Introduction for Grain Bikes

This project was supported mainly by the Northeast Sustainable Agriculture Research and Education (SARE) program (www.nesare.org). SARE is a program of the National Institute of Food and Agriculture, U.S. Department of Agriculture.

Unlike some "hacks" for small farmers, the Grain Bikes don't solve an acknowledged problem so much as create new opportunities for small farmers. The grain bikes enable a small farm to dabble with growing dry beans, grain, and seeds. These three new products are non-perishable, can be sold, eaten, or planted to avoid seed costs (such as rye for cover crops), and, the labor for processing them can be shunted to the winter when more time is available.

In general, these plans do not provide instructions for safety features (cowlings, guards, goggles, respirators, etc.). It is the responsibility of each farmer to add safety features appropriate for their application and environment.

Since most small farms already own equipment for planting and cultivating dry beans and grains, the grain bikes make it possible to process these crops from dry material to finished product in about 1 minute per pound (per process). For example, dry beans or rye seed require only threshing and fanning, so that's 2 minutes per pound. Rice requires threshing, fanning, de-hulling, and re-fanning, so that's 4 minutes per pound. It makes sense for a farm to use slower, safer bike power while "proving" the process and the market for various crops. Later, as the market grows and greater efficiency is sought, the investment in faster equipment (or using electric motors instead of bikes) with more safety features is justified. The old bike powered equipment, having paid for itself, can be retired, passed on to a younger farmer, or stored for the kids to use at harvest festivals.

I have tried to make the design of these tools as adaptable as possible to various crops and conditions. Right away we learned that the behavior of dry beans on a dry week differs from that of the same beans after a humid week. So with the thresher, the swipples can be changed quickly, as can the screen. We have experimented with swipples made from bicycle spokes, chain (plastic and metal) and hardwood. With the fanning mill, different screen sizes, adjustable tilt angles of the screens, adjustable frequency and amplitude of the shaker, and adjustable speed of the blower are all possible. The de-huller is adjustable for different size grains, and adjustable for how hard the grains are abraided during de-hulling. In addition, the de-huller is convertible to a flour mill for making flour from grain. All of this adjustability comes at little cost and supports farmers who want to process a variety of crops for a variety of markets while getting the benefit of polyculture on their farm. In addition, adjustability makes it advantageous for more than one farm to share the equipment and grow different crops from eachother's , getting the benefit of sharing without the detriment of market competition.

There are two hidden costs not accounted for in these instructions. The first is that because the grain bikes are constructed from un-painted wood, they can't be left outside like some agricultural equipment. The grain machines must have an indoor location protected from rain and sun. The second hidden cost is that in order to dry the crops for processing (and in order to spend the least time harvesting during the high season), the farm needs a location to hang the drying plants-- either a garage, a barn, or an unused greenhouse. These "real estate" costs could easily overshadow the cost of the machines.

The total cost of the materials for the three grain bikes, the thresher, the fanning mill, and the de-huller, assuming the bike stuff is scavenged, is ~$600. The design uses wood and bicycle parts because they are cheap or free. Wherever bicycle parts are specified, regular shafts, bearings, and sprockets may be substituted. The transmission for the fanning mill blower relies on the discovery that 1/2" drive socket wrench sockets fit on most square-drive bottom bracket spindles. This allows the fabricator to make custom parts that remain centered (without machining) and bolt to a bicycle bottom bracket.

In addition to bicycle mechanics, the builder will need to weld. Since welding has to be done to minimize distortion (especially on centered parts like the blower transmission of the fanning mill), I recommend an electric welder such as MIG rather than an oxy-acetylene welder. If oxy-acetylene is used, than brazing