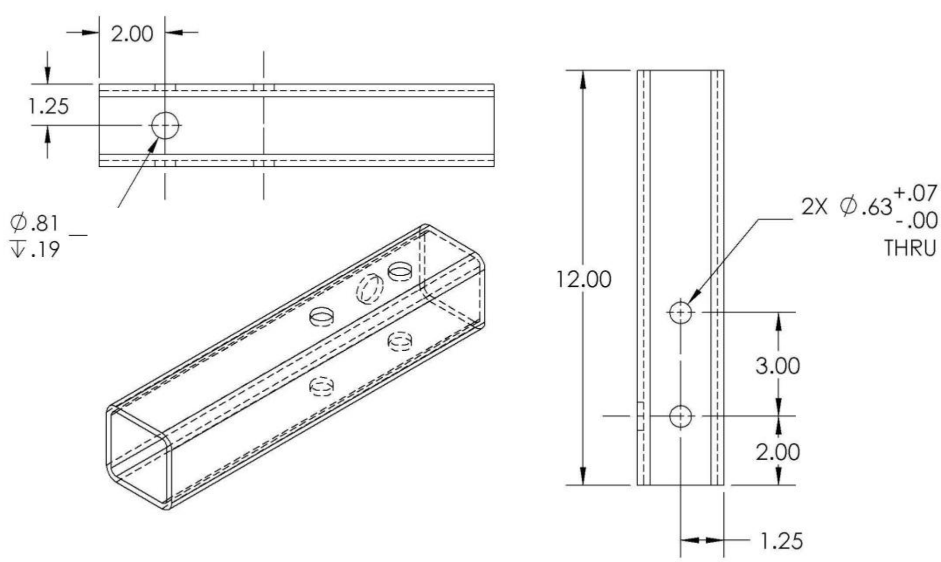
1. Punch the hole as shown.
2. Torch away the corners as shown.



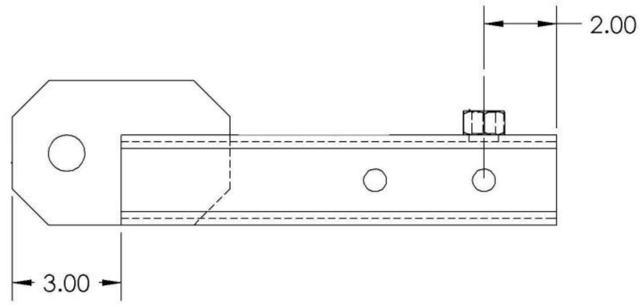
Large Tube

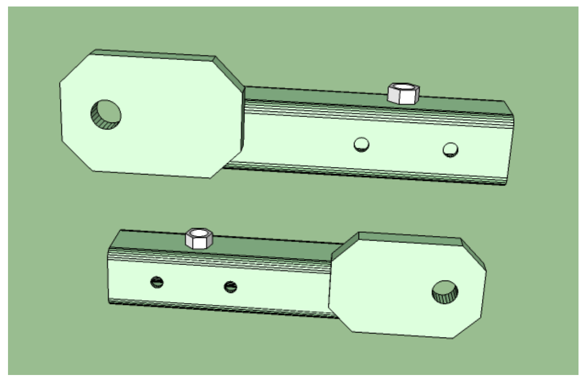
You need 2 of these.

1. Torch the holes as shown.
   - Insure a .75" bolt can go thru the big hole.
   - Insure the ½" rod can go all the way thru the tubing through the smaller holes.
2. Grind away the slag.

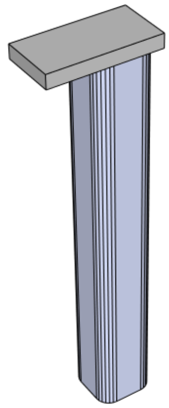


3. Fully weld the nut and Joint Plate to the Large Tube as shown.
    - The two will be mirror images of eachother.
    - When welding the nut, cover the top of the nut so no spatter goes inside, and insure the hole is clear and the nut level.





Parts Fabrication - Arm Rest



Tools:

- Welder

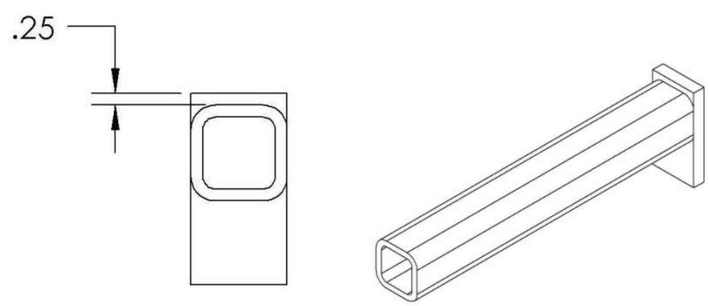
Materials:

- 2”x2”x1/4” Square Tubing- 13.5” (2)
- ½”x2 Flat- 4” (2)

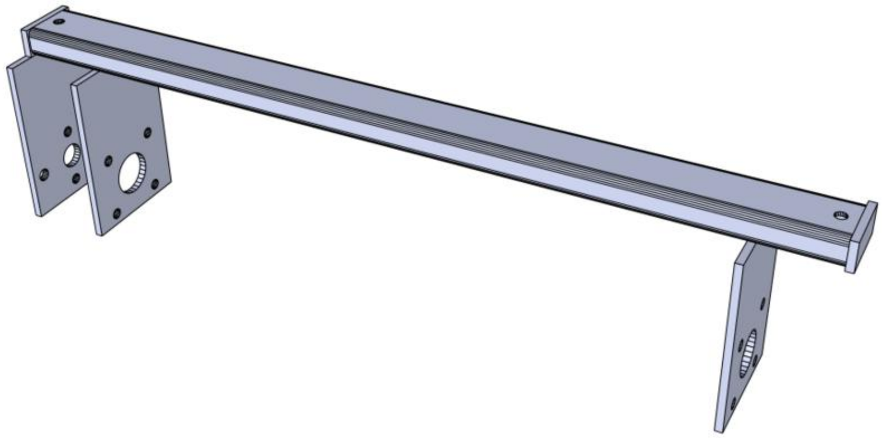
Steps:

You need two of these.

- Fully weld the plate to the tubing as shown.



Parts Fabrication - Shaft and Motor Frame



Tools:

- Torch
- Welder
- Hole Puncher
- Angle Grinder

Materials:

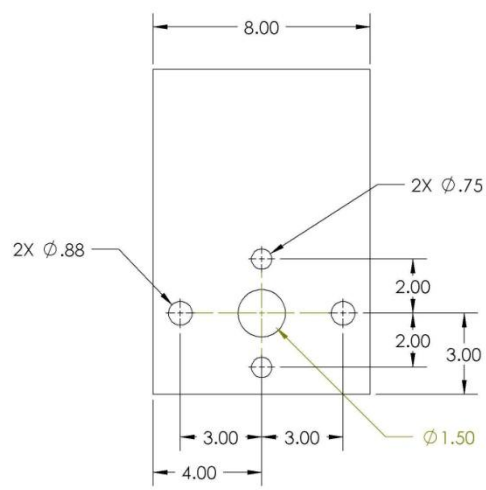
- 1/2”x2” Flat- 4.25” (2) – End Plates
- ½”x8” Flat- 12” (3) – Bearing and Motor Plates
- 2”x4”x1/4” Rectangular Tubing- 56” (1) - Cross Tube

Parts Preparation

Motor Plate

You need 1 of these.

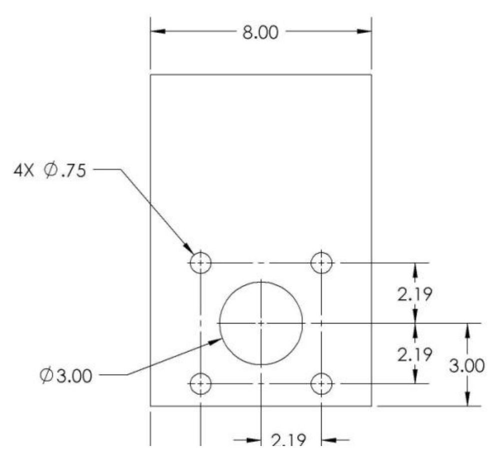
1. Punch the smaller holes.
2. Torch the larger hole.
3. Grind it smooth.



Bearing Plate

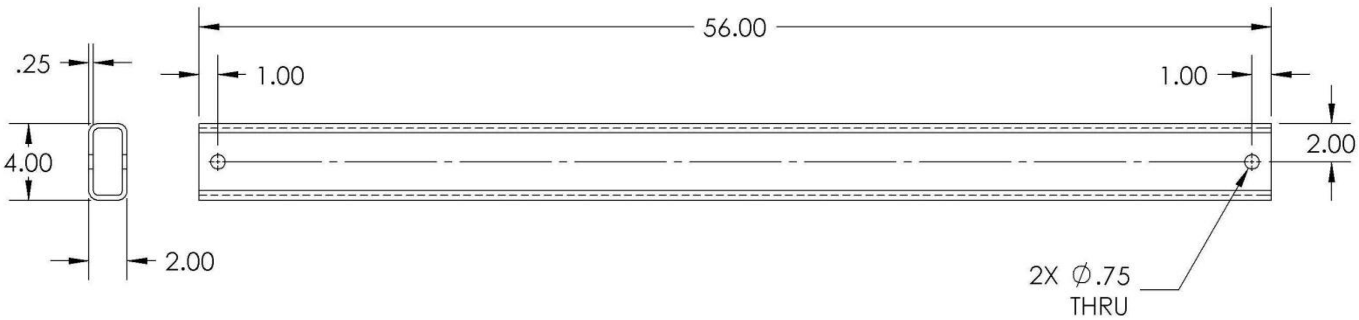
You need 2 of these.

1. Punch the smaller holes.
2. Torch the larger hole.
3. Grind it smooth.



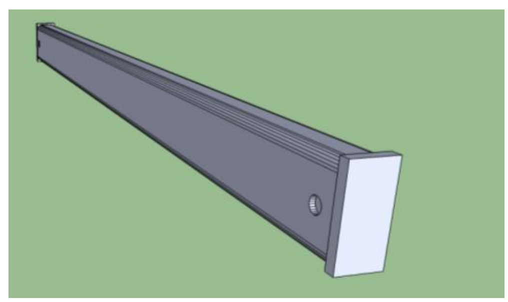
Cross Tube

1. Torch the holes shown.
   - Insure .75" bolts will go all the way through the tube.
2. Grind away the slag.

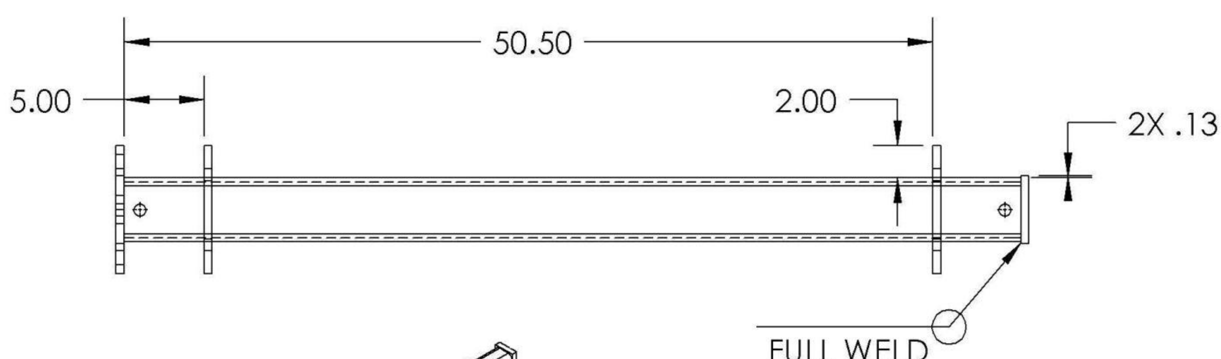


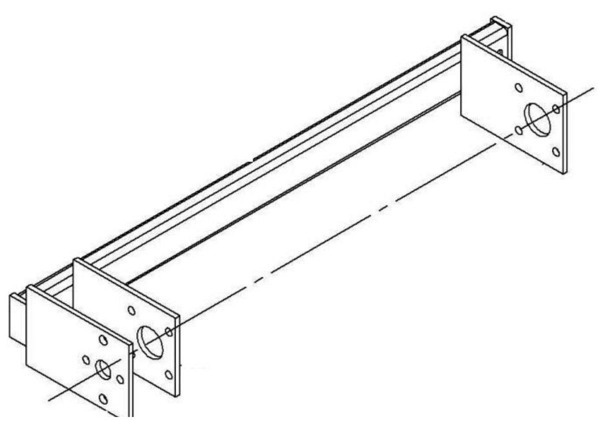
Parts Assembly

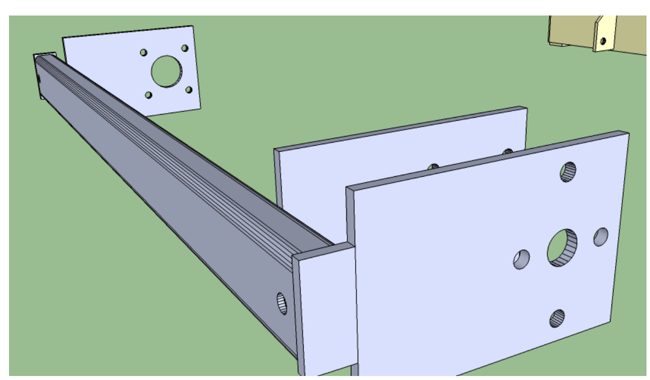
1. Fully weld the end plates centered to each side of the cross tube.



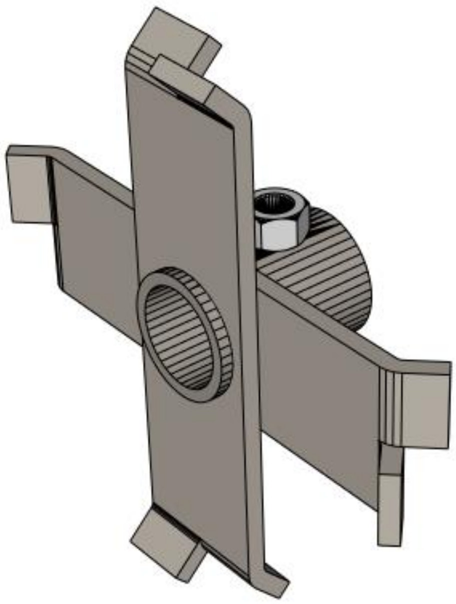
2. Fully weld the motor and bearing plates to the cross tube.
   - It is crucial that these all be square in every direction! Double check it, and weld it slowly so it doesn't warp.
   - Note that the motor plate is welded to the end plate.







Tines



1 Note: Tines will not have bent tips until a later step.

Tools:

- Torch
- Welder
- Hole Puncher
- Angle Grinder

Materials:

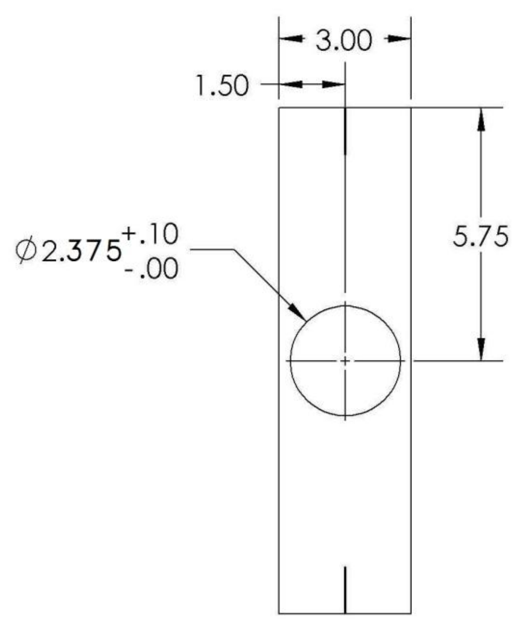
- .375"x3" Flat- 11.5" (24)
- 2" Sch. 80 Pipe- 3.5" (12)
- .75" Nut, Steel – (12)

You need to make 12 of these total.

Procedure

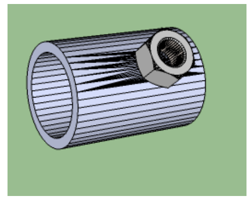
Prepare the tines:

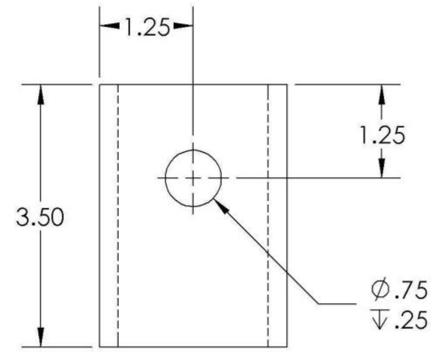
1. Torch a hole in the center of each flat as shown.
   - Check that the pipe will go through it.
2. Torch approximately 1" slits at each side of flat as shown.
3. Grind away any slag.



Prepare the Pipe:

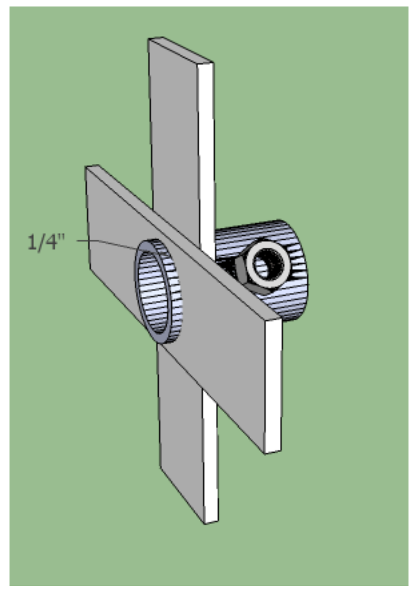
1. Torch a hole in the pipe as shown.
   - Insure a .75" bolt will go through.
2. Grind it smooth.
3. Weld a nut over the hole, insuring the hole remains clear.
   - Protect the threads while welding.





Weld the tines to the Pipe:

1. Weld the tines onto the pipe as shown.
   - They should be perpendicular to eachother.
   - The one closest to the end should be .25" away from the edge of the pipe.
   - Fully weld all joints.
   - Make sure no spatter enters the nut



Parts Fabrication - Coupler

Tools:

- Bandsaw
- Welder
- Drill Press with 3/8" bit.

Materials:

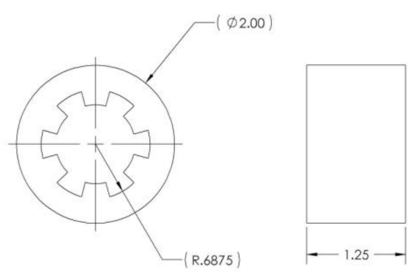
- Coupler, 1-3/8" 6T Splined
- 2" Sch. 80 Pipe- 2.5" (1) – Shaft side coupler
- 2" Sch. 40 Pipe- 1" (1) - Sleeve
- 1.875" Round – 52" (1) – Shaft
- 3/8"x3" bolt

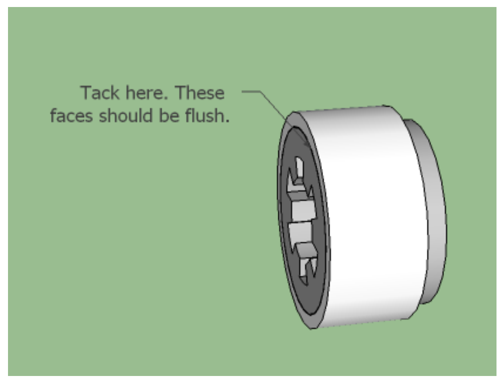
Procedure

Note: if you have access to a lathe, you can simply lathe out about 1/8" long section of the splined coupler so it fits directly into the Sch 80 pipe. This ensures concentricity. You could do away with the sleeve and weld these two directly together.

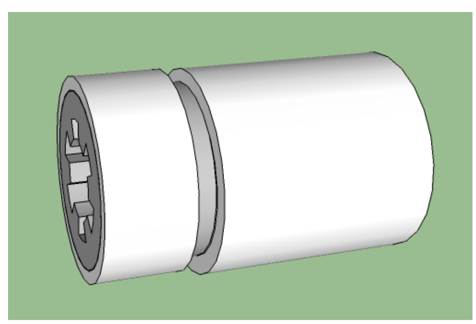
1. Cut down the splined coupler so it is 1.25" long.
2. Tack it to the sleeve as shown.

- If there's any play, get the coupler as centered as possible in the sleeve.

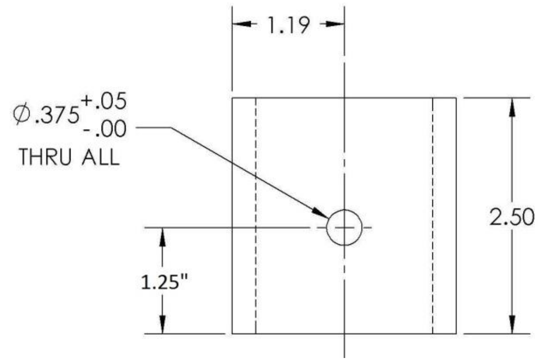




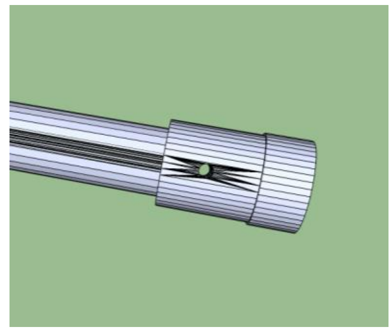
3. Tack the pipe and coupler with sleeve together as shown.
   - Insure that the sleeve and the pipe are concentric!! This is a critical part.
   - It would help to set the two on the welding table and tack from the top, then twist until they're perfect.
4. Tack them in many dimensions to insure nothing warps.
5. Weld it fully, with at least 3 layers of weld.



6. Mark and center punch where the hole in the pipe will be.



7. Insert the shaft fully into the coupler.
8. Drill through the coupler and the shaft.
9. Insure the 3/8” bolt goes through both the coupler and the shaft. If not, re-drill with a slightly larger bit.



Parts Fabrication - Additional Piece Parts

Tools:

- Torch
- Angle Grinder
- Welder
- Hole Puncher
- Drill Press

Small Tube

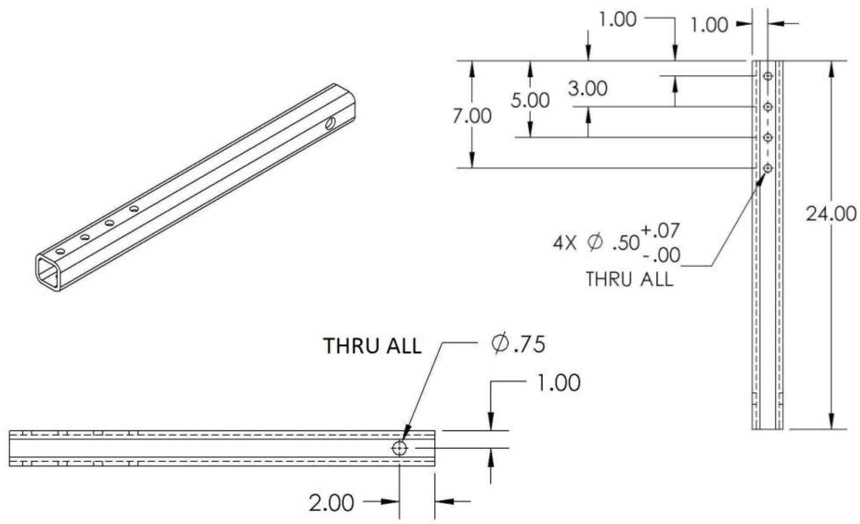
Materials:

- 2”x2”x.25” Square tubing- 24” (2)

You need to make 2 of these.

Steps:

1. Torch all holes as shown.
    - Insure the proper size bolt or rod can go through each hole.
2. Grind away all slag.



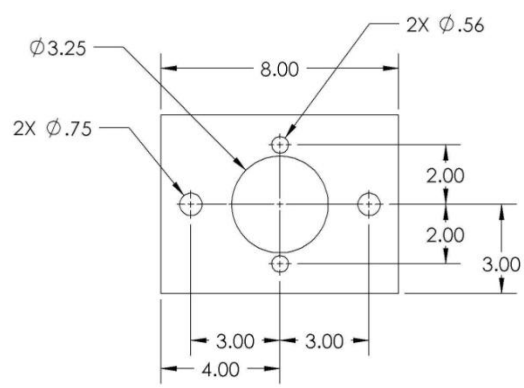
Motor Mount Plate

Materials:

- ½”x6” Flat- 8” (1)

Steps:

1. Punch the smaller holes as shown.
2. Torch the center hole.
3. Grind away the slag.



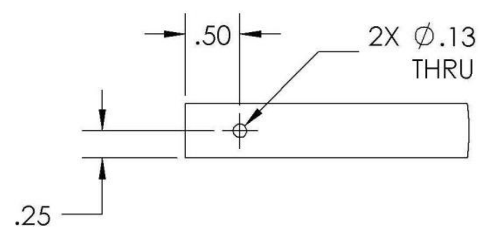
Hinge Rod

Materials:

- .5” Round- 50” (1)

Steps:

1. Drill a hole as shown at each end of the rod.



Hinge Pin

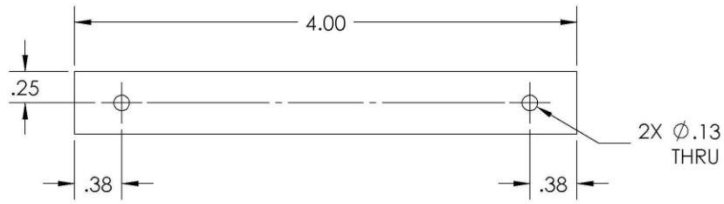
Materials:

- .5” Round- 4” (2)

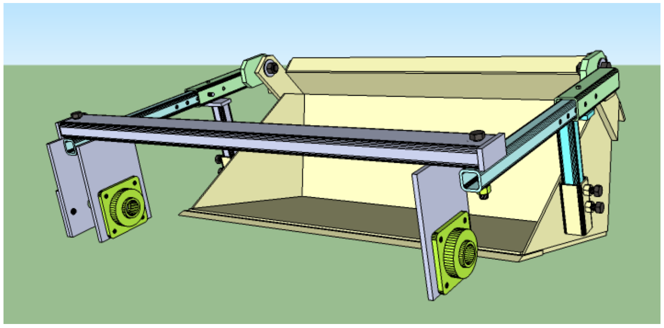
You need 2 of these.

Steps:

1. Drill the holes as shown.



Assembly- Front Frame



An assembly video is also available. Note that not all steps will be the same, as some parts still need to be welded or bent. Follow the written instructions.

Tools:

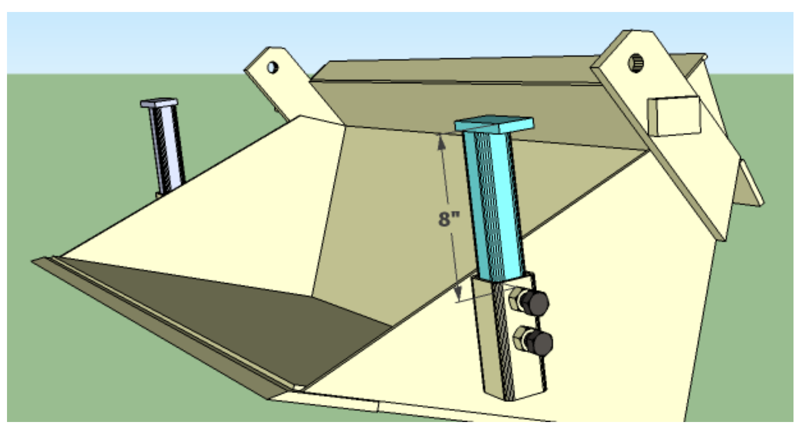
- Various Wrenches

Materials:

- Assembled Parts:
  - Bucket
  - Arm Rests
  - Frame Pivot Hinges
  - Shaft and Motor Fram
- 1 7/8” Bearings (2)
- 1/8” x 2.5” Cotter Pins
- Fasteners
  - 1”x3”x2.25” Bolts (2)
  - 1” Washers (4)
  - 1” Nuts (2)
  - ¾”x5.5”x1.75” Bolts (2)
  - ¾”x1.25” Bolts (2)
  - ¾”x1.5” Bolts (4)
  - ¾” Nuts, Galvanized (2)
  - 9/16”x2” Bolts (8)
  - 9/16” Nuts (8)
  - 9/16” Washers (8)

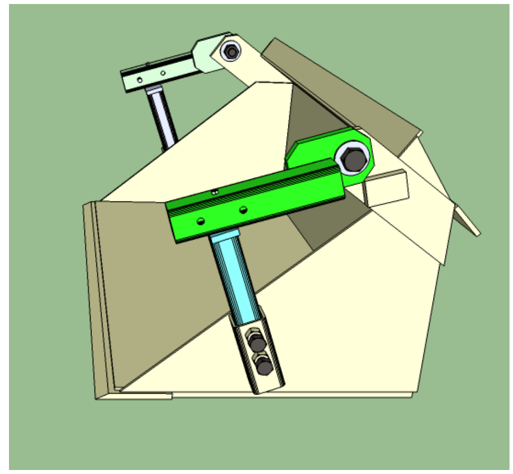
Procedure

1. Insert the Arm Rests into the Arm Rest Slots in the side of the Bucket as shown.
   - Make sure the arm rests have the correct orientation. See the illustration.

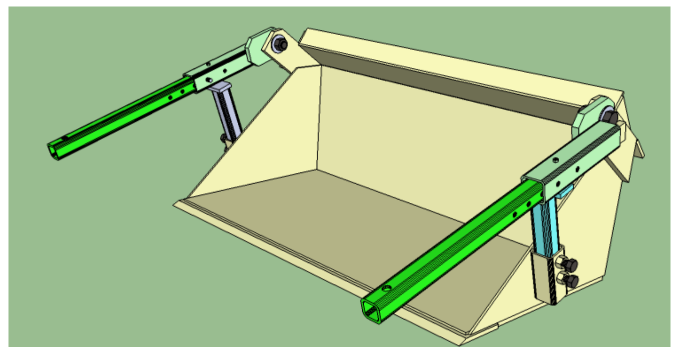


2. Insert and tighten both ¾”x1.5” bolts on each side to hold them in place.
   - The arm rests should both be sticking up about 8” from the slots.

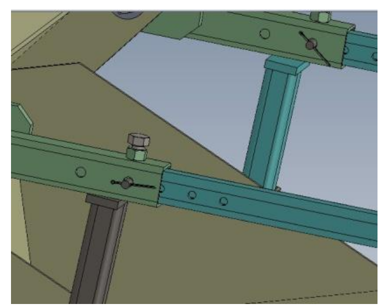
3. Bolt the Frame Pivot Hinges to the top side of the bucket so it rests on the arm rests.
   - Make sure they both have the right orientation by looking at the image.
   - Use the 1" bolts and nuts with a washer on each side.
   - Tighten the bolt, but leave a little space so the Pivot Hinges are free to rotate.



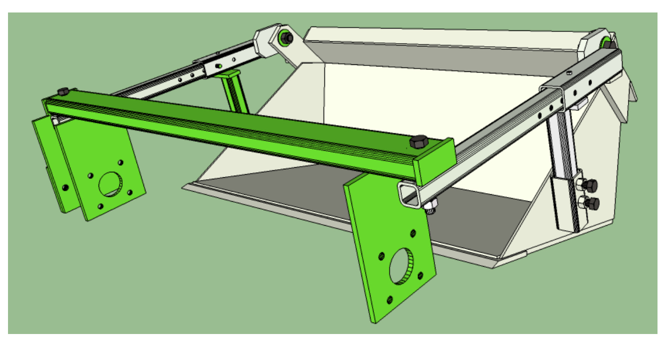
4. Insert the Small Tubes into the pivot hinge, as shown, so that the ¾" holes are on the outside of the bucket.



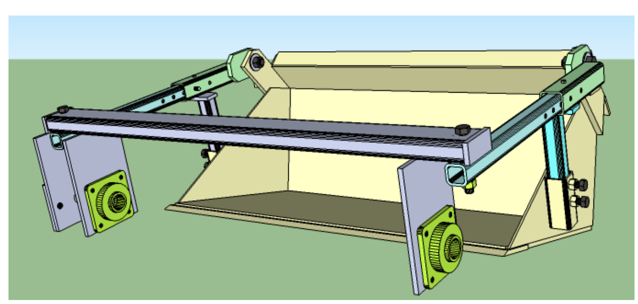
5. Put the hinge pin through both sets of tubing as shown on each side.
   - Which holes you put it through are not crucial, as this can be adjusted later. However, insure both small tubes are adjusted the same..
   - Put the cotter pins though each side of the pin.
6. Tighten a ¾"x1.25" bolt into the nut welded to each pivot hinge.



7. Bolt the Shaft and Motor Frame to the Small Tubes as shown.
   - Use the long ¾" bolts. You need washers on each side of the bolts.



8. Loosely bolt the bearings to the shaft and motor frame as shown.
   - You will tighten the bolts in a later step.
   - Use the 9/16" bolts, with a washer near the nut.



Assembly- Bend the Tines

Tools:

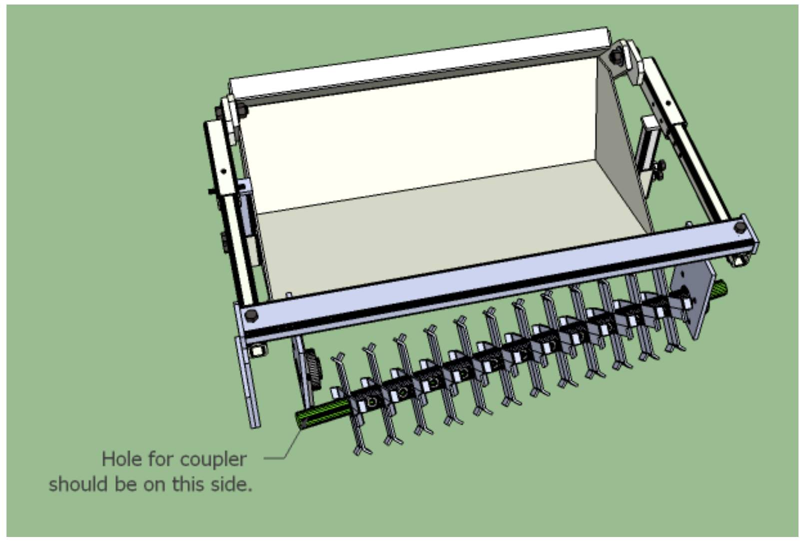
- Pipe wrench
- Mallet

Materials:

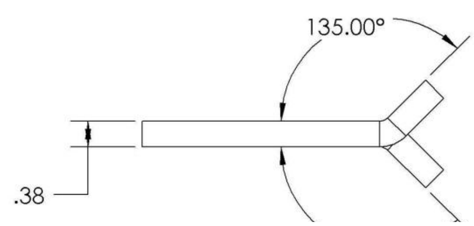
- Assembled Parts:
  - Tines
  - Bucket/Front Frame
  - Shaft

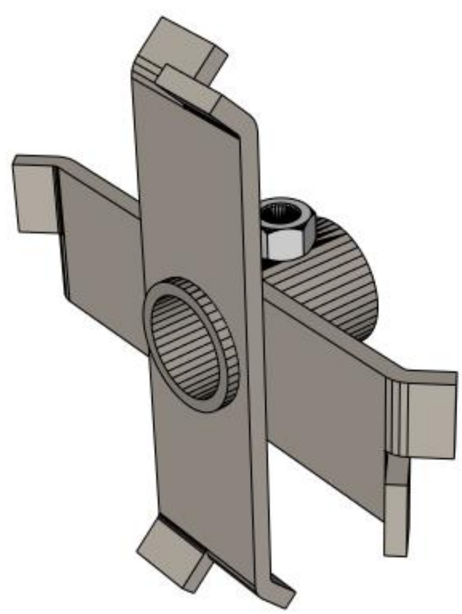
Procedure

1. Hammer the shaft through one bearing as shown, so the hole for the coupler is positioned as shown.
   - Angle it to the side to allow room for the tines to slide on.
2. Slide all tines on the shaft so they are all oriented in the same direction, as shown.

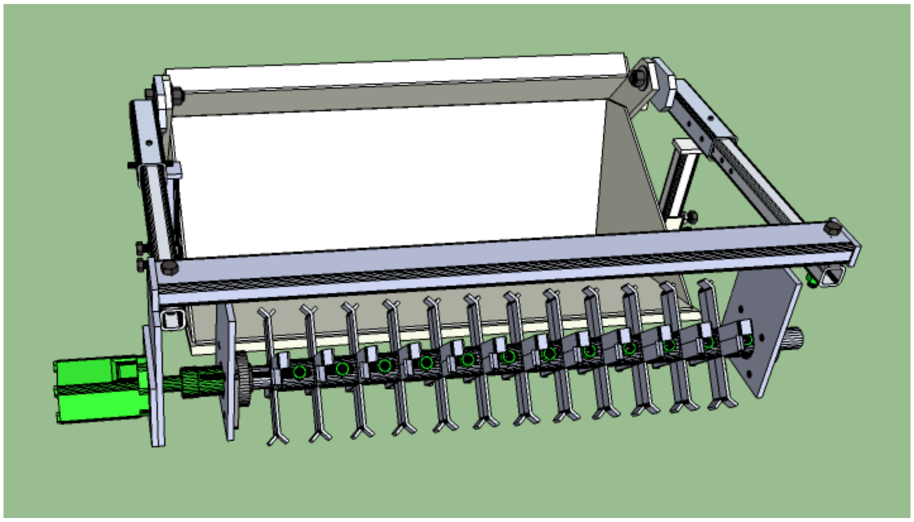


3. Use a pipe wrench to bend each of the tines as shown. If it is too difficult, you can use a torch to heat them up.
   - Their shape doesn't need to be precise.
   - Make sure you bend each piece as in the lower image.





Assembly- Install the Shaft and Motor



Tools:

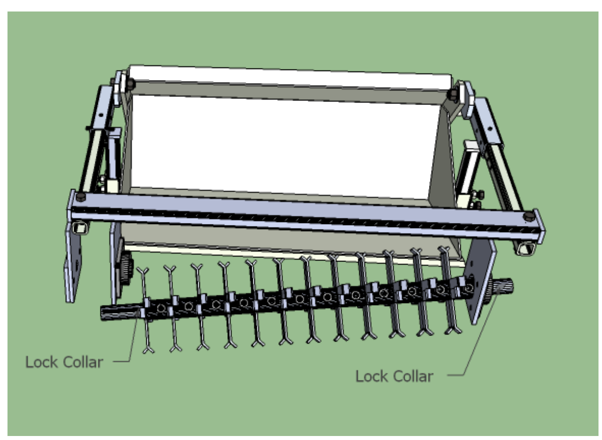
- Mallet
- Various wrenches
- Ratchet/ socket set
- Socket extension
- Allen Wrench
- Loctite

Materials:

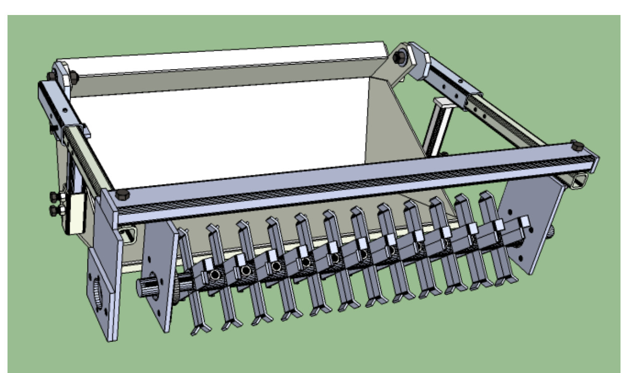
- Assembled Parts:
  - Bucket/Front Frame
  - Motor Mount Plate
- Motor
- Lock Collars for Bearings
- ¾”x1.25” Bolts (12)
- ¾”x2” Bolts
- ¾” Nuts, Galvanized (2)
- ¾” Washers (2)
- ½”x2.5” Bolts (2)
- ½” Nuts (2)
- ½” Washers (2)
- 3/8”x3” Bolt (1)
- 3/8” nut (1)

Procedure

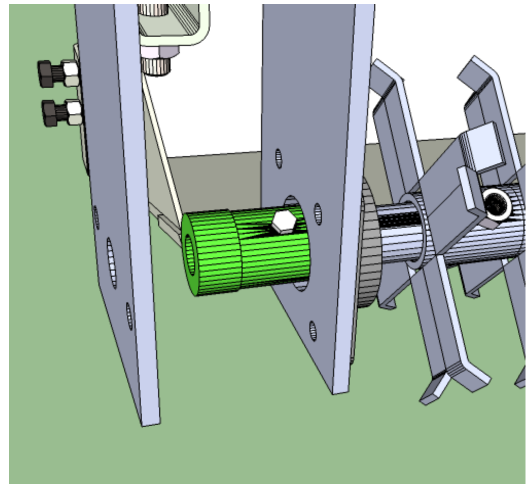
1. Place the lock collars on the shaft as shown.
   - Be sure they are in the right orientation to lock onto the bearings.
   - Don’t lock them yet, you’ll do this later.



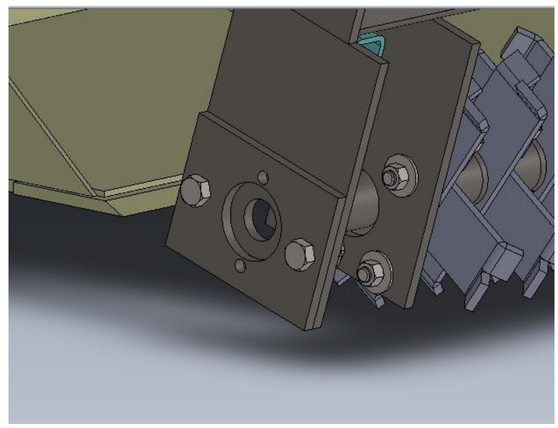
2. Angle the shaft properly, and hammer it though the other bearing until it’s poking through the bearing mount plate about 1”.



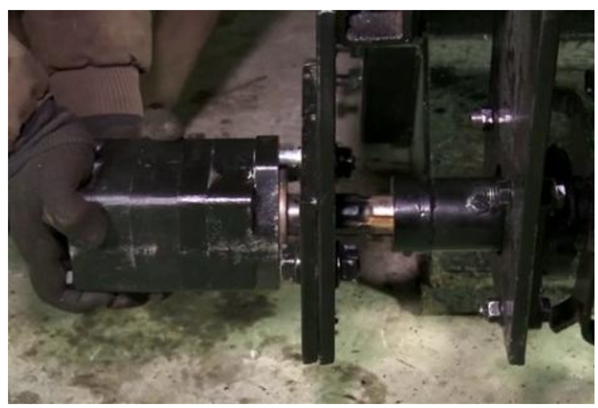
3. Install the coupler onto the shaft.
    - Insert the coupler onto the shaft.
    - Once the coupler is on, hammer the shaft through until it is fully inserted in the coupler and it is positioned as in the photo on the right.
    - Rotate the coupler so that the holes in the coupler and the shaft line up.
    - Insert the 3/8” bolt through the hole and tighten the nut onto it. Use loctite on the bolt.



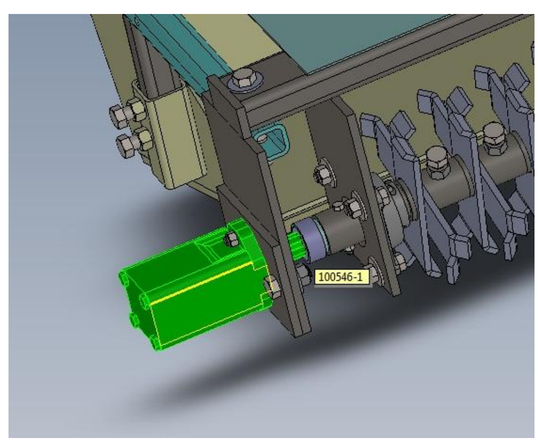
4. Loosely bolt the motor mount plate to the frame, using the ¾”x2” Bolts.
    - Use a washer the side of the nut.



5. Slide the motor through the mount and into the coupler.
    - Make sure the motor is oriented so that you will be able to bolt it to the frame.
    - You may need to rotate the motor shaft, or the shaft with the tines on it to get the motor shaft to fit into the coupler.
    - Don’t insert it all the way yet, just get it started.



6. Loosely bolt the motor to the frame, with the ½”x2.5” bolts, with a washer on the side of the nut.
7. Lightly hammer the motor until it is flush with the motor mount plate.
8. Tighten the bolts on the motor and the motor plate.
9. Tighten the set screw on the coupler and the bearing lock collars.
10. Tighten ¾”x1.25” bolts into each tine, using a socket with an extension.



Assembly – Install the Top Plate

Tools:

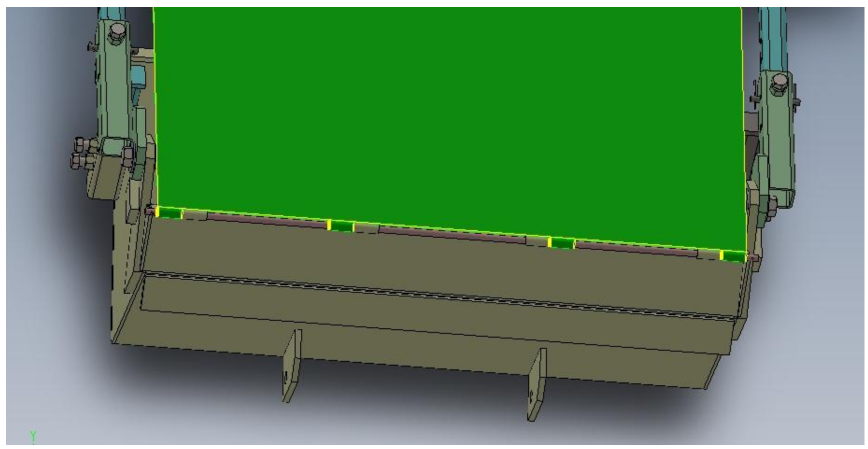
- Welder
- Mallet

Materials:

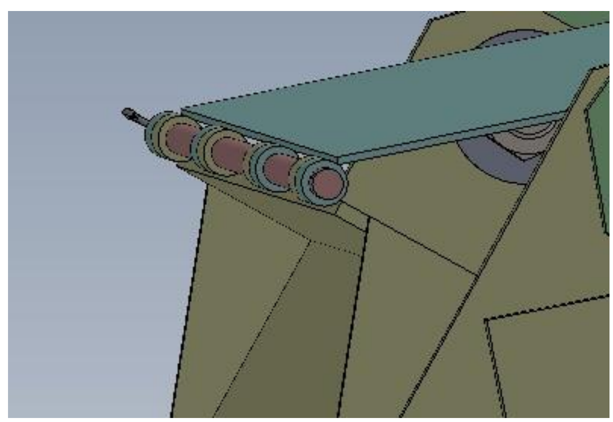
- Assembled Parts:
  - Bucket/Front Frame
  - Hinge Rod
- .5 ID x .75 OD Round Tubing- 2” (8)
- 1/8” Sheet- 40”x48” – Top Plate
- 1/8”x2” Cotter Pins (2)

Procedure

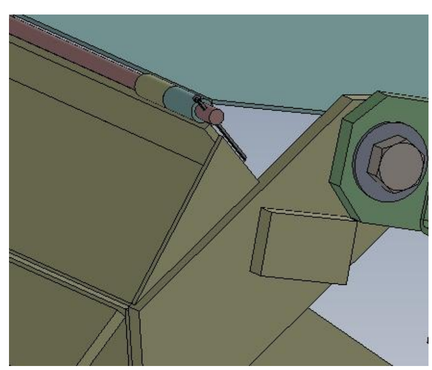
1. Lay the top plate onto the frame as shown.
2. Insert the pipe onto the Hinge Rod as shown, and position pipe and rod as shown.
   - Space the pipes approximately as shown, so they are in 4 sets of 2, evenly spaced.



3. Position the top plate and rod/pipes approximately as shown on the right.
4. Weld one pipe from each set to the cross support piece, and one to the top piece.
   - Protect the shaft so that no welding spatter sticks to it.
   - Weld the highlighted ones in the photo above to the top piece, and all others to the cross support piece.



5. Insert the cotter pins into the holes at each end of the rod.



Assembly- Paint

Procedure

1. Check all external surfaces for sharp edges and smooth with angle grinder.
2. Remove any surface rust with wire brush and / or sandpaper.
3. Apply a thorough coating of paint to all steel surfaces.
    - You will need to prop up the top piece while painting, so you can paint everything.
    - Do not paint the motor.
4. Allow 24 hours to dry before handling.

Assembly – Hydraulics

Tools:

- Rags
- Jar
- Various Wrenches
- Thread Tape

Materials:

- SAE 10 to 1/2 NPT swivel (2)
- SAE 4 to 1/4 NPT swivel (1)
- 30 gpm Quick Coupler set, Body Size: 1/2, Thread Size: 3/4-14 NPT (3)
- ¼" Quick Coupler set (1)
- ¼" Male quick coupler (1)
- 1/4 NPTM x 12' Hose (1)
- 1/2 NPTM x 12' Hose (2)

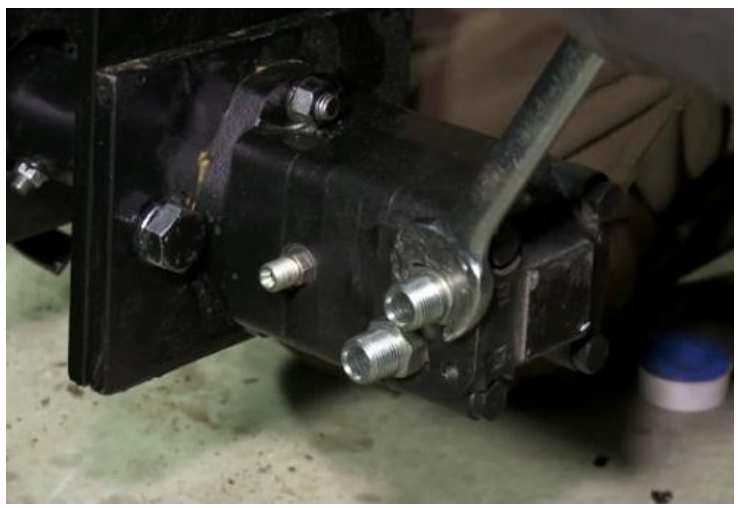
Procedure

Prepare the hoses

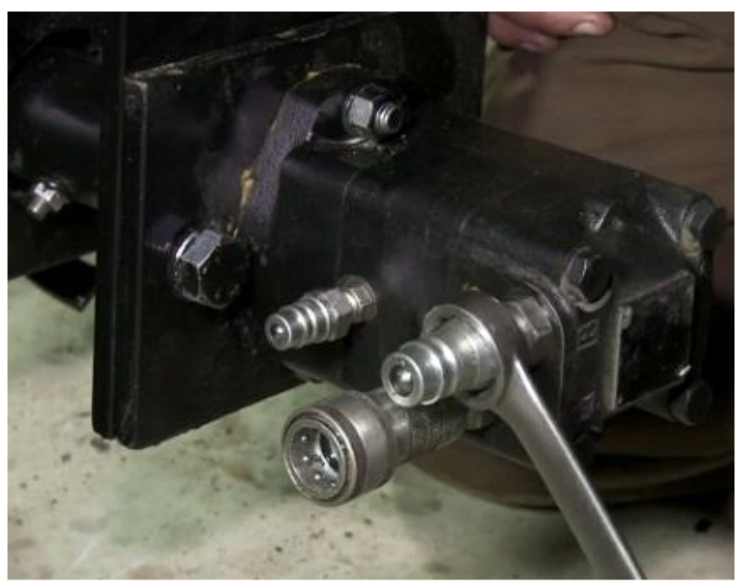
- To each hose, attach a male quick coupler at one end and a female at the other.
- Use thread tape between each connection.

Assemble motor hydraulics

1. Remove the plugs in the motor.
    - Have rags and a jar ready in case there is fluid in the motor.
2. Install the swivels into the ports as shown in the photo.
    - Do not use thread tape on the swivel fittings.



3. Install the quick couplers as shown on the right, using thread tape for each connection.



4. Attach the hoses to the quick couplers in preparation for attaching to a hydraulic power source.

Safety

When pulverizer is in operation, do not go near the spinning shaft and tines.
Be very aware of where others are when operating the pulverizer.
Debris can and will be ejected to the sides of the pulverizer bucket. Keep bystanders well away and ensure everyone is wearing safety glasses to prevent eye injury.

Troubleshooting

See Appendix: Hydraulics System Troubleshooting

User Agreement

The User takes on the full responsibility of using the plans to build a Soil Pulverizer, by ensuring that the User follows all Soil Pulverizer build, safety, maintenance, and operation procedures. It is the duty of the User to accept that accidents and unforeseen circumstances may occur by using, and that such happenings may place the User in danger of injury or even death. The User agrees to not hold OSE liable for any accidents or deaths, and the User agrees to not pursue any legal action against OSE and his or her agents and collaborators in the case of harm, injury, or death resulting from use of the Machine, regardless of the cause or reason for the accident. It is the duty of the User and his/her collaborators or work crew to read and understand the Assembly, Setup and Testing Procedure, Machine Adjustment, Troubleshooting, and all of the above safety, maintenance, and operation procedures. Furthermore, the User agrees to not solicit the services of any agents, assigns, or other third parties to pursue legal action against the Producer in the case of accidents or death related to use of the Machine. If the User allows any other person or group to use the machine or participate in brick production, the User likewise agrees to take on the full responsibility and liability associated with any harm or injury that may happen to anyone involved in using the Machine, and shall hold the Producer in indemnity.

Therefore, the User hereby agrees to release and forever discharge OSE from any and all liability, claims, and demands of whatever kind either in law or in equity, which arise or may hereafter arise from the building or use of the Machine by: (1), the User, (2), others involved with the User in the build or use of the Machine, and (3), others to whom the User grants use of the Machine. The User furthermore agrees and understands that this contract discharges OSE from any liability or claim that the User may have against OSE with respect to bodily injury, personal injury, or property damages that may result from the User's and Beneficiary's production or use of the machine, wherever the Machine may be used. The User also understands that the Producer does not assume any responsibility for or obligations to provide financial or other assistance, including but not limited to medical, health, or disability insurance in the event of injury or loss – unless OSE agrees to help the User or Beneficiary out of voluntary, good faith and honor.

Power Cube

Design Rationale

The Power Cube is an interchangeable power source. This design approach satisfies a number of the OSE Core Values:

1. ***Modular*** - Power Cubes are easily traded out and the design is easily altered. At the same time, there is an overall logic to the design that encourages interoperability.

2. ***User-Friendly*** - The Power Cube can be transported without special equipment and swapped out with only a few minutes training.

3. ***Do-It-Yourself*** - Build it yourself. Use it yourself. Repair it yourself. Nothing about a Power Cube requires special tools or proprietary information.

4. ***Resilience*** - Power Cubes work for you, not against you. If one breaks, you can swap it out in the field and get back to work.

5. ***Systems Design*** - The Power Cube does not maximize the performance of any particular machine. Rather, it maximizes the performance of the entire GVCS system of systems.

6. ***Substitutability*** - Any GVCS machine designed to accept a Power Cube can just as easily be powered by a commercial equivalent or by manual activity. Additionally, Power Cubes can replace commercial and manual equivalents in non-GVCS applications.

7. ***Scalability*** - The concept of the power cube automatically lends itself to smaller versions, larger versions and versions with different power in/out puts.

8. ***Simplicity*** - Each Power Cube is composed of the bare minimum components necessary for go-anywhere power production.

9. ***Sufficiency*** - The Power Cube is “good enough” but could be augmented to achieve any specified level of performance.

10. ***Realistic Immediacy*** - Power Cubes are doing real work right now and the design is already in its fourth version.

Definition

The Power Cube is a universal power unit, and it is a module that can be attached to the LifeTrac, Microtrac, Bulldozer, and Open Source Car (OSCar) platforms. As such, any of these platforms can be used as power sources for other devices, such as workshop tools, power generators, ironworker machines, or any other devices which require a power source. The key to this flexibility is the self-contained nature of the Power Cube, where quick-connect hoses and quick-connect physical mounting allow the Power Cube to be coupled to use with other devices. It has frame-integrated fuel and hydraulic reservoirs. It currently contains an 18 or 27 hp gasoline engine, coupled to a hydraulic pump, and produces fluid flow up to 15 gallons per minute and up to 3000 pounds per square inch (PSI) pressure. It connects to other devices via quick couplers and quick-connect hydraulic hoses. A modern steam engine will be retrofitted as soon as it is developed to allow complete fuel flexibility.

Problem Statement and Solution

Power machinery and equipment typically uses dedicated engine units, such that a large number of different engines is required to power a large number of powered equipment. The engine unit is the heart of any powered device.

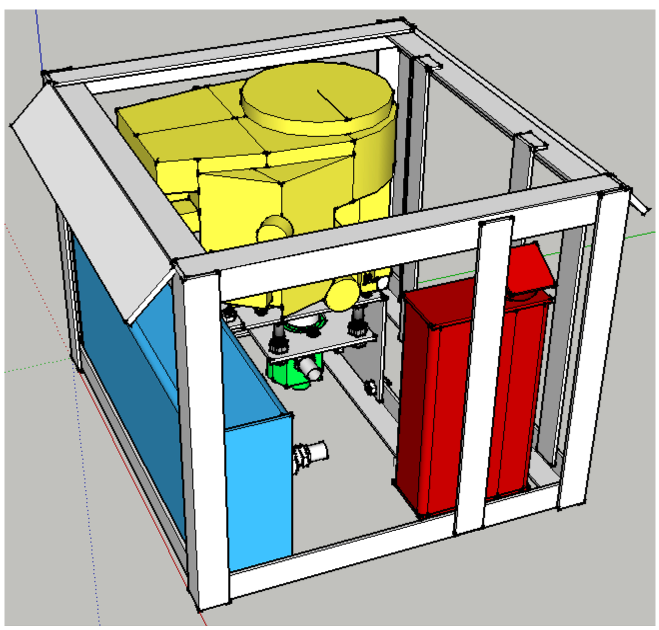
Solution

By decoupling the power unit from a powered device via quick-attach coupling – it is possible to turn a dedicated power unit into a flexible power module. We have shown proof of concept – in that power units can be shared between different machines. This allows for drastic cost reduction in the overall cost of mechanical infrastructures.

Product Ecology

The current iteration of the power cube is an off-the-shelf gasoline engine, but the design is intended to be as power source agnostic as possible so that the power production can be readily changed. There will likely be many variations on the power cube design, but all fitting inside a similar size profile so that a GVCS machine can readily swap out one Power Cube for another.

Power Cube



Version 4

Bill Of Materials

Discrete parts

Name	Qty	Dimensions	Manufacturer / Retailer	Part No.
Engine	1	28 HP	Briggs & Stratton	49M777 Series
Solid Shaft Coupling	1	1 1/8” x 5/8”	Sweiger Shop	Custom
Hydraulic Pump	1	0.976 cu in	SurplusCenter.com	9-1766-B
SAE 10M x 3/4” NPTF Adapter	1	3/4” NPTM	SurplusCenter.com	9-6405-10-12
3/4" NPTF Return Filter & Head	1	20 GPM	SurplusCenter.com	9-059
14 GPM Hydraulic Tank Strainer	1	1 1/2” F x 1” M	SurplusCenter.com	9-7290-100
3/4" NPTM TO 3/4" NPTM 90 Elbow	1	¾”	SurplusCenter.com	9-5500-10-12
JIC 12M x 3/4 NPTM 90 ELBOW	1	12M x 3/4”	SurplusCenter.com	9-2501-12-12
3/4" Quick Coupler S40-6 F/F	1	3/4”	SurplusCenter.com	928-C
1/4" NPT Quick Coupler S40-2	1	1/4”	SurplusCenter.com	9-6314
1/4 NPTM TO 3/4 NPTF ADAPTER	1	1/4” x 3/4” NPT	SurplusCenter.com	9-5405-12
NPT Weld-In Tank Flange	1	1 1/2”	SurplusCenter.com	9-7843-24
NPT Weld-In Tank Flange	2	3/4”	SurplusCenter.com	9-7843-12
NPT Weld-In Tank Flange	1	¼”	SurplusCenter.com	9-7843-4
Hose barb	1	¼" NPTM x 1/4"	SurplusCenter.com	455-AA
1" Hose Barb to SAE 12M Adapter	1	1” Hose x SAE 12M	SurplusCenter.com	9-4604-16-12
1" Hose Barb to 1" NPTM Adapter	1	1” x 1” NPTM	SurplusCenter.com	9-4404-16-16
Hydraulic Suction Hose	1	3'	SurplusCenter.com	9-1279
Hydraulic Oil Cooler	1	Approx 12” x 15”	SweigerShop.com	Custom
JIC 12F X JIC 12F 3000 PSI HYD HOSE	1	3/4” x 12”	SurplusCenter.com	951-2212
3/4" NPT PLASTIC TANK BREATHER	1	3/4”	SurplusCenter.com	9-7957-12
3/4" X 3/4" X 3/4" NPTF TEE	1	3/4" x 3/4" x 3/4"	SurplusCenter.com	9-5605-12-12-12
3/4" NPT HEX NIPPLE	4	3/4”	SurplusCenter.com	9-5404-12-12
JIC 12M x 3/4" NPTM 90 Elbow	1	3/4”	SurplusCenter.com	9-2501-12-12

Name	Qty	Dimensions	Manufacturer / Retailer	Part No.
JIC 12M x JIC 12M UNION	1	JIM 12M	SurplusCenter.com	9-2404-12-12
Solenoid	1		SurplusCenter.com	11-1108
12 Volt radiator fan	1	12” - 14”	Auto Part	
Rubber Fuel Line	1	24”	Auto Part	
Battery	1	5" x 7.5" x 7.5"	Walmart	UIP-7
Galvanized Nipple	4	1”	Home Depot	64310
Galvanized Elbow	2	1”	Home Depot	510-003HN
Galvanized Washer	4	2 ½”	??	??
Galvanized Round	2	2”	??	??
Teflon Tape	1 roll	½” wide	Home Depot	??
1 Gauge Wire	30”	1 gauge	Auto Part	??
1 gauge ring connector - or - Copper tubing	6 - or - 9”	1 gauge - or - 3/8”	Auto Part	??
Ignition Switch	1			
12 V Fan Switch	1			
Bolt (Angle iron attach)	4	½” x 2” x 12 TPI		
Nut (Angle iron attach)	4	½” x 12 TPI		
Washer flat	8	½”		
Bolt (Engine mount)	4	¼” x 2” 16 TPI		
Nut (Engine mount)	4	¼” x 16 TPI		
Bolt (Hydraulic motor mount)	4	¾” x 3.5” x 12 TPI		
Nut (Hydraulic motor mount)	8	¾” 12 TPI		
Lock washer (Hydraulic motor mount)	4	¾”		
Nut (Fan mount)	4			
Bolt (Fan mount)	4			
Bolt (Solenoid mount)	2			
Tractor Enamel: Glossy Black	1	pint		

Steel

Type	Thickness	Width	Total Length (rounded up)
Angle	¼"	2" x 2”	408" (34 ft)
Angle	1/8”	2” x 2”	6”
Plate	¼"	8"	38" (4ft)

Plate	¼”	2”	120”	(10 ft)
Plate	¼"	6"	24"	(2 ft)
Plate	3/8”	4”	54”	(5 ft)
Tube	¼”	4” x 8”	14 ½”	(2 ft)
Tube	¼”	6” x 12”	27 ½”	(Hydraulic reservoir)
Tube	1/8”	4”	2”	(black pipe)
Tube	1/8”	1 9/16”	12”	(Galvanized Muffler Pipe)
Tube	1/8”	6 cm	14”	(Galvanized Muffler Pipe)
Expanded Steel	13 gauge	12”	22”	(Oil cooler grill)

Subassembly Fabrication

Many of the items listed in the Bill Of Materials require preparation before use in assembly of the Power Cube. This includes drilling and cutting steel up to 3/8" in thickness. These are the parts for assembling a Power Cube. Parts without special detail are not illustrated.

1. Engine and Hydraulic Pump mounts

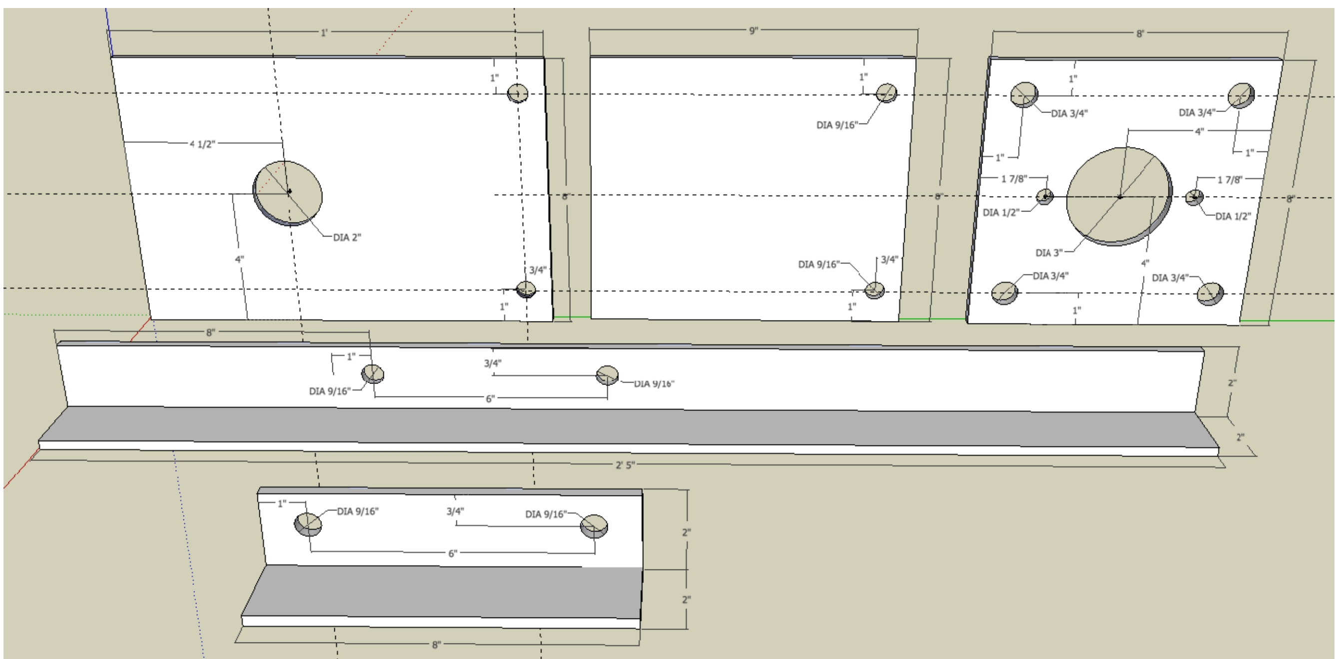
   a) ¼" x 8" x 12" Plate

   b) ¼" x 8" x 9" Plate

   c) ¼" x 2" x 2" x 8" Angle

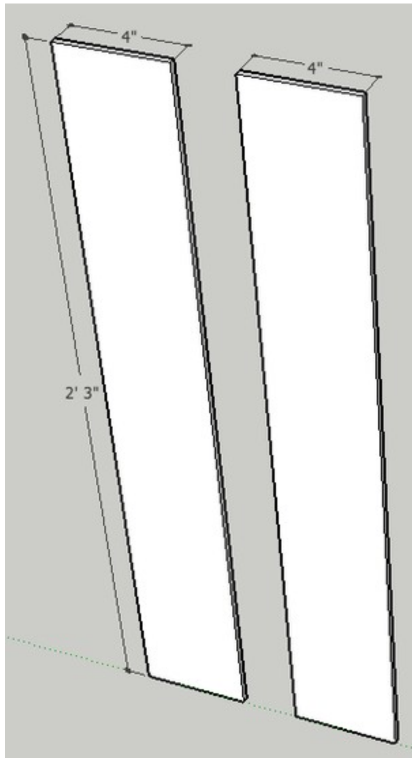
   d) ¼" x 2" x 2" x 29" Angle

   e) ¼" x 8" x 8" Plate

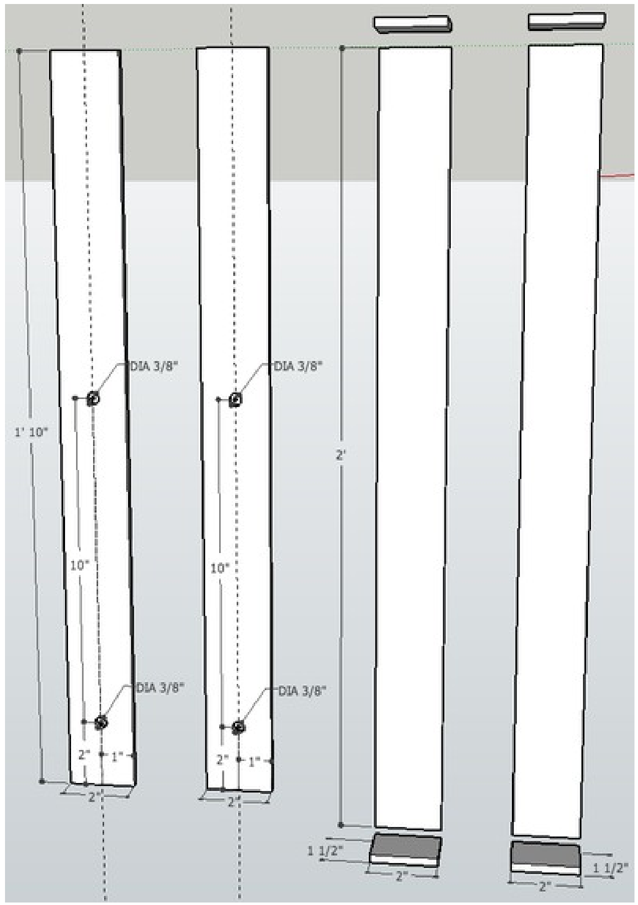


2. Quick attach mounts

   a) [2] 3/8" x 4" x 27" Plates



3. Fuel tank
   a) [2] ¼" x 4" x 8" Plates
   b) 4" x 8" x 14 ½" Tube
   c) ¼" x 2" x 24" Plate
   d) All welds assembling the tank must be quality welds, as they must not leak. Be careful not to "over weld" the tank to the mount.
   e) Clean the inside of the ¼" x 4" x 8" tube and the two ¼" x 4" x 8" plates – anything left on these surfaces will end up in the gasoline and could clog the engine when started. Tack and weld the plates on each end of the tube, taking care to orient the top plate with the filler hole as shown in the diagram below.
   f) Weld the 1/4" tank flange to the hole in the side of the tank tube.


DIA 3/8"
DIA 3/8"
1' 10"
10"
DIA 3/8"
DIA 3/8"
2"
1"
2"
DIA 3/8"
DIA 3/8"
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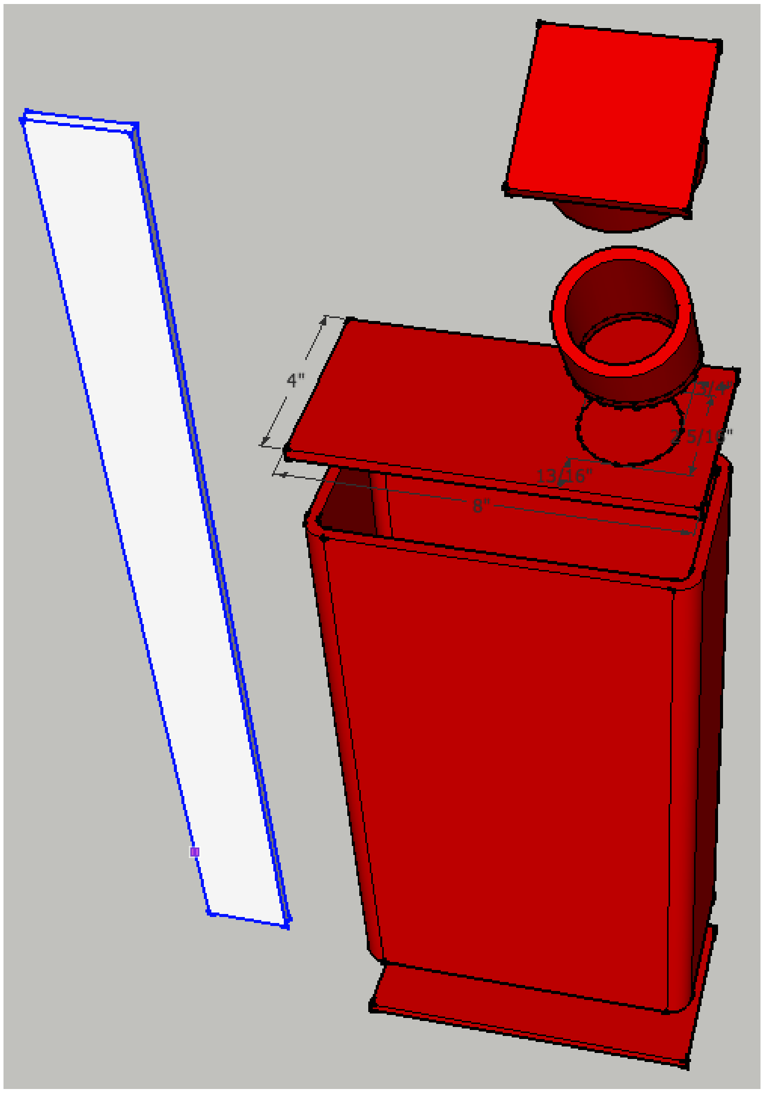
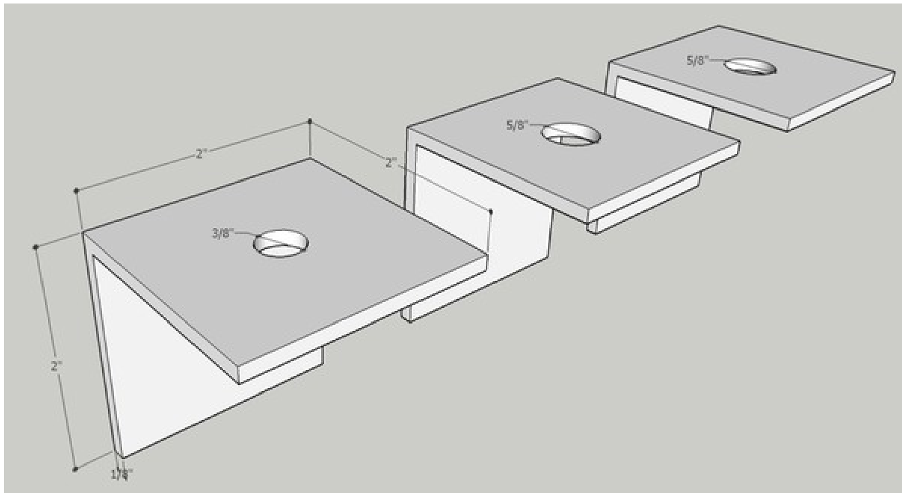
2"
1 1/2"
2"



4. Oil Cooler Mount
   a) [2] ¼" x 2" x 24" Plates
   b) [2] ¼" x 2" x 1" Plates
   c) [2] ¼" x 2" x 22" Plates (Note: the holes in these plates may need adjustment based on oil cooler mounting holes)

5. Key Switches and Choke Brackets
   a) [3] 1/8" x 2" x 2" x 2" Angle



6. Electrical cables

a) The connectors can be purchased from an auto parts store – be aware that they usually require a crimper to attach to the cables. Alternatively, 3/8" copper tubing can be used in 1 ½" long pieces instead. Strip 1 ½" insulation from the cable, fully insert fully into 1 ½" copper tube, flatten end with a hammer and drill hole.

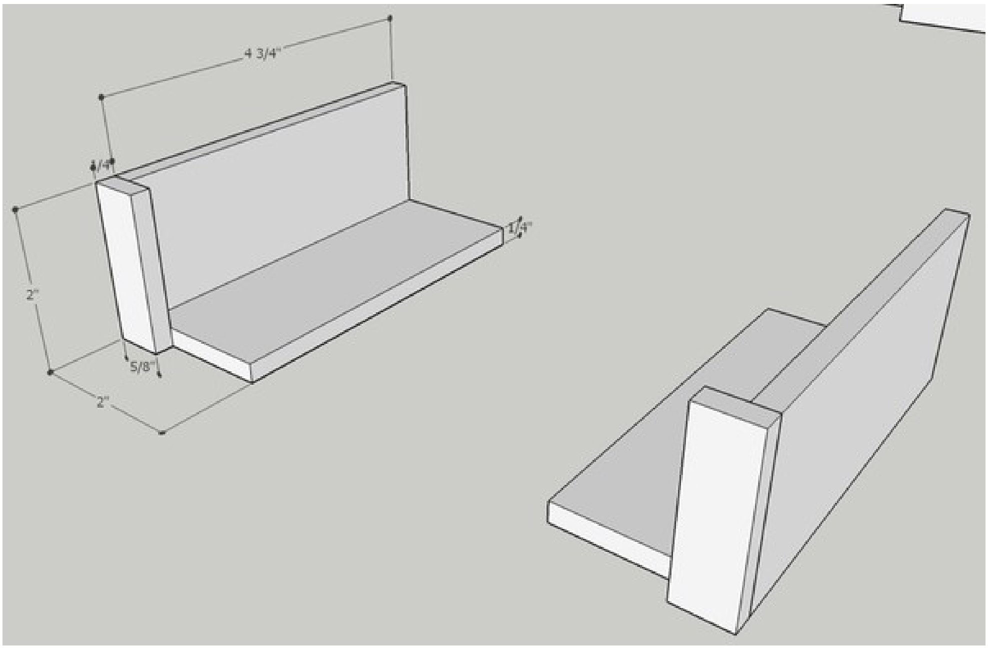
b) [2] 1 gauge cables: 11" (verify length first!)

c) 1 gauge cable: 8 ½" (verify length first!)

7. Battery Mounts

   a) [2] ¼” x 2” x 2” x 4 3/4” Angle

   b) [2] ¼” x 2” x 5/8” Plate



8. Oil filter Assembly

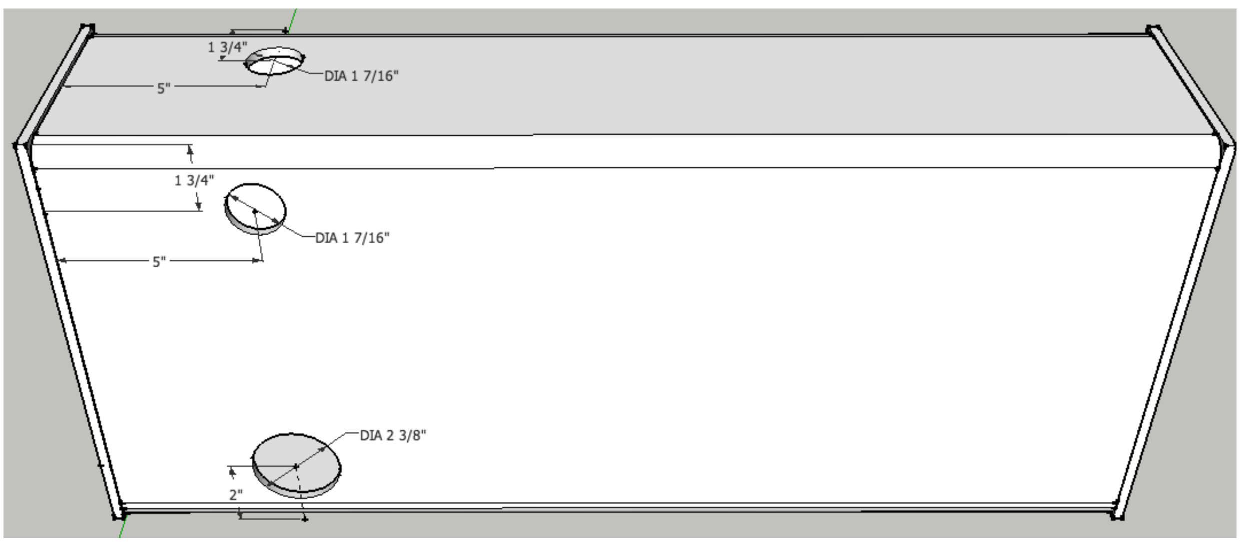
   a) Assemble as shown, using teflon tape on all threaded components.

   b) The parts for this are (from left to right):

      - 1” nipple
      - Oil filter and header
      - 1” to ¾” reducer

- ¾” nipple
- ¾” T adapter
- ¾” to 3/8” recucer
- ¼” quick connect
- ¾” T adapter
- ¾” quick connect

9. Hydraulic reservoir
   a) [2] ¼” x 6” x 12” Plates
   b) ¼” x 6” x 12” x 27 ½” Tube
   c) All welds assembling the reservoir must be quality welds that do not leak. Be careful not to “over weld” the reservoir.
   d) Clean the inside of the tube and the two end plates – anything on these surfaces will end up in the hydraulic oil and could damage the pump or cylinders.
   e) Tack and weld the 6” x 12” plates to both ends of the 6” x 12” tube. Pay attention to the orientation of the plate with the filler hole and the side of the tube with other holes – see the diagram below.

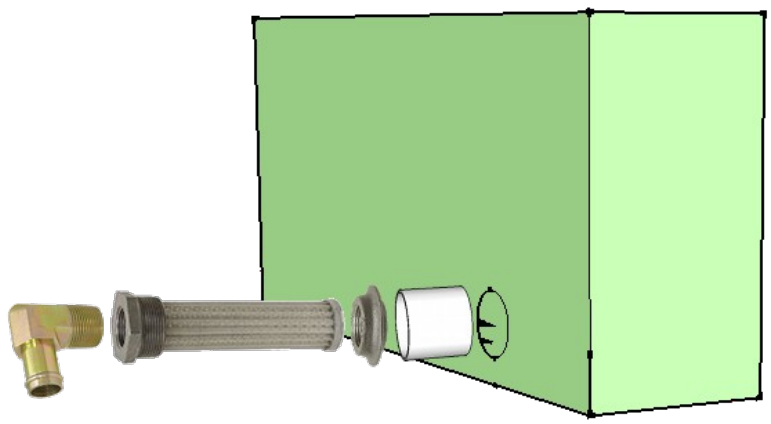


   f) Tack and weld the strainer extension tube to the tank, centered around the strainer hole.
   g) Insert the strainer into the flange and insert it into the strainer extension tube – verify that it slides without binding or bottoming and that the flange is flush with the end of the tube.

Remove the strainer from the flange, then tack and weld the flange to the tank.

CAUTION: Keep the strainer away from the welding, as its thin wires burn easily.

h) Install the suction strainer and the hose barb with the hose barb pointing toward the hydraulic pump (Photo below is for assembly, hose barb is oriented differently).



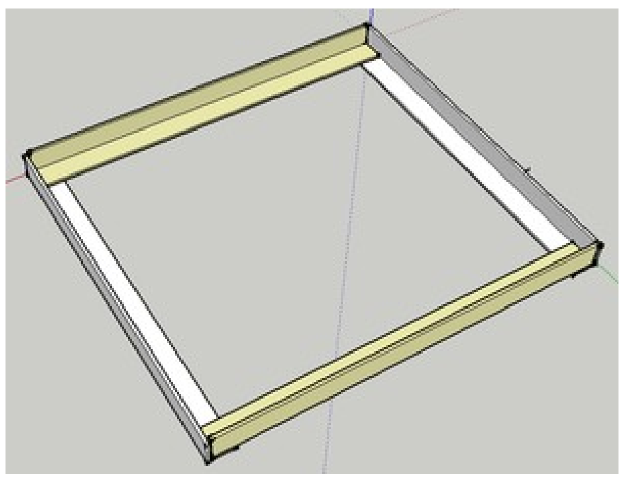
Assembly

Power Cube assembly requires all the parts listed in the Bill Of Materials to be available and prepared as detailed in the "Fabrication" section (above). Assembly requires a welder (electric or torch) capable of welding metal 3/8" thick.

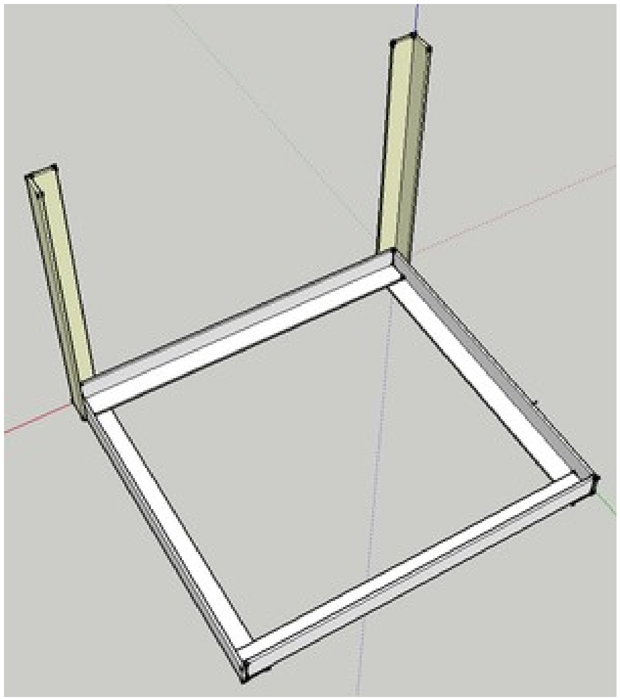
An optional jig can be used to aid in assembly. See Appendix 1 for details.

1. Frame
   a) Top / Bottom Rectangles

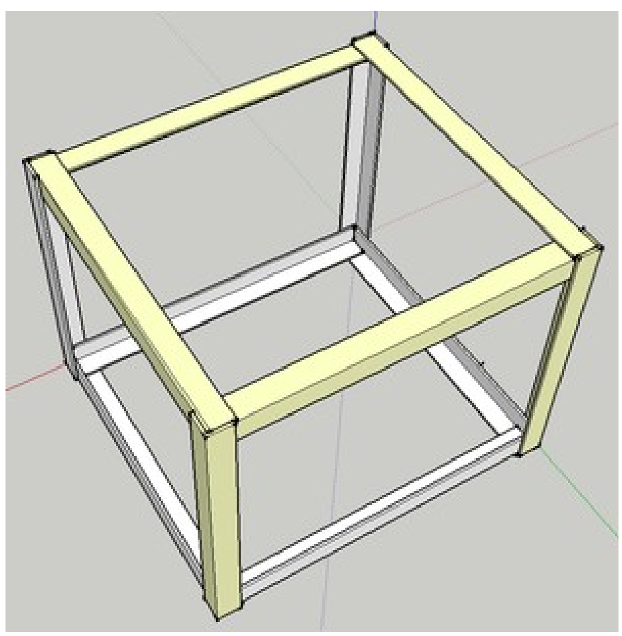
   Position two ¼" x 2" x 2" x 29" pieces angle iron on top of two 27" angle pieces as shown below. Check that all joints are square, then tack and weld joints.



   b) With one welded rectangle on the bottom, position two 24" pieces outside corner joints as shown below. Check that the angles are square, then tack and weld. Note: The optional jig makes this much easier and accurate. Repeat the prior procedure and this one for another half of the frame assembly.



c) Position the second rectangle as shown below, then tack and weld. Inspect all corners to verify secure welds.



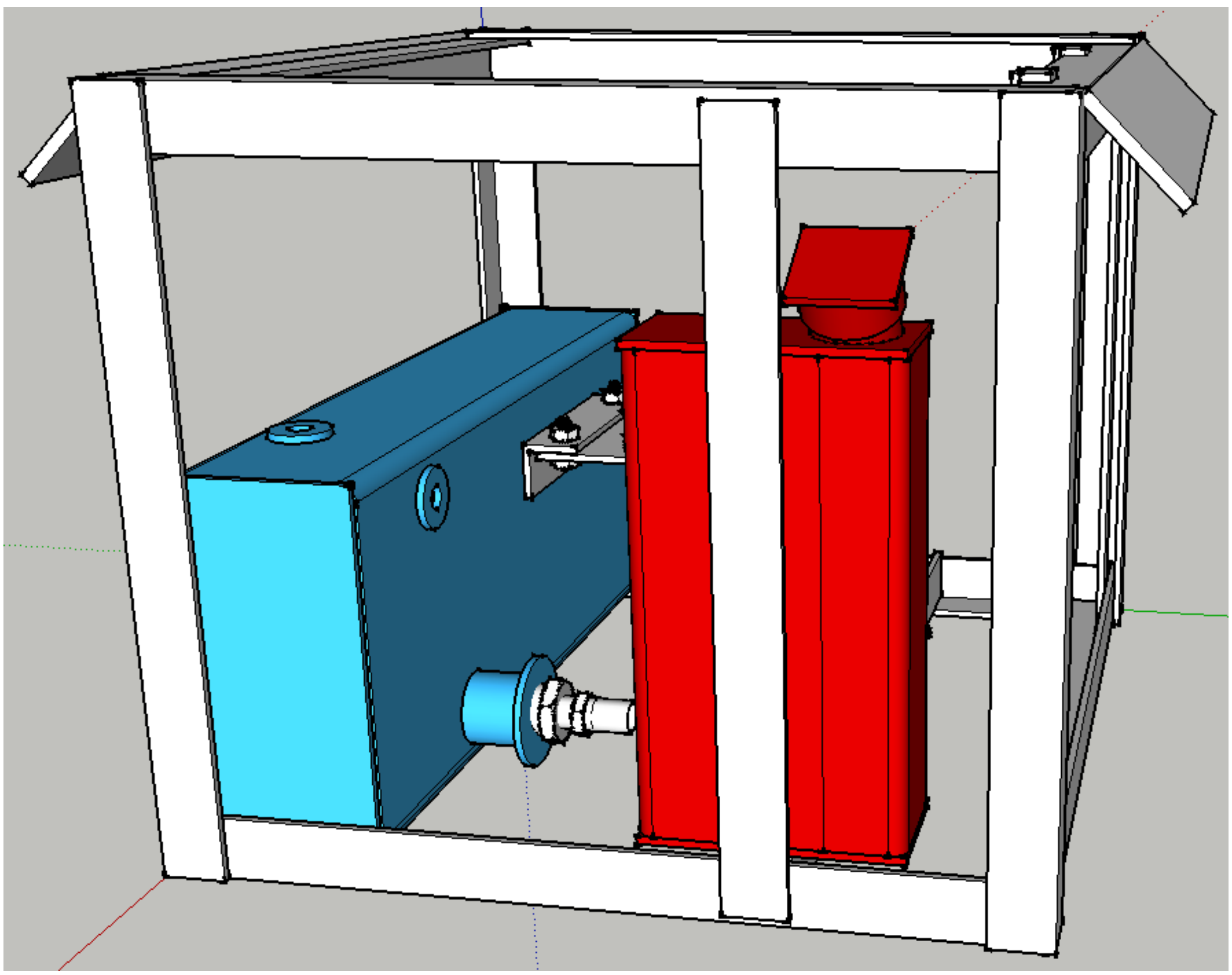
2. Gas tank

a) Screw the 1/4" hose barb into the 1/4 NPT flange welded into the gas tank.

b) Perform a “soap bubble” test on the tank. Securely cover the larger hole (use something like strong tape), pressurize the tank using the smaller hole and cover the tank surface with soapy water. Look closely for new bubbles, mark any leaks and re-weld securely. Repeat soap bubble test if re-welded.

c) Tack and weld the gas tank mount (¼” x 2” x 24” plate) to the frame. Position it so the gas tank is 1" from the nearest vertical angle iron support.

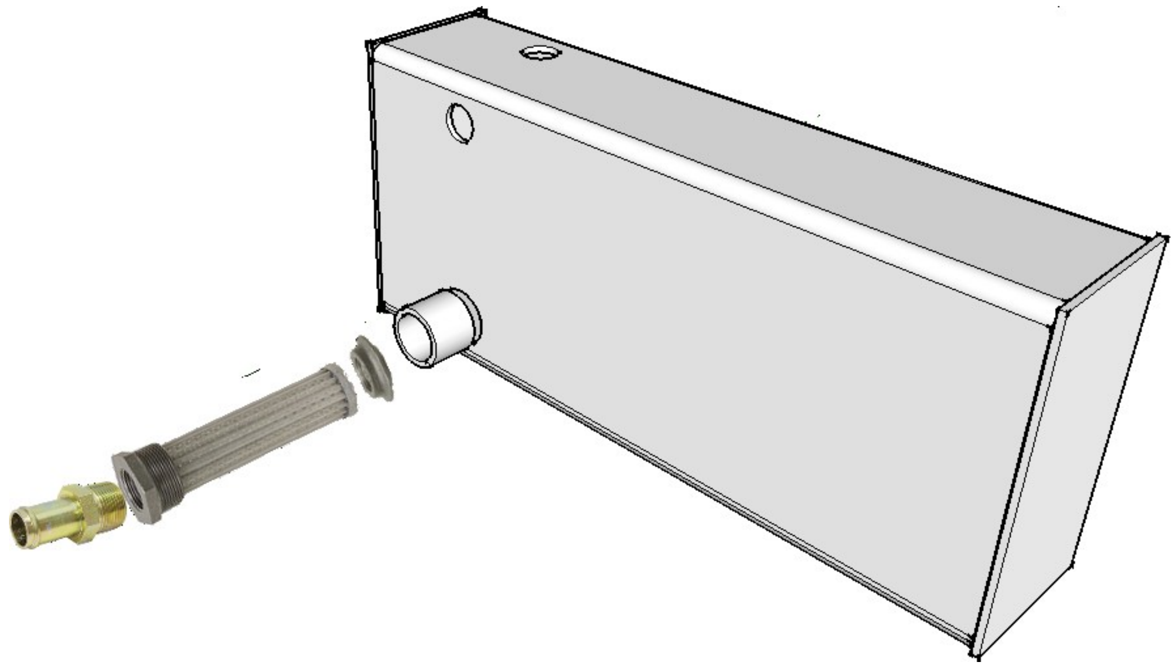
d) Tack and weld the gas tank to the gas tank mount as shown below.



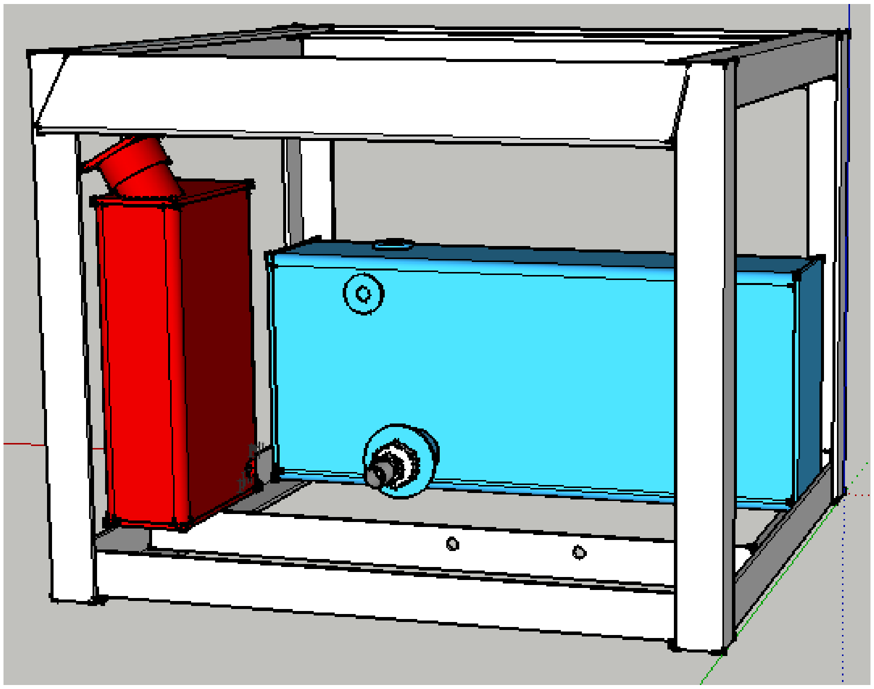
3. Hydraulic reservoir

The reservoir should already be pre-assembled and ready for installation.

a) Perform a "soap bubble" test on the tank by securely covering the larger hole (use something like strong tape), pressurizing the tank using the smaller hole and cover the tank surface with soapy water. Mark any leaks and re-weld securely. Repeat soap bubble test if re-welded.

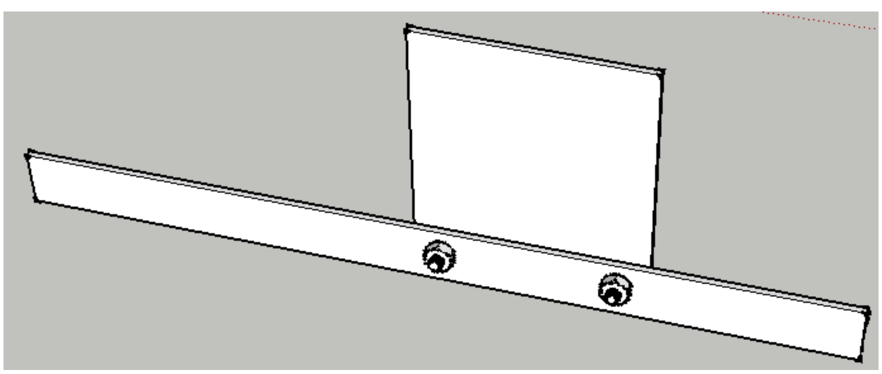


b) Secure the hydraulic tank to the frame with clamps, then weld it with 4 x 1" welds. The tank is ¼" and it can be easily damaged by over-heating. Spacers may be needed on the sides near the top to keep everything snug.

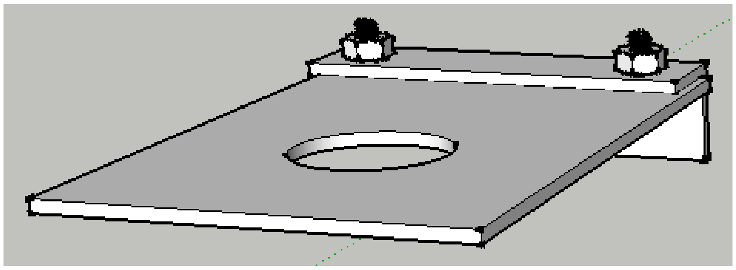


4. Engine Mounts and Hydraulic Pump Mount

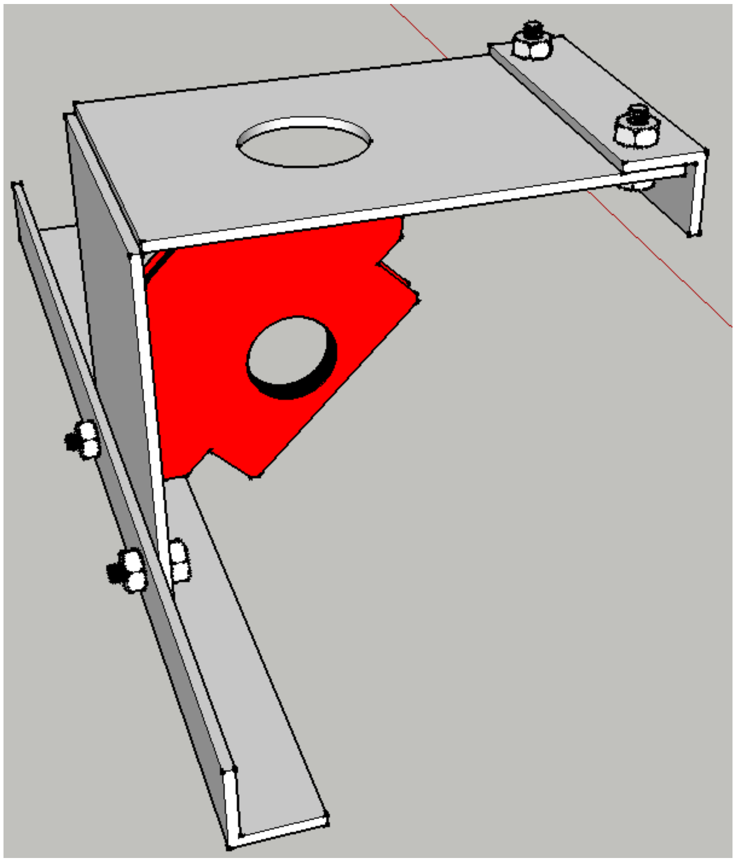
   a) Bolt the ¼” x 2” x 2” x 8” plate to the ¼” x 2” x 2” x 29” angle as shown using 1/2” x 2” bolts:



   b) Bolt the ¼” x 8” x 12” plate to the 8" angle as shown using 1/2” x 2” bolts:



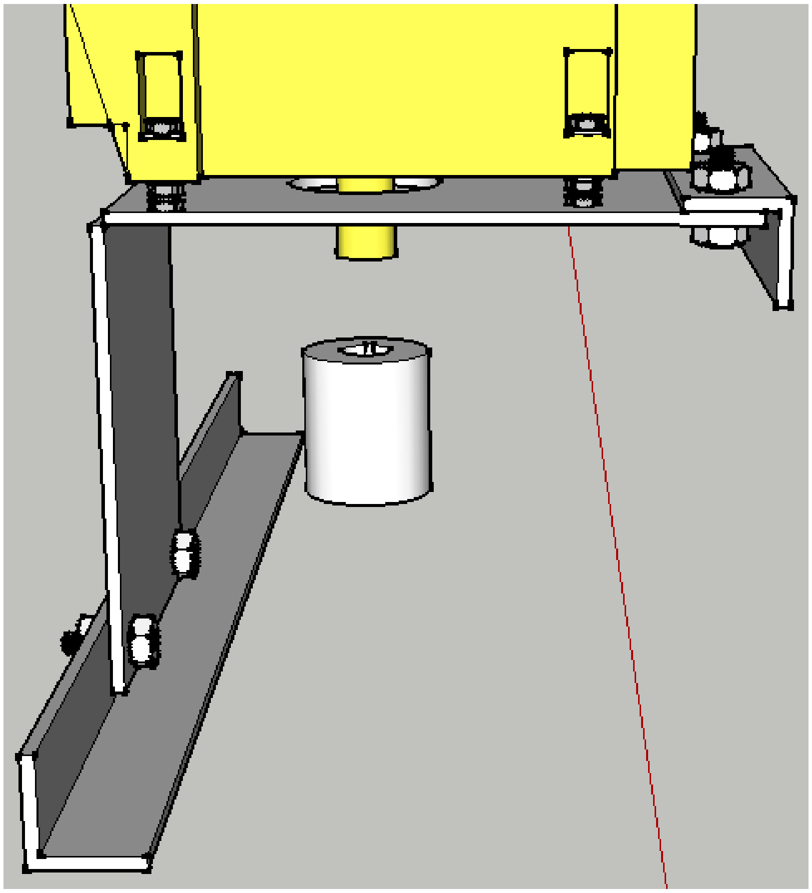
c) Align the plate edges and secure at 90 degree angle and weld. We use welding magnets to hold the plates at 90 degrees:



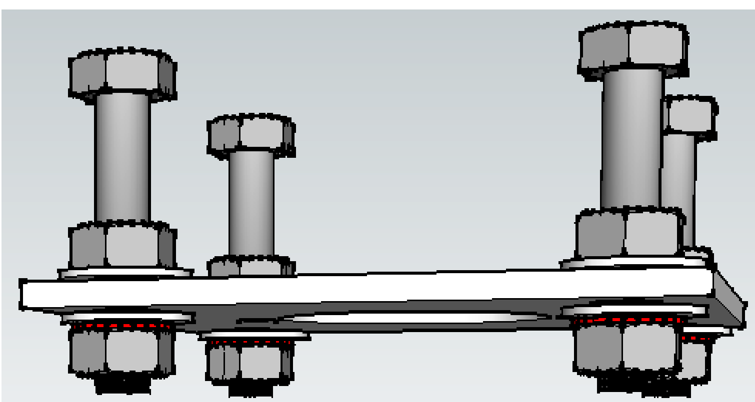
d) Mount the engine to the engine plate using [4] 5/16" x 2" bolts. The method for mounting may depend on your engine. See the following video for details:

http://youtu.be/DO6wbwOjWNA

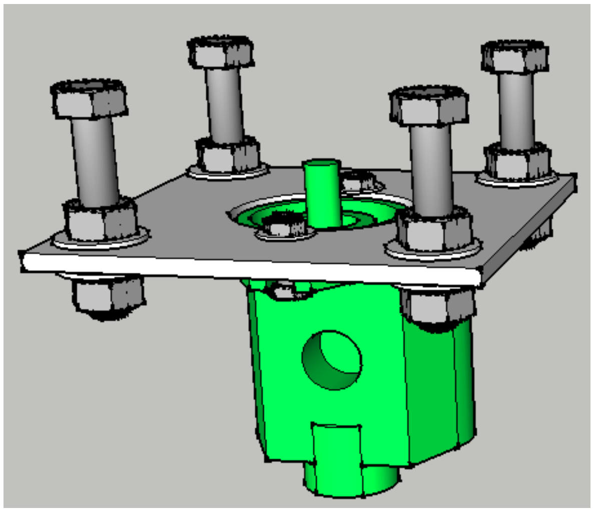
e) Examine the engine shaft – it should be 2" long. If longer, cut the shaft to extend no more than 2" from the case. This length is necessary for the coupling. Put the larger keystock in the engine shaft and slide the shaft coupling on the engine shaft and tighten the allen screws to hold it in place.



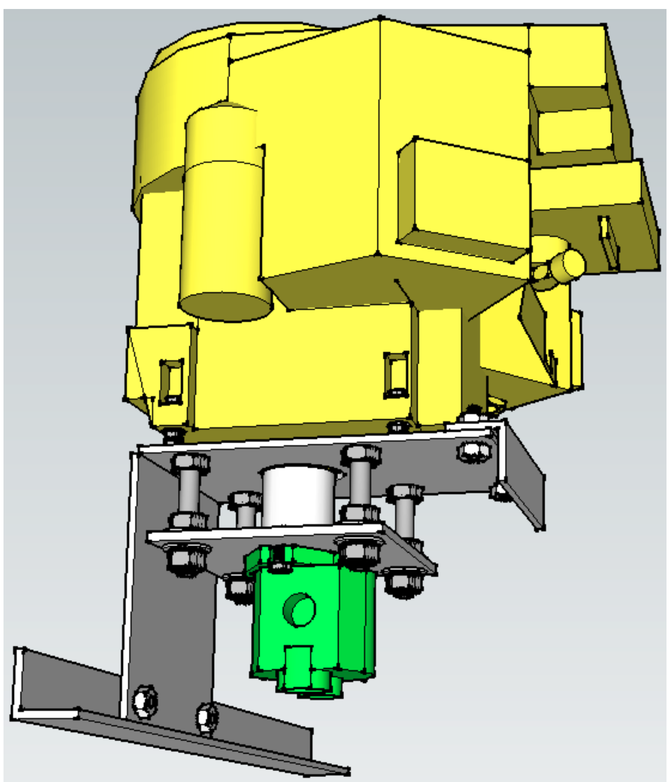
f) Assemble the 8" x 8" pump plate as shown with [4] ¾" x 3.5" bolts and [8] 3/4" nuts, [8] washers and [4] lockwashers. Tighten the nuts to hold the plate firmly:



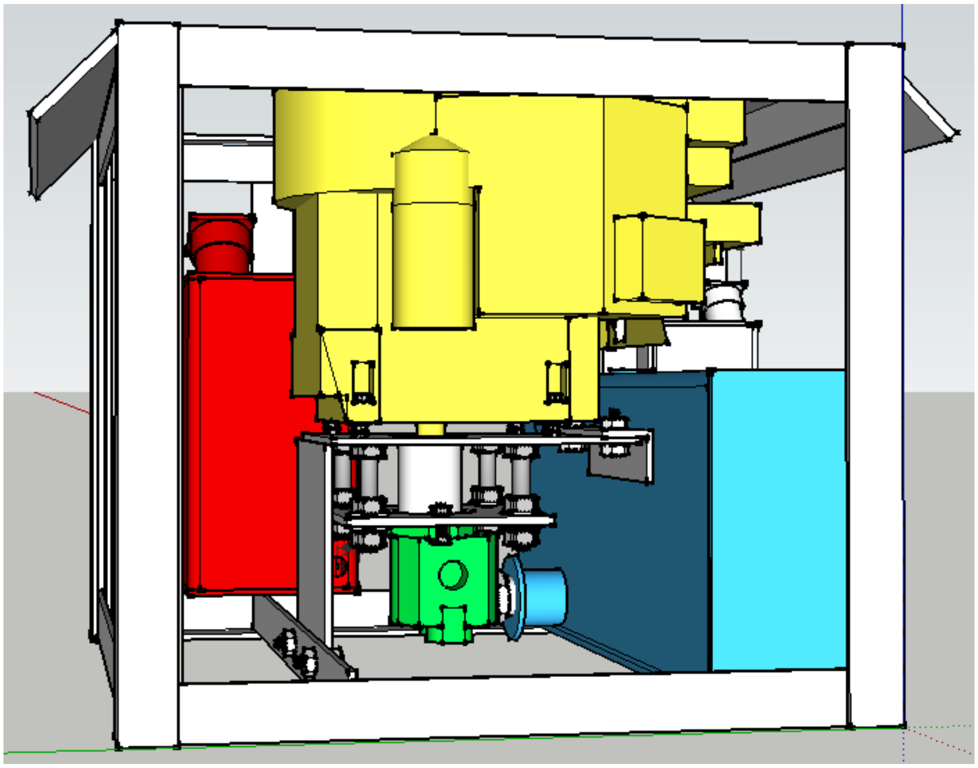
g) Mount the pump to the pump plate using [2] 7/16 bolts, nuts and washers:



h) Make sure the key is in the pump shaft and slide the pump shaft into the bottom of the shaft coupling and tighten its allen screws. The bolt heads should just be touching the bottom of the engine plate. Tack and weld the bolt heads to the engine plate.

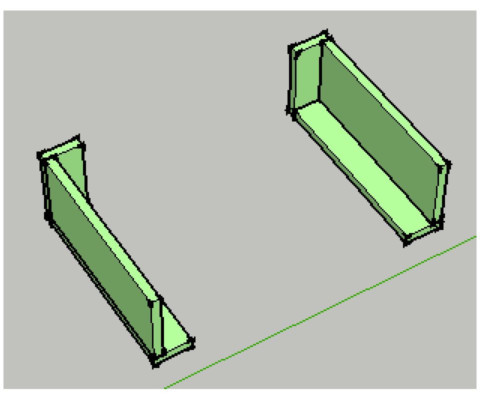


i) Lower the engine/pump assembly into the frame. Adjust it so the engine plate is parallel with the frame and weld the 8" angle iron to the reservoir and the 29" angle iron to the frame.

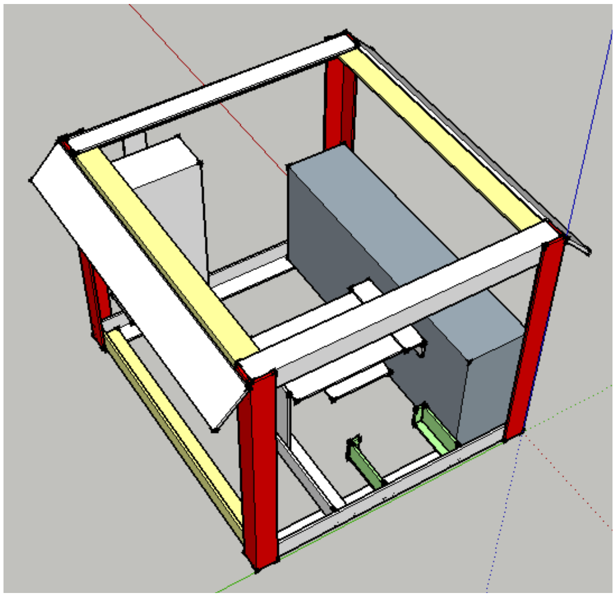


5. Battery mount

a) Weld the ¼” x 2” x 5/8” plates to the ends of the ¼” x 2” x 2” x 4 3/4” plates as shown below.



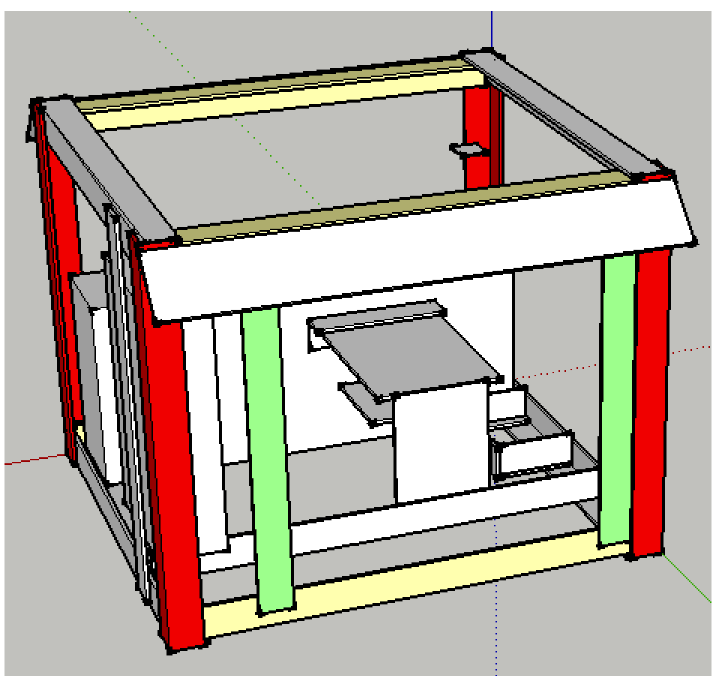
b) Weld the two mounts to the angle iron and tank to form a rectangle for the battery as shown below.



c) After the mount has cooled, lower the battery into the rectangle to verify a proper fit.

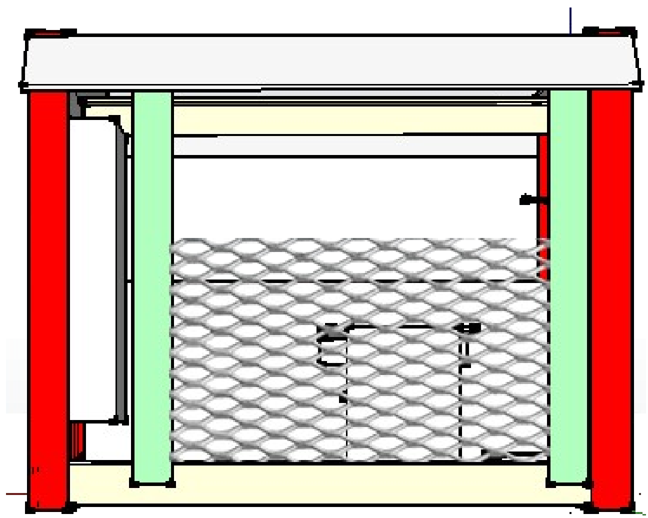
6. Oil cooler and fan mounts

a) Position the two ¼" x 2" x 22" plates to the outside of the frame, adjust so the oil cooler mounting bolts match the holes in the plates and is positioned as in the diagram below. Tack and weld the mounts in to the frame. Verify that the oil cooler bolts match the holes in the mounts.



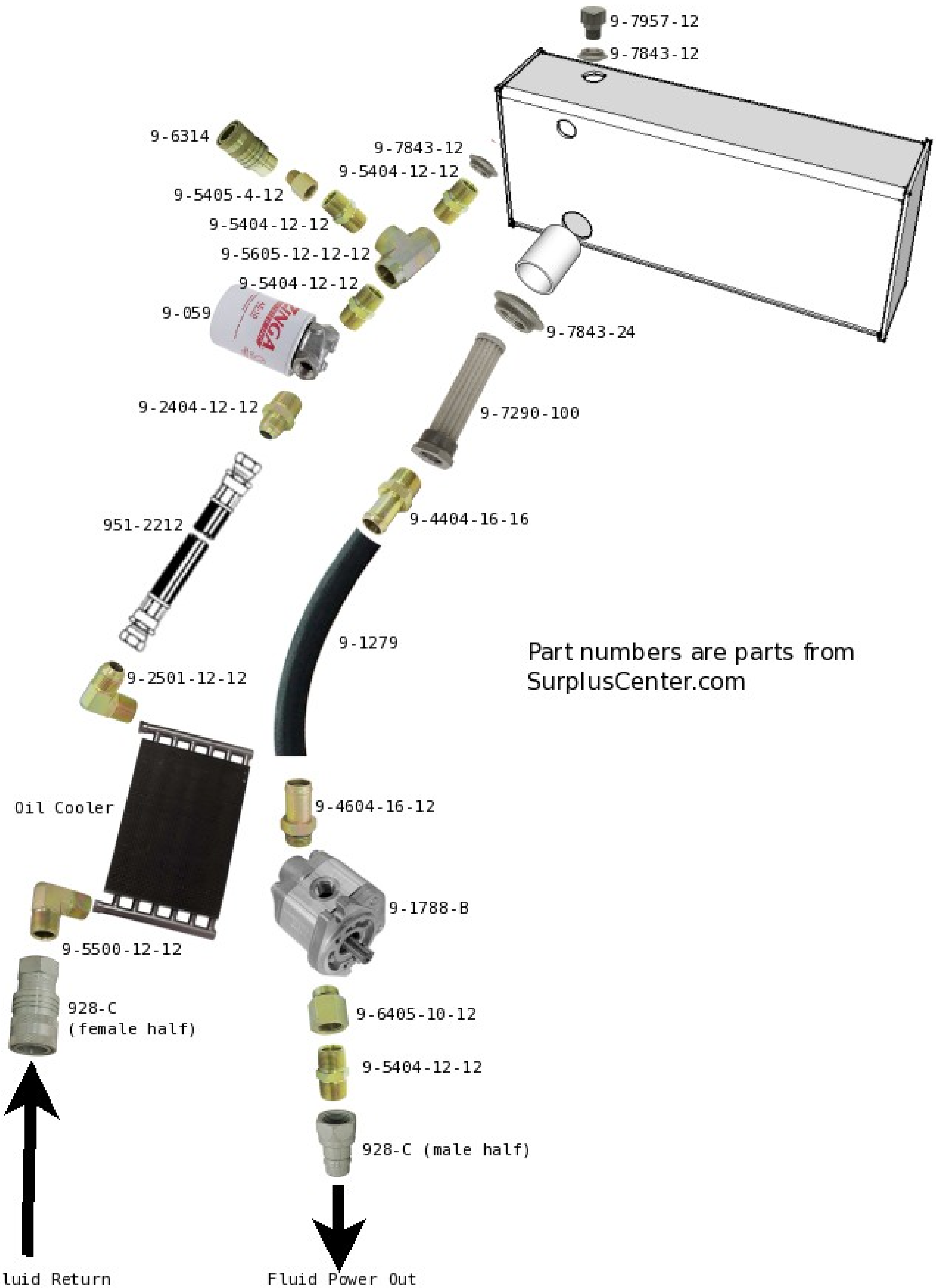
b) Use the mounting holes in the fan shroud and the oil cooler width for positioning the mounting plates as shown in the diagram below. Position the four ¼” x 2” x 1” plates, then tack and weld. Position the two ¼” x 2” x 24” plates against the 1” plates, then tack and weld. Place the fan on the supports and mark the mounts with bolt hole positions. Place the bolt heads against the fan mounting plate and weld in place. Verify that the bolts match the holes in the fan. Inside the frame, adjust the fan position to position fan shroud ¼” from oil cooler fins. Be careful with radiator as the delicate fins are easily bent and damaged.

c) Place the 9 gauge x 12” x 22” expanded steel grill in front of the oil cooler mounting plates, positioned to cover the entire oil cooler and check if any holes are necessary to secure with oil cooler mounting bolts.



7. Screw the filter assembly into the flange on the side of the hydraulic reservoir.

8. Connect the 1” suction hose between the strainer and the pump intake.
9. Connect a male ¾” quick connect hydraulic coupler to the pump output.
10. Connect a female ¾” to ¾” elbow to the cooler port nearest the battery cage.
11. Connect one end of the ¾” x 1' hydraulic hose to the second cooler port, then connect the other end of the ¾” x 1' hydraulic hose to filter assembly.



Part numbers are parts from SurplusCenter.com

12. Weld the 1/8" x 2" x2" x 2" angle brackets to the frame in the positions shown below. Pay special attention to the hole sizes, as the bracket for the choke has a smaller hole.
    <image>
13. Weld the solenoid mounting bolts to the hydraulic reservoir as shown below.
    <image>
14. Wire the switches.
15. Fix the throttle control, connect to throttle plate.

User Guide

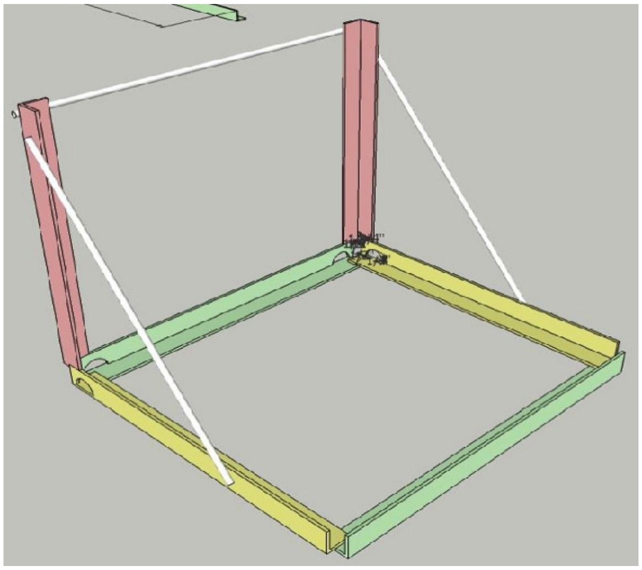
This section is intended for the end user of the Power Cube.

1. Caution
   a) Weight
   b) Hydraulic hazards
   c) Ventilation
2. Mounting
   a) Quick attach connector
3. Initial startup and testing
   a) Initial Setup
      - Gasoline
      - Hydraulic Fluid
      - Battery Connection
   b) Startup
   c) Hydraulic Test
4. Routine use
5. Maintenance
   a) Engine Oil
   b) Hydraulic Fluid
6. Troubleshooting
   a) Engine won't start
   b) Loud noise
   c) No hydraulic power

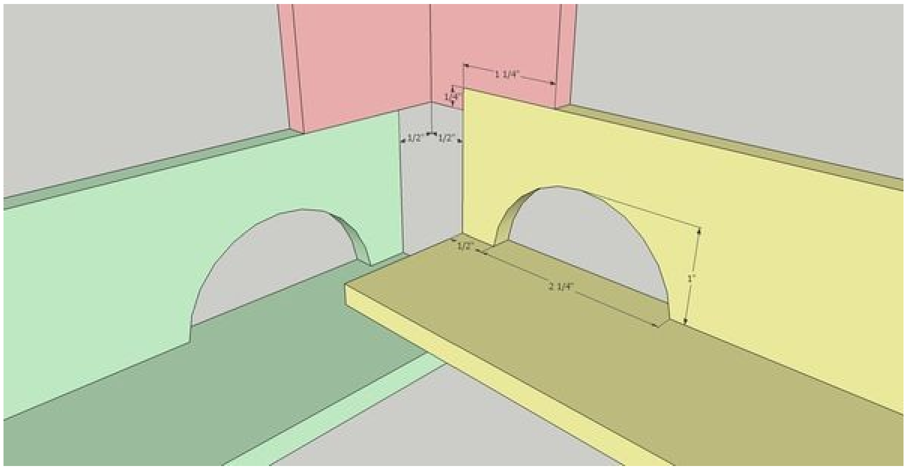
Appendix

Frame Assembly Jig

The welding "jig" in the image below is helpful to insure square angles while assembling the Power Cube. It is very useful if building multiple Power Cubes.



Note the corner holes that provide access for welding:



Materials List

- ¼" x 2" x 2" Angle Iron: 14'

- ½" Rebar: 7' 2”

Cut List

Type	Length	Dimensions	Quantity	Color
Angle	22"	¼” x 2 x 2"	2	(red)
Angle	26"	¼” x 2” x 2”	2	(yellow)
Angle	29"	¼” x 2" x 2	2	(green)
Rebar	30.5"	½"	1	
Rebar	27"	½"	2	

Warnings

- Never force a hydraulic connection that doesn't seem to fit.
- Use only fasteners of the proper size.
- Beware of corroded, loose or missing fasteners.
- Do not operate hydraulics below minimum rated flow.
- Do not open vent or drain valves while system is pressurized.
- Lock out power before working on system.
- Use proper lifting and support equipment to avoid injury.
- Properly decontaminate skin, clothing and tools.

Hydraulic System Maintenance

Safety & Cleanliness

Wear your Personal Protective Equipment.

Hydraulic systems operate under very high pressures. Shut the system down and relieve system pressure before opening any part of the system that is under pressure. Do not allow spray from any high pressure leak to contact any part of the body, as serious injection injuries may result. Pumps, valves and motor may become hot; be cautious of incidental contact between bare skin and hot surfaces. Keep hands and clothing away from moving parts of the system.

No grinding or welding operations should be done in the area where hydraulic components are being installed.

All cylinder, valve, pump and hose connections should be sealed and/or capped until just prior to use.

When installing pumps or motors, always align coupling halves as closely as possible, within 0.007 inch.

Generic

- Any intervention must be carried out with pressure and tension released.
- Check for visible leaks (particularly at connections). Tighten or seal if necessary.
- Check state of hydraulic fluid. Completely replace if deteriorating (sunk color, odor, milky aspect).
- Check hydraulic fluid level. Refill with same viscosity and to same line if necessary.
- If system is to be shut down for a long time, leave hydraulic oil in the circuit.
- Replace hydraulic fluid: every 24 months of use
- Replace hydraulic fluid filters: every 12 months
- Inspect hoses for damage, blisters, leaks or fraying. Replace if necessary.
- Ensure pressure relief valve is not held partially open by contamination.
- Check for corroded or loose fasteners.

Pump/Motor Maintenance

Performance parameters:

- suction pressure (Ps)
- discharge pressure (Pd)
- flow (Q)
- pump speed (Nr)
- pumpage properties
- power

Measure power with a clip on amp meter. It's not all that accurate, but it's good for a baseline comparison.

Locate suction and discharge gauges to determine (Ps) and (Pd).

normal (perpendicular) to the pipe wall
on centerline of pipe
in a straight section of pipe
not in the bottom or top (avoid air and solids)

Measure flow. It's difficult if a permanent flow meter isn't installed.

insert a pitot tube into the pipe
use a doppler or transitime device (non-intrusive)
each measuring device must be calibrated (don't underestimate the importance of this)

Measure Vibration

- There is no absolute vibration reading that indicates a problem.
- Since each installation is unique, the best thing to do is take measurements at first power-on and at regular intervals to establish a baseline and trending.
- When possible, measure vibration amplitude at these locations:
    - motor outboard & inboard bearing housings in vertical & horizontal direction
    - motor axial direction
    - pump outboard & inboard bearing housings in vertical & horizontal direction
    - pump axial direction
- Also record operating mode of whatever is being measured. The vibration will increase as the pump/motor works outside of its Best Efficiency Point (BEP; that is normal.
- Vibration frequency will indicate what is causing the problem while amplitude indicates how bad the problem is. Bearing manufacturers will publish information on bearing defect frequency as a function of bearing speed.

Measure Temperature

- Fluid (oil and water) must remain within certain temperature boundaries.
- Bearings must not exceed a certain temperature.

Measure Shaft Play

Use a dial indicator, mounted solidly to something that doesn't move in relation to the shaft, to measure how far out of perfect round the shaft is. Anything more than 2 mil/in (0.002in) is unacceptable at any speed. 1 mil/in is acceptable up to about 4,000RPM.

Fluid Maintenance

Control the Temperature

- Excessive temperatures will oxidize the oil and can lead to varnish and sludge deposits.
- Running the temperature too low will allow condensation in the reservoir and increase the likelihood of pump cavitation.
- Typical industrial hydraulic system temperatures often range between 110 to 150ºF.
- Keep systems which operate on a water based fluid below 140ºF to prevent the water from evaporating.
- To allow heat to radiate from the system, keep the outside of the reservoir clean and the surrounding area clear of obstructions.
- Keep air-cooled radiators free of dirt.
- Normal temperature drop for most oil coolers is 5 to 10ºF.
- Reservoirs should be filled to the proper level to allow enough time for the heat to dissipate.

Keep the Area Clean

Even new systems may be contaminated and should be cleaned before use. Prevent contaminants such as dirt, water, cutting fluids, and metal particles from entering the system around the reservoir cover, openings for suction and drain lines, through breather fill openings, past piston rod packing, and through leaks in pump suction lines.

Keep the Fluid Clean

- Reservoirs should be filled to the proper level to allow time to shed water and dirt
- Deposits caused by oil degradation can plug valves and suction screens and cause high-tolerance servo valves to seize and/or operate sluggishly
- To prevent contamination before use, store new fluid in a protected area and dispense it in clean, DEDICATED containers.
- Clean the fill cap before removing it to add hydraulic fluid.
- Inspect fluid filters frequently and change or clean them before they go into bypass mode.

Follow an Oil Analysis Program

- Contaminants act as a catalyst for wear. This generated wear debris further acts as a catalyst for additional component wear.
- With an effective oil analysis program, you can safely increase the standard 1 year interval while at the same time provide yourself with an “early warning” of possible mechanical problems.
- At minimum, check your critical and large volume hydraulic systems at least annually by oil analysis.
- Semi-annual or even quarterly sampling intervals may be required for extremely critical machines.

In modern equipment using servo valves, oil degradation can be even more damaging. High pressure (up to 4000 psi), high temperatures, and small reservoirs stress the fluid. With minimal residence time and high pressures, entrained air bubbles can cause extreme localized heating of the hydraulic fluid. This results in nitrogen fixation that, when combined with oil oxidation, can form deposits which will plug oil filters and cause servo valves to stick.

On critical NC systems, use quick disconnect hoses and filter all oil added to the reservoir through a 5 micron filter.

Portable filters will supplement permanently installed filters and should be constantly rotated from system to system regardless if you think the system requires filtering or not. Systems should be filtered long enough to pass the total volume of oil through the filter at least 10 times. Portable filters should be used when transferring new oil from drums or storage tank to a system — especially for NC machines.

10 Point Check

Perform weekly

1. Check fluid levels. Add oil (if needed) via portable filtration(if available). DO NOT MIX OILS! Use the same oil brand andviscosity grade that is being used in the system.
2. Inspect breather caps, breather filters and fill screens — DO NOT punch holes in screens in order to expedite adding oil.
3. Check filter indicators and/or pressure differential gages.
4. Visually inspect all system hoses, pipes, pipe connections for leaks and frays. Hydraulic fluid leakage is a common problem for industrial systems. Excessive leakage is an environmental and safety hazard, increases waste streams and oil consumption, and, if ignored, canreduce the system capacity enough to overheat the system.
5. Check system temperature via built-in thermometers or hand-held infrared detectors. Normal temperature range for most systems is110-140ºF. If temperatures are high, check cooler operation andrelief valve settings.
6. Visually inspect the inside of the reservoir for signs of aeration (via the fill hole using a flashlight). Aeration is a condition in which discrete bubbles of air are carried along in the stream of oil as it enters the pump. Visual signs of aeration in the reservoir are generally foaming and/or little whirlpools taking small gulps of air into the suction strainer. Causes of

aeration include: low fluid levels; airleaks in the suction line; low fluid temperature; fluid is too viscous to release air or maintain suction at the pump; or faulty shaft seals.When air leaks are suspected on the suction line, smotheringthesepoints with oil will usually pinpoint the leaks by creating a markedchange in pump noise. A pump ingesting air sounds as if it weregargling marbles.

7. Listen to the pump for the signs of cavitation. Cavitation is slightly more complicated than aeration, but bares somesimilarities. Cavitation occurs when air is released from the hydraulic oil during momentary depressurization at the pumpsuction and then imploded onto metal surfaces upon discharge.These implosions are extremely destructive to pump surfaces. A cavitating pump will emit a high-pitched whine or scream. Causes of cavitation are the same as those of aeration with the exception of suction side air leaks. How do you discern aeration from cavitation? One way is to install a vacuum gage on the suction side and make sure the pressure is equal too or greater than that prescribed by the pump manufacturer. Foaming in the reservoir is usually the telltale sign of aeration.
8. Inspect a small sample of fluid for color, signs ofcontamination and odor. Keep in mind that visual inspectionis limited in that it will only detect signs of excess contamination.
9. Scan electrically controlled servo valves with an infraredthermometer. High valve and solenoid temperatures(over 150ºF) usually indicate the valve is sticking.
10. Scan the electric drive motor with for housing hot spots and rotor bearing temperatures using an infrared thermometer.

Change The Fluid

- Drain the system while the fluid is hot to keep contaminants in suspension.
- Empty fluid from cylinders, accumulators and lines that might not drain properly.
- Mop, siphon, or pump out oil left in the reservoir.
- Wipe reservoir clean with lint free rags and remove rust and free paint.
- Replace or clean filter elements and strainers and clean filter housings.
- Refill the system with new fluid making sure to vent high points.
- Restart and check system for proper operation.

Oil Analysis

Identify “Mission Critical” Equipment It’s not necessary to perform oil analysis on every single lubricated system. Identify critical applications that would seriously jeopardize production if they were to shut down unexpectedly.

Register Your Equipment It is important to have your equipment properly registered with a lab. This supports routine trending and plays a key role in early detection of lubricant or equipment problems. There’s no need for you to decide which tests are appropriate for a particular application because the lab has already established test slates for specific applications.

Establish Best Practices Establish a consistent “how-to” practice for taking oil samples from your equipment and train your maintenance personnel to use this practice. Correct sampling practices are critical to the value received from the analysis data. This extremely important step rarely gets the attention it needs.

Sample Retrieve samples in accordance with your best practice and send them to the lab as soon as possible. Samples that are set aside may deteriorate and give non-representative results. Analyze A thorough analysis, keyed on trends, helps determine your systems' conditions. Interpret Reviewing the results and determining what, if any, action is required can make or break a successful program. It's important to remember that an alert sample does not necessarily mean imminent failure. Seek consultation on alert samples and re-sample to confirm present data before taking massive corrective action.

Take Corrective Action and Document, Document, Document!!! As always, documentation is the key to knowing where you've been and where you're going. Document corrective actions resulting from oil analysis.

Mechanical System Maintenance

Engine Maintenance

- Check oil level: every 5 hours
- Change oil and oil filter: after first five hours
- Change oil: every 50 hours or every season (more often if dirty conditions)
- Change oil filter: every 100 hours or every season
- Replace foam air cleaner: every 25 hours or every season
- Replace paper air filter: every 25 hours or every season
- Replace paper air filter w/ foam air cleaner: every 100 hours or every season
- Replace spark plugs: every 100 hours or every season
- Replace fuel filter: every 100 hours or every season

	hydraulic failure				mechanical failure					
Cause	**pump does not deliver liquid**	**pump does not deliver sufficient capacity**	**pump does not deliver sufficient pressure**	**pump delivers flow intermittently**	**bearings run hot and/or fail on a regular basis**	**high rate of mechanical seal failure**	**packing has short life**	**pump vibrates at higher-than-normal levels**	**pump is drawing too much power**	**wear of internal wetted parts is accelerated**
pump not primed or prime lost	x	x	x	x						
suction and/or discharge valves closed or clogged	x	x	x					x		
suction piping incorrect	x	x	x							
insufficient NPSH available*	x	x	x			x		x		x
excessive air entrapped in liquid	x	x	x	x						
RPM too low*	x	x	x							
incorrect rotation		x							x	
broken impeller or bent vanes		x	x		x			x		
incorrect impeller or impeller diameter		x	x							
system head too high		x								
instrumetns give erroneous readings		x	x							
air leaks in suction line				x						
excessive shaft misalignment					x	x		x		
inadequate lubrication					x					
lubricant contamination					x					
inadequate lubricant cooling					x					
axial thrust or radial loads higher than bearing rating					x					
improper coupling lubrication					x			x		
suction pressure too high					x	x				
bearing incorrectly installed					x	x		x		
impeller out of balance					x	x		x		
overheating of seal faces						x				
excessive shaft deflection					x	x		x		
lack of seal flush at seal faces						x				
incorrect seal installation						x				
pump is run dry						x				
pump is run off design point					x	x	x	x	x	
shaft/shaft sleeve worn						x	x			
packing gland not properly adjusted							x		x	
packing not properly installed							x			
impeller clogged	x							x		
coupling out of balance					x	x		x		
baseplate not installed properly					x	x		x		
pump operating speed too close to system's natural frequency								x		
bearing failure					x	x		x		
piping not properly anchored					x	x		x		
pump and/or driver not secured to baseplate					x	x		x		
specific gravity higher than specified					x	x			x	
viscosity higher than specified					x	x			x	
internal clearances too tight								x	x	
chemicals in liquid other than specified										x
pump assembled incorrectly			x		x	x	x	x		x
higher solids concentration than specified										x

NPSH = Net Positive Suction Head; difference between liquid pressure and vapor pressure at a certain temperature. Too little of it means your liquid is boiling.

RPM = Revolutions Per Minute; speed at which something turns. Too little of it means not spinning fast enough.

problem	probable cause	remedy
no liquid delivered	pump not primed	reprime pump, check that pump and suction line are full of liquid
	suction line clogged	remove obstructions
	impeller clogged with foreign material	back flush pump to clean impeller
	wrong direction of rotation	change rotation to concur with direction indicated by arrow on bearing housing or pump casing
	foot valve or suction pipe opening not submerged enough	consult factory for proper depth. Use baffler to eliminate vortices
	suction lift too high	shorten suction pipe
pump not producing rated flow or head	air leak through gasket	replace gasket
	air leak through stuffing box	replace or readjust packing/mechanical seal
	impeller partly clogged	back flush pump to clean impeller
	worn suction sideplate or wear rings	replace defective part as required
	insufficient suction head	ensure that suction line shutoff valve is fully open and line is unobstructed
	worn or broken impeller	inspect and replace if necessary
pump starts then stops pumping	improperly primed pump	reprime pump, check that pump and suction line are full of liquid
	air or vapor pockets in suction line	rearrange piping to eliminate air pockets
	air leak in suction line	repair (plug) leak
bearings run hot	improper alignment	realign pump and drive
	improper lubrication	check lubricate for suitability and level
	lube cooling	check cooling system
pump is noisy or vibrates	improper pump/driver alignment	align shafts
	partly clogged impeller causing imbalance	back flush pump to clean impeller
	broken or bent impeller or shaft	replace as required
	foundation not rigid	tighten hold down bolts of pump and motor or adjust stilts
	worn bearings	replace as required
	suction or discharge piping not anchored or properly supported	anchor per Hydraulic Institute Standards Manual recommendation
	pump is cavitating	system problem
excessive leakage from stuffing box/seal chamber	packing gland improperly adjusted	tighten gland nuts
	stuffing box improperly packed	check packing and repack box
	worn mechanical seal parts	replace worn parts
	overheating mechanical seal	check lubrication and cooling lines
	shaft sleeve scored	remachine or replace as required
motor requires excessive power	head lower than rating, pumps too much liquid	consult factory. Install throttle valve, trim impeller diameter
	liquid heavier than expected	check specific gravity and viscosity
	stuffing packing too tight	readjust packing. Replace if worn
	rotating parts bind	check internal wearing parts for proper clearances

Appendix

Civilization Starter Kit Credits

The following is a comprehensive list of individuals who contributed to the Civilization Starter Kit DVD v0.01.

Machines and CAD

1. Brianna Kufa - CEB machine fabrication procedure lead
2. Tom Griffing - Power Cube fabrication procedure lead, 2D and Sketchup modifications
3. James Slade - build of bent loader arms; first CEB replication; machine disassembly instructionals
4. Mike Apostol - full CAD drawings of tractor, CEB press, Pulverizer; Pulverizer fabrication procedure
5. Marcin Jakubowski - OSE Paradigm page, others
6. Yoonseo Kang - electrohydraulic integration to mechanical part of CEB; videos and instructions
7. James Wise - OSE CEB Controller board development
8. William Cleaver - LifeTrac III CAD
9. Daniel Worth - Power Cube fabrication drawings
10. Mike Doty - Full Fabrication drawings, CEB mechanical
11. Chris Fornof - Power Cube frame instructionals in Sketchup
12. Rob Beddingfield - CEB drawer and shaker Fabrication Drawings
13. Hardi Meybaum - GrabCAD challenge on tractor

Video

1. Isaiah Saxon - GVCS in 2 Minutes video, Kickstarter Video
2. Ian Midgley - major video contribution, such as Practical Post Scarcity Video, disassembly of machines, others
3. Rebecca Roger - construction update video
4. Sean Church - machine operation videos, construction review

Construction

1. Floyd Hagerman - construction detail, shallow insulated foundation
2. Pawel Sroczynski - model 40 sq meter CEB/Straw microhouse
3. Larry Dobson - gasifier hot water stove plans
4. Ken Morton - beginning of ergonomic analysis of construction

Editing/Publishing DVD

1. Matt_Maier - organization of Table of Contents, background info on hydraulic systems
2. Simon Walter-Hansen - DVD publishing

Other

1. Mark Norton - Product Ecology Diagrams

2. Aaron Makaruk - OSE Enterprise Plan Video / Civilization Starter Kit v.0.01 - PDF

Kickstarter Supporters

Special thanks go to True Fans and the Kickstarter Supporters who funded The Last Mile on the construction tool kit. Here is the list of a total of 1384 Kickstarter Supporters.

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Introduction

OSE Specifications are a metric for assessing qualities that contribute to the creation of re-localized economic production, as a basis for community prosperity in an interconnected world.

The OSE Specifications are a standard aimed at defining and evaluating the criteria of products, services, and their production - which serve to promote the creation of abundance economies, and therefore, the creation of resilient communities. Abundance exists where a community uses its resource base in such a way that human needs and desires are provided abundantly - with significant surplus to fuel cultural and scientific progress.

GVCS Specifications/Core Values

These are the values of OSE that inform the development of the GVCS which are to be embodied in the development process, in the recruitment of volunteers, in its corporate structure, and in all operations, public and private:

1. ***Open Source*** - we freely publish our 3d designs, schematics, instructional videos, budgets, and product manuals on our open source wiki. We strive to harness open collaboration with a globally-distributed team of technical contributors. We value transparency of our operations, business model, strategic development, “code” (blueprints and designs), management information, and any other aspects that can lead to distributive economics. Commentary: Our main goal is to contribute to the creation of open culture, where sharing and collaborative development is valued over greed and exclusiveness. This type of culture promotes life and growth, as opposed to fear-based aggressiveness. Open source culture includes publishing ‘early and often’ to expose errors and dead ends – where rapid growth occurs by adjusting to failure. Failing early allows solutions to be found early. Failure and dead ends are abundant in life – and the mark of a successful individual is their ability to respond to failure in a manner that leads to growth and transcendence.

2. ***Distributive Economics*** – We publish our business models openly so that others can replicate any enterprise. “Everything we know, you know.” This is intended to generate truly free enterprise and life-giving competition, as opposed to monopoly capitalism or militarism. In one word - distributive economics are called sharing. In the political sense, this phenomenon may be described as decentralization engineering. It should be noted that information should be free, because the cost of distributing information is negligible. However, atoms or physical objects are not ‘free’ in the same sense, as significant human energy is required to produce and distribute physical goods.

3. ***Low-Cost*** - The cost of buying or making our machines are, on average, 5-10x cheaper than buying from an industrial manufacturer- including an average labor cost of $25 hour for a GVCS fabricator.

4. ***Modular*** – Components of the GVCS function as interchangeable modules. Motors, parts, assemblies, and power units can interchange, where units can grouped together to diversify the functionality that is achievable from a small set of units. To see how the different parts fit together.

5. ***User Friendliness*** – Design-for-disassembly, simplicity, transparency, and open source documentation allows the user to comprehend, take apart, modify, service, maintain, and fix tools readily without the need to rely on expensive repairmen.

6. ***DIY*** - The user gains control of designing, producing, and modifying the GVCS tool set. DIY is intended to promote the maker, doer, creator, non-consumer culture – in people who are interested in creating their own custom environment as opposed to accepting massively-standardized options. DIY, however, does not imply substandard or economically-insignificant production - as the product still could and should have industrial efficiency and high performance. High performance is not inconsistent with DIY culture, as long as the enabling tools and techniques are accessible. There is no limit to the tooling available in the DIY context - as long as the tools are appropriate, open source, and user-centered.

7. ***Closed-Loop Manufacturing and Material Cycles*** – Any product should never be a waste, but a feedstock for another process. Our project relies on recycling metal into virgin feedstock for producing further GVCS technologies - thereby allowing for cradle-to-cradle manufacturing cycles.

8. ***High Performance*** - Performance standards must match or exceed those of industrial counterparts for the GVCS to provide a comparable or better standard of living. Note that this is not inconsistent with DIY culture.

9. ***Industrial Efficiency*** - In order to provide a viable choice for a resilient lifestyle, the GVCS platform matches or exceeds productivity standards of industrial counterparts.

10. Ecological Design - Our products promote a harmonious co-existence between nature and humans. The entire process and technology must fit the criteria for being environmentally friendly and regenerative.

11. ***Resilience*** - The systems that we are designing are designed to be adaptable. This arises from the ability to modify, scale and replicate the components and systems to meet requirement of constantly changing conditions.

12. ***Systems Design*** – Our designs consider the whole system of life support, in terms of how the different machines and services interface with one another. Different machines can functions as modules in a wide array of integrated systems. We do not choose technologies with peak point performance, but with peak systems performance as they fit into a resilient community integrated with its natural life support systems. Part of the systems design is synergy – in that the GVCS is intended to attain its maximum potential when all of its components are working with one another.

13. ***Lifetime Design*** – Our products are designed for a lifetime of use – via solid design, user serviceability, open source, DIY design.

14. ***Substitutability*** – Our products tend to the substitutability of common resources for less common or strategic resources.

15. ***Robustness*** – Applications of our work range from the 1st to the 4th worlds, from the city to the country, from high technology to low technology applications, at different scales of operation.

16. ***Multipurpose Flexibility*** – Our tools are typically not dedicated devices, but ones that can be used flexibly in a wide range of applications.

17. ***Best Practice*** – we focus on optimization of our products to achieve the best possible design and functionality.

18. ***Simplicity*** - We design for absolute simplicity without sacrificing performance standards.

19. ***Complete Economy*** – The work of OSE is intended to be a workable blueprint for a complete economy. Our designs are geared for a maker lifestyle on the part of community members. This is also known as a neo-subsistence lifestyle – where communities can provide all the requirements of a complete economy, such that trade is only an option, not a necessity.

20. ***Freedom from Material Constraints*** – The GVCS is intended to provide all the material needs of a community in an efficient way. This allows people to have free time, which allows people to choose their pursuits freely, beyond constraints of material scarcity. This is also known as High-Tech Self-Providing.

21. ***Division of Labor*** – Our designs focus on the needs of a modern village enjoying a high quality of life, as opposed to individual utilization. All of the technologies may be adapted to an individual's use, but division of labor is more desirable for achieving a complete economy in a community.

22. ***Scalability and Fractality*** – The GVCS tools are designed to be scalable to different sizes of operations, from individual households to agglomerations of villages (cities). The design should be fractal, in that each unit of operation should be self-contained (complete) and resilient.

23. ***Village Scale*** – The GVCS is intended to be optimized for a village scale of about 200 people, or Dunbar's number – as the number of people who can maintain face-to-face interaction.

24. ***Nonviolence*** – The GVCS is designed to provide for all the needs of a community without killing or stealing from others.

25. ***Amicable Social Contract*** – The GVCS toolset is designed to promote a just, equitable, and life-giving social contract for a village community living with the GVCS. The qualities of the GVCS are intended to promote good relationships between a village-scale group of people. The social contract is based on collaborative division of labor, where productivity of individual members contributes to the well-being of the whole community. The basic requirement is lifelong learning and regenerative stewardship of land and resources, along with non-violence.

26. ***Community and Family*** – OSE promotes the reconnection of people to one another as a result of increased freedom from material constraints. This reconnection also includes reconnection to

one's true needs, to one's family, and to the global family of all living creatures.

27. ***Proven Techniques*** – We focus on time-proven concepts, techniques, and technologies. All are principles are generally regarded as common, historical knowledge or wisdom learned through eons of civilization.

28. ***Cross-Disciplinary Integration*** – We provide cutting edge practice in so far as they are integrations of knowledge from many fields and disciplines. We value unabashed boundary-crossing and cross-fertilization, drawing from as many cultures, regions, and time periods as possible.

29. ***Sufficiency*** – Our design focuses on sufficiency – i.e., we understand that we need to reach a certain level of performance, and that is sufficient. This is distinct from continuous addition of frivolous bells and whistles.

30. ***New Economics*** – One aspect of OSE is that it allows for the creation of a resource based economy, where true wealth is based on the value of natural, primarily local resources, where wealth is created from adding value to natural resources by transforming them to human-usable form.

31. ***Flexible Fabrication*** – This is a mode of production distinct from specialization. In flexible fabrication, general purpose machinery is used by highly skilled workers to produce a wide array of products – as opposed to specialized machines, operated by highly deskilled workers, producing only a single item. Our means to flexible fabrication is the open source fab lab.

32. ***Technological Recursion*** – The flexible fabrication technology also allows producers to produce more complex machines and parts. This allows a local community to, eventually, attain the capacity to produce any technology known to humankind.

33. ***Industry 2.0*** – This is a concept that flexible fabrication, combined with a collaboratively-developed, global repository of down-loadable product design has the potential to become the new engine of production. This is particularly useful towards relocalization of productive economies and towards distributive economics. Industry 2.0 is a direct goal of OSE.

34. ***Permafacture*** - ecological fabrication with lifetime design.

35. ***Local Resources*** – The GVCS is fueled by local resources, such as water, sunlight, rock and soil, via technological recursion.

36. ***Replicability*** – OSE work is intended to be replicable, self-replicating, and viral. The open source nature, low-cost, and simplicity of our designs are key to this.

37. ***Meaning*** – Technology, when used appropriately, is intended to reconnect one to meaning, and to natural ecosystems. Reconnection to nature can occur from constant interplay between humans and nature, as natural resources are stewarded responsibly to meet human needs by

benign processes.

38. ***Appropriate Automation*** – We favor automation of production or other tasks whenever repetitive, difficult, dangerous, or otherwise unrewarding tasks can be carried out with computer assistance instead of human labor. We favor this if this truly increases quality of life and reduces toil, without loss of meaning, violence, or other negative systems consequences.

39. ***Long Term Approach*** – OSE is seeking long-term solutions on the 100 year scale into the future, not Band-Aids on superficial issues. We are looking at issues for the long haul, with lasting peace and stability for humanity as the goal.

40. ***Network*** – OSE is interested in creating a network of like-minded communities that follow OSE values, such that cultural exchange can happen between different communities. This refers to the 1000 Global Villages concept - which serves as model communities that influence the rest of the world in a positive way. This brings in an element of mobility into the community social fabric.

41. ***Model Community*** - The OSE Village with the GVCS are intended to provide a positive, best-practice example of integrated, meaningful lifestyles along the principles of abundance and prosperity - as a shining point of light to inspire people in many walks of life.

42. ***Land and Resource Stewardship*** – Each OSE facility functions as a land steward. Land is not for sale, but is preserved for ever as a permanent site of human heritage and cultural growth. Resources are stewarded so that they improve in quality with time, as opposed to becoming depleted.

43. ***Iconoclastic Innovation and Transformation*** – OSE favors iconoclastic approaches which address issues at the root, not symptoms – towards addressing pressing world issues (war, poverty, corruption, distribution of wealth, disease, etc.). We are not looking for mass-culture compromises swayed by political or special interests, but for authentic solutions based on virtues common to all humankind.

44. ***Absolute Creative Approaches*** - We do not promote destroying anything, just creating a better solution that makes the old paradigm obsolete. We do not hate any group or politic, because we are all in this together. We believe in positive psychology, inspiration, and bringing out the virtues in people – by appealing to their absolute creativity.

Methods and Strategic Approaches

1. ***Open*** – Open Source Ecology endorses open source culture of sharing and collaborative development throughout, towards the end of distributive economics. This applies at the level of our process, organizational structure, business and products. On the process level, we encourage others to collaborate openly, yet respectfully of other developers' needs. To this end, we are aiming to create collaboration structures and platforms that allow others to collaborate freely, and to publish meaningful results openly. We seek to design all of our operations to be consistent with this principle. We encourage everybody on the development team to be transparent about

their work, and to ask openly for collaborative assistance. We encourage everybody to give information away for free – as the cost of sharing information is zero.

2. ***Distributive Economics*** - We recognize the challenges of sharing information openly – in that someone else can 'steal' an idea and capitalize on it. We address this issue by encouraging people to publish openly, so that prior art makes information accessible to all, and therefore, making information un-patentable and therefore incapable of being appropriated. In order to capture value, we encourage humans to organize around information resource commons, while building in a physical, productive infrastructure to convert information into the substance of modern-day living via benign, industrial processes

3. ***Notes on Patents*** - These make sense only in a world based on scarcity. We encourage each community that adopts OSE principles to build complete, open source, economic productivity – where true wealth can be generated easily. In this case, what is the need for patents? If a community can provide all of its needs - then we enter into the concept of sufficiency. State-of-art point technologies that optimize one feature of performance are not necessarily useful for an ecological tool set. We are interested more in overall, or ecological, performance - as opposed to point performance.

4. ***Creative Approach*** - There is a number of movements that cater to fears regarding the end of the world or other comprehensive collapse scenarios. Our approach is intended to empower people from a perspective of what is a-priori favorable and benign - whether or not any cataclysm is on the horizon. IT is important to underscore that we focus on positive psychology and transcendence, which we favor over an approach based on fear, because fear-based response is not as likely to create long-lasting solutions.

5. ***Modular/Lifetime Design*** – The core of lifetime design is design-for-disassembly and modularity. Design-for-disassembly is synonymous with user ability to 'look under the hood' of a certain device. Modules are interchangeable units of functionality.

6. ***Closed Loop Manufacturing*** – OSE endorses closed loop eco-industry, where waste does not exist as the waste is turned into feedstock for other processes.

Components of OSE Specifications

OSE Specifications cover a number of aspects of economically-significant production, covering the development and production aspects:

- Economic significance
- Open documentation
- Distributive economic nature
- Transformative nature of enterprise
- Systems design
- Transparency and participatory nature of production model and development process
- Creation of post-scarcity levels of production

- Simplicity and low cost
- Lifetime, modular design; design-for-disassembly; design-for-scalability
- Localization of material sourcing and of production
- Ecological qualities
- Economic Feasibility and Replicability
- Minimization of waste, overhead, and bureaucracy
- Product Evolution
- Fabrication Facilities
- Open Franchising or Open Business Model
- Startup Assistance

Economic Significance

Economic significance refers to the overall economic importance of a given product or service. The assumption here that economic significance is defined on the basis of relevance for meeting the material needs of humans. For example, fuels and tractors constitute multibillion dollar global markets, and are thus economically significant. On the other hand, plain discussion may have little economic significance, if is not more than hot air.

Open Documentation

Open Content

We begin with open content as a foundation – content that is free of restrictions on use or dissemination. The optimal license for content that we promote is the public domain. This keeps it simple from the practical and legal perspective. We have a philosophy that the users should decide for themselves as to how to use the information. We support open licensing. We are not interested in policing.

We believe that to claim something as 'one's own' is arrogant, as it does not address the fact that any single 'invention' is simply a small additional to a large pool of existing knowledge that made the 'invention' possible. We believe that there is no point in trying to police the patenting of forks, as are simply so many different forks or development paths that could be taken nonetheless: creativity is unlimited. We believe that the more we contribute to the commons, the more new content will be generated.

Readily accessible or downloadable documentation and design

Distributed information in the computer age is made most readily accessible if it is available for immediate download from the internet. If material is available in electronic format, it may be manipulated or utilized readily with software tools. For example, digital designs may be edited or used immediately in CAD or CAM. If CAM formats are available, then data at one point in space can be readily transformed into a physical object at another point in space, in the presence of digital fabrication capacities.

Design Drawings

This is a start towards replicability.

Bill of Materials (BOM)

Next to design drawing, the BOM is the second most important towards replicability. This is a detailed listing of all parts used, sourcing, and prices. Availability of the BOM saves the potential builder countless hours of searching for part availability and for reasonable pricing. Relevant comments should be made alongside the BOM, such as, quality or reliability of certain vendors, their quality of service, and any other useful comments. The only difficulty with a BOM may be that if the audience is global, sourcing may not be readily available or shipping may be prohibitive, so local substitution of parts must be made. If a BOM is available, then the building of a specific product can commence immediately: there is no guessing which parts would work, or which supplier is reliable.

At best, the process for one-off individual production can be as follows:

1. an individual decides that they need a certain product
2. they look that product up on an online repository of open source products, download fabrication procedures and parts lists
3. purchase parts locally all on the same day if they are located in an urban area where many suppliers are available
4. and start building a certain project.

All these steps can potentially be completed in one day when the BOM is available. Open design drawings and plans are only one aspect, but the critical point to enabling immediate production is the availability of BOMs, as the last step prior to actual fabrication.

Under this scenario, a realistic possibility emerges that a large number of individuals discontinue purchasing slave goods from who-knows-where, and begins to fabricate them locally. This is feasible on the individual level for anyone equipped with a robust Fab Lab, or when small groups (a few to a dozen people) get together to purchase low-cost, open source, digital fabrication equipment. These people could operate out of backyard garages, rented workshop spaces, co-working facilities, or other community supported manufacturing operations. The types of products that yield themselves particularly to this type of production are those items that fall beyond the class of disposable goods, and are more or less long-use items. These items include electronics, mechanized tools, semi-heavy machinery, green vehicles, and renewable energy systems, among others.

Tools

CAD by Mariano Alvira and SKDB are two different tools that can improve and automate different aspects of handling a BOM.

Free information

If information is free, it is most easily accessible.

Distributive Economics

Distributive economics refer to economic models that tend to distribute economic power as opposed to monopolizing this power.

Transformative Nature of Enterprise

We are interested in transformative economics, or those economics which tend towards community and global resilience, while having qualities that, proactively, move the world away from: concentration of societal power; perennial warfare; loss of meaning; bureaucracy; globalization of economic activity; newspeak; loss of freedom; and so forth.

Systems Design

Systems design refers to design of economic paradigms which consider the whole human and natural ecosystem, and the relationships involved, not just an isolated part of that system. For example, non-systems thinking may lead one to conclude that a modern steam engine for transportation is a bad idea compared to biodiesel or fuel alcohol because the thermodynamic efficiency of a steam engine is two times lower than that of diesel engines or gasoline engines. The systems design perspective will claim that the steam engine is a great idea, because biomass pellets can be used as fuel, and the yield of cellulosic biomass per acre is about 10 times higher than the yield of oil or alcohol. The systems thinker will continue, by stating that if the whole system is considered, biomass pellet production is much simpler to accomplish, and that biomass-growing areas can be integrated with other uses such as orcharding or livestock raising, and the systems thinker will continue to make other claims that such an energy source allows for absolute decentralization of production and resilience of communities using the simplest means possible. The point to be made is that the systems thinker can continue to make a large number of claims on how a particular activity is desirable based on a number of systems connections, which the non-systems thinker dismisses as simply not being part of the question.

We believe that destructive non-systems thinking is so pervasive in our society, that in general, individual and societal decision-making is completely partisan, thin on logic, and downright retarded. We are including a metric for systems design in the OSE Specifications to raise awareness of this issue, with a hope, which even if futile, attempts to bring a glimmer of light to the situation.

Transparency of Production Model and Development Process

The development process for products, and their production model, should be transparent to any interested observer. This allows for study of, input into, and improvement of the topic of interest. Transparency allows feedback loops to become active, and empowers those who are interested in learning more about a topic. Transparency is one of several qualities of a distributive, economic process.

Transparency of some program implies that the program is open to suggestions, correction, or replication of itself, stemming from an ethical foundation of the given program. Therefore, tools such as non-disclosure agreements, patents, trade secrets, and other means of protectionism are inconsistent with the creation of transparency.

Development Process

1. Participation in the development process is entirely voluntary. No compensation for alienation is necessary. As a result, the best designs are produced from the commitment of passionate stakeholders.
2. Anyone may join or leave the development group at any time
3. Collaborative development process utilizes the input of diverse stakeholders
4. Steps and results of the development process are documented

Creation of Post-Scarcity Levels of Production

Post-scarcity levels of production imply the availability of effective tools of production, including both hardware and techniques - which allow for the ample meeting of human needs. Post-scarcity levels of production also imply that local, nonstrategic resources can be utilized effectively, reliably, and with the capacity to produce significant surplus. The goal of attaining post-scarcity levels of production of something are thus synonymous with a particular community being able to transcend physical survival as a basis for evolving to pursuits beyond mere survival.

Simplicity and Low Cost

The design and implementation of any product or service should be the simplest from both the fabrication and cost perspective, such that it is the most readily replicable. Attaining simplicity is indeed the most difficult design challenge. Most people confuse high performance with extra features, because they externalize the hidden liabilities that accompany the extra features. Simplicity is synonymous with efficient resource use. Simplicity should also apply to the fabrication procedure of an object. As such, simplicity is also synonymous with low cost. The basic design philosophy of OSE is to include simplicity in design and fabrication - i.e., design-for-fabrication should be applied.

Lifetime, Modular Design; Design-for-Disassembly; Design-for-Scalability (DfS)
(Note: For mainstream reference on lifetime design, see the work of Saul Griffith)

Simplicity of design promotes the features of lifetime, modular, and scalable design-for-disassembly (DfD).

Lifetime design implies that the value of a product does not depreciate over time. This implies freedom from labor required to replace a certain product, which has direct implication for one's access to free time.

Modular design is a design which allows different modules to be used and interchanged, giving the user control over and flexibility with the object of use.

DfD means that parts of modules may be replaced readily, by taking the module apart. This has profound implications to lifetime design.

DfS is more than a design that can be scaled. It is the principle of designing things with ease of scalability as one of the features - i.e., design that can be scaled easily. This is a slight improvement over design that can be scaled, in that DfS includes explicit features that make scalability easy.

Scalability means that a basic building block can be used to make larger or smaller versions. This contributes to low cost and efficiency.

Multipurpose Modular Design

Objects should be designed so that they are made as building blocks, or modules, of other or larger objects. This way, objects can be modified. Instead of a whole object having to be replaced to add new functionality, a module may be added. This gives products a flexibility that is built into their very nature, such that the user has additional control with minimum expense. Modularity may sometimes be synonymous with inter-operability, and may sometimes be synonymous with scalability. It may contribute to lifetime design if an object is 100% modular and each module may be replaced. Modularity also means that an object may function as a building block of other objects. In all cases, modularity implies that an object may be modified. The combination of flexibility, adaptability, scalability, interoperability is desirable. These features expand the range of applications, increase lifetime, reduce cost, as well as provide and retain high value. In a material world, these are features that contribute to wealth and prosperity. In a nutshell, modularity provides large value and has low associated costs. These are good implications for individual and community well-being.

If modular design is followed, then the type of interoperability of using building blocks leads us to a Pattern Language of technology. In this pattern language, the modules or building blocks serve as the sentences of a larger language, or technology infrastructure.

Scalability

Products should be designed so that they can be scaled up or down - such as by addition of new modules, or using multiples of a part in parallel. For example, a solar concentrator system designed according to the principle of scalability should be a linear design (see Solar Power Generator), so that it could be enlarged either by lengthening or widening the array.

Localization of Material Sourcing and of Production

For community resilience, ability to use local resources is key. While it is important that a community have this ability for essential needs, it is optional, though desirable, for other nonessential items.

Using local resources may necessitate that a given community have additional technology to produce a certain item. For example, if a given community does not have the conditions to grow a certain crop easily, it may want to invest in the additional technology required to grow that crop successfully. Or, if a certain community does not have adequate water, it should invest in well-drilling or roof-catchment technology, instead of importing water from unsecured sources.

A community should thus, in general, strive to increase its technology base to accommodate the provision of all essentials, and not settle on its ability to trade to procure these essentials, as trade may be vulnerable to disruption. Trade is quite acceptable for non-essential items, such as musical instruments, since disruption of such supply does not threaten the survival of a community. The level of technology in which a community is autonomous should be determined on practical grounds.

Moreover, in today's world, we already hear about 'produced locally.' We should add 'sourced locally' to our vocabulary - as resilience implies not only local production, but also local sourcing. Local sourcing typically requires that a community have additional technological infrastructure and knowhow for providing the necessary feedstocks.

Localization Levels

Level 1 - production is local
Level 2 - sourcing of materials used in production is local
Level 3 - raw material production is local
Level 4 - production machinery used in the production process above is open source and locally fabricated.

Localization applies to the creation of natural economies, or those economies based on the substance of their own, natural resources, free of supply chain disruptions.

An example of Level 3 is that local aluminum is made by Smelting aluminum from local clays.

If localization is taken to all the 4 levels, for all necessities of sustaining its population - that means that a region is autonomous, and as such, has no built-in tendency to wage war for others' resources. This is the critical point of localization - its benign effect on global geopolitical struggle. In simple words, people don't kill and steal.

Ecological Qualities

The product of interest must be good for the environment.

Economic Feasibility and Replicability

Minimization of Waste, Overhead, and Bureaucracy

The key point to the competitiveness of agile, open source enterprise is its lean structure with minimal overhead. Minimization of waste occurs by collaborative development, such that R&D costs are shared by a number of stakeholders. Competitive waste is eliminated by open enterprise giving services away rather than competing for market share, which is the ethical marketing strategy for open enterprise.

Other strategies for keeping overhead low are crowd-funding the production facility, such as in Factor e Farm's case. We also propose paperwork reduction by operating as an un-incorporated entity, with contractually-based fiscal fiduciaries and liability management, operation in the Republic via private contract, and by in-house legal literacy.

Product Evolution

A process should be in place for continued maintenance and development of a product. This could be a support community, foundation, or users.

Fabrication Facilities

Concrete Flexible Fabrication mechanism exists for others to purchase the product at reasonable cost. This is a means to assuring that a diversity of suppliers exists, such that monopoly is avoided.

Open Franchising or Open Business Model

This point defines how easily one can obtain access to replicable enterprise design. See our motivation with respect to Open Business Models, as described under the OSE License.

There are a number of details that goes into enterprise replications. These are all the standard details found in a Business Plan, plus the actual technical details that go into that plan, such as designs and CAD, fabrication procedures, BOM and sourcing information, economic analysis, ergonomic analysis, and so forth.

If you are interested in replicating an enterprise, then please inquire with us regarding practical considerations. For those interested in replication, we are looking for long-term commitment to provide the necessary due diligence of business model documentation.

Startup Assistance

Producer training is the key to assisting others to start up enterprise. Dedicated workshops should be available for others to learn the trade. We plan on offering a 2 year immersion program, which includes not only workshop skills, but agriculture, as well as theoretical and organizational aspects.

Calculation of a Metric Score

See OSE Specifications Metric Score

Summary

In summary, we aim to raise the standards embodied in open source product development efforts by articulating the possibilities. OSE Specification describes all the desirable features that can be embodied in open economic development, under the assumption that maximum advancement of distributive production is the best route to human prosperity.

OSE Specifications, as applied to technology - imply liberatory technology - defined as technology which serves the true needs of people and liberates time for other pursuits beyond survival. This is distinct from technology which controls people - where in today's world - with ever-advancing technology, people enjoy less free time.

Application of OSE Specifications to Assessing the Liberatory Potential of Technologies

OSE Specifications, when applied to production of physical products, allow for transparent assessment of the overall openness or accessibility of so-called open source products. This specification is intended to help people assess distributive production aspects of projects, by distinguishing between the various degrees of 'open source-ness' embodied in projects. This is because some projects call themselves 'open source' when only a small portion of the hardware, or even no physical portion, is open source.

For example, in the case of the OS Green Vehicle, the only open source component is an apparent design process, but the output of the design process is proprietary. As quoted from the website, 'Your rights to use, modify and re-distribute any data from this web site are limited.' Moreover, the components used in the car are proprietary. Therefore, the OS Green Vehicle has a low OSE Specifications metric score.

Access refers to use for both private or market purposes. The specification is not neutral in its goals, just as no technologies are ever neutral. The intent goes so far as to point out the nuances that contribute to a particular direction of: (1), promoting ecological integrity, (2), contributing to the highest possible quality of life, and (3), creating the widest possible distribution of wealth. Because the open source method of product development has immense potential in transforming the economic system, the OSE Specification aims to address the evaluation of positive change endorsed by various open source projects.

The scope of OSE Specifications is far-reaching: it considers all the steps necessary for a product to be user-accessible. This includes open access to relevant information and affordable access to physical products. The goal is distributive economics.

OSE Specification stipulates access to physical production facilities that can build wealth in re-localized communities. But OSE Specifications go even further: replication and viral spread of wealth - or distributive production. OSE Specifications address the means for replicating the production process itself. This includes not only self-replicating machines and systems, but the development of open business models, training materials, and apprenticeships for entrepreneurs. As the final step, we consider the availability of capitalization assistance within the metric. The capitalization assistance may be part of a new entrepreneur's apprenticeship - where, for example - real products can be made and sold within the apprenticeship. We redefine the 'capital' in 'capitalization assistance' from 'money' to 'the ability to produce just about anything required for business startup at low cost.'

Such level of commitment to the success of replication may imply a hidden agenda behind this program. Indeed there is: the greatest possible empowerment of people and communities to be the masters of their destinies, by unleashed human productivity fueled by open access to information and enabling hardware.

OSE Spec addresses access to both producers and users - both on the individual and community scale. Production could occur by do-it-yourself means on the individual scale in flexible fabrication facilities. The community scale promotes division of labor, and therefore a high standard of living. The OSE Spec addresses the availability of blueprints or digital designs, which can be used readily in manual or automated, computer-controlled fabrication facilities.

Scaling Calculations

Scaling calculations are best done with CAE analysis. We can determine the lifetime and weight-bearing strength of the existing design, and we also know that we can build a smaller microtractor. However, to build a larger tractor such as a bulldozer - with at least 20,000 lb. weight, we should perform CAE analysis based on the specific geometry in question. This will determine the shaft sizing, coupling, and gear reductions allowable in the system based on a 100 year design lifetime. From back-of-envelope calculations, 2.5” shafts, dually or trually wheels on the exact same drive system as now, with jackshaft gear reduction, could yield approximately 15,000 pounds of traction power by simply using 16” truck tires with 4 wheel drive. This is based on the 5000lb traction limit of an F250 truck - assuming 4 wheel drive and single tires.

Traction

The 15,000 Inch Pound Motors of LifeTrac Prototype IV produce approximately 1000 lb. of force at the 15” radius of the wheels, combining to a total of 4000 pounds of traction force in 4 wheel drive operation. Assuming 1 as the coefficient of friction for a 5000 lb. gross weight tractor, this translates to traction comparable to an F250 truck.

The motor shaft is 1.5” tapered, and the wheel shaft is 1-7/8”, or an approximate good match for direct transfer of torque from wheel motor to shaft.

Traction CAE Analysis

These tests are useful:

1. Determining the shear limit of a 3/4” grade 8 bolts holding the wheel in place. This would involve 3 points of failure: the shearing of the bolt (simple pin-through with metal lock nut); ripping of the 3/4” bolt hole through the cold-rolled steel shaft; ripping of the reinforced collar holding the wheel. Test for maximum safe torque with a safety factor resulting in 30 years of continuous operation (equivalent to 8 hours per day for 100 years).

2. Determining the wheel mounting strategy (multiple bolts, key, or spline that would achieve the above lifetime). If practical considerations require replacement as the only lifetime design option, that may be the outcome.

Load Tests

1. Test for maximum weight bearing capacity of 1-7/8” shaft based on wheel geometry of Quick Attach Wheel.

2. Test of weight bearing capacity of Quick Attach Wheels system.

3. Weight holding capacity of frame assuming point load on 2 upper horizontal long members for

a deflection of 1/2” or until bolt failure, whichever is earlier.

4. Shock absorbing capacity of frame using Grade 2 bolts prior to bolt shearing, and same with Grade 5 and 8 bolts. This is used to determine if Grade 2 bolts are satisfactory for lifetime design.

5. Scaling frame 2x to determine weight bearing capacity of tractor with a larger frame. This is used to determine whether the tractor can be weighed down with concrete or other weights, height being scaled to about 10x16 feet - or the size required for a bulldozer of 20,000 lb. minimum weight.

6. Using 2.5” bearings, determining the maximum weight bearing capacity for a jack-shaft drive system, 4 wheel drive, for a bulldozer - using all-steel wheels like in old steam traction engines from about 100 years ago.

Problem	More Specifically	Possible Cause	Fix Actions
excessive noise	pump noisy	cavitation	fluid may be too cold; also see "A"
		air in fluid	see "B"
		coupling misaligned	align unit and check condition of seals, bearings and coupling
		pump worn/damaged	overhaul or replace
	motor noisy	coupling misaligned	align unit and check condition of seals, bearings and coupling
		motor/coupling worn/damaged	see "B"
	relief valve noisy	setting too low or too close to another valve setting	install pressure gauge and adjust to correct pressure
		worn poppet and seat	overhaul or replace

Problem	More Specifically	Possible Cause	Fix Actions
excessive heat	pump heated	see “fluid heated”	
		cavitation	see “A”
		air in fluid	see “B”
		relief or unloading valve set too high	install pressure gauge and adjust to correct pressure (keep at least 125 PSI difference between valve settings)
		excessive load	see “C”
		worn/damaged pump	overhaul or replace
	motor heated	see “fluid heated”	
		relief or unloading valve set too high	install pressure gauge and adjust to correct pressure (keep at least 125 PSI difference between valve settings)
		excessive load	see “C”
		worn/damaged motor	overhaul or replace
	relief valve heated	see “fluid heated”	
		valve setting incorrect	install pressure gauge and adjust to correct pressure (keep at least 125 PSI difference between valve settings)
		worn/damaged valve	overhaul or replace
	fluid heated	system pressure too high	install pressure gauge and adjust to correct pressure (keep at least 125 PSI difference between valve settings)
		unloading valve set too high	install pressure gauge and adjust to correct pressure (keep at least 125 PSI difference between valve settings)
		fluid dirty or low supply	change filters and also system fluid if improper viscosity; fill reservoir to proper level
		incorrect fluid viscosity	change filters and also system fluid if improper viscosity; fill reservoir to proper level
		faulty fluid cooling system	clean cooler and/or cooler strainer; replace cooler control valve; repair or replace cooler
		worn pump/valve/motor/cylinder/ other	overhaul or replace

Problem	More Specifically	Possible Cause	Fix Actions
incorrect flow	no flow	pump not receiving fluid	fill reservoir to proper level and/or see "A"
		pump drive motor not operating	overhaul or replace
		pump to drive coupling sheared	check for damaged pump or pump drive; replace and align coupling
		pump drive motor turning in wrong direction	reverse rotation
		directional control set in wrong position	check position of manually operated controls; check electrical circuit on solenoid operated controls; repair or replace pilot pressure pump
		entire flow passing over relief valve	adjust
		damaged pump	check for damaged pump or pump drive; replace and align coupling
		improperly assembled pump	overhaul or replace
	low flow	flow control set too low	adjust
		relief or unloading valve set too low	adjust
		flow by-passing thru partially open valve	overhaul or replace or: check position of manually operated controls; check electrical circuit on solenoid operated controls; repair or replace pilot pressure pump
		external leak in system	tighten leaking connections (fill reservoir to proper level and bleed air from system)
		yoke actuating device inoperative (variable displacement pumps)	overhaul or replace
		RPM of pump drive motor incorrect	replace with correct unit
		worn pump/valve/motor/cylinder/other	overhaul or replace
	excessive flow	flow control set too high	adjust
		yoke actuating device inoperative (variable displacement pumps)	overhaul or replace
		RPM of pump drive motor incorrect	replace with correct unit
		improper size pump used for replacement	replace with correct unit

Problem	More Specifically	Possible Cause	Fix Actions
incorrect pressure	no pressure	no flow	see “no flow”
	low pressure	pressure relief path exists	see “no flow” and “low flow”
		pressure reducing valve set too low	adjust
		pressure reducing valve damaged	overhaul or replace
		damaged pump/motor/cylinder	overhaul or replace
	erratic pressure	air in fluid	tighten leaking connections (fill reservoir to proper level and bleed air from system)
		worn relief valve	overhaul or replace
		contamination in fluid	replace dirty filters and system fluid
		accumulator defective or has lost charge	check for damaged pump or pump drive; replace and align coupling
		worn pump/motor/cylinder	overhaul or replace
	excessive pressure	pressure reducing, relief or unloading valve misadjusted	adjust
		wok actuating device inoperative (variable displacement pumps)	overhaul or replace
		pressure reducing, relief or unloading valve worn/damaged	overhaul or replace

Problem	More Specifically	Possible Cause	Fix Actions
faulty operation	no movement	no flow or pressure	see “no flow” or “no pressure”
		limit or sequence device (mech/elec/hydro) inoperative or misadjusted	overhaul or replace
		mechanical bind	locate bind and repair
		no command signal to servo amplifier	repair command console or interconnecting wires
		inoperative or misadjusted servo amplifier	adjust, repair or replace
		inoperative servo valve	adjust, repair or replace
		worn/damaged cylinder/motor	overhaul or replace
	slow movement	low flow	see “low flow”
		fluid viscosity too high	fluid may be too cold or should be changed to clean fluid of correct viscosity
		insufficient control pressure for valves	see “low or no pressure”
		no lubrication of machine ways or linkage	lubricate
		misadjusted or malfunctioning servo amplifier	adjust, repair or replace
		sticking servo valve	adjust, repair or replace
		worn/damaged cylinder/motor	overhaul or replace
	erratic movement	erratic pressure	see “erratic pressure”
		air in fluid	see “air in fluid”
		no lubrication of machine ways or linkage	see “erratic pressure”
		erratic command signal	repair command console or interconnecting wires
		misadjusted or malfunctioning servo amplifier	adjust, repair or replace
		malfunctioning feedback transducer	overhaul or replace
		sticking servo valve	clean and adjust or replace; check condition of system fluid and filters
		worn/damaged cylinder/motor	overhaul or replace
	excessive speed/ movement	excessive flow	see “excessive flow”
		feedback transducer malfunctioning	overhaul or replace
		misadjusted or malfunctioning servo amplifier	adjust, repair or replace
		Over-riding work load	adjust, repair or replace counterbalance valve

A: any or all of the following	replace dirty filters
	wash strainers in solvent compatible with system fluid
	clean clogged inlet line
	clean or replace reservoir breather vent
	change system fluid
	change to proper pump drive motor speed
	overhaul or replace supercharge pump
B: any or all of the following	tighten leaking connections
	fill reservoir to proper level (with rare exceptions all return lines should be below fluid level)
	bleed air from system
	replace pump shaft seal (and shaft if worn at seal journal)
C: any or all of the following	align unit and check condition of seals, bearings and coupling
	locate and correct mechanical binding
	check for work load in excess of circuit design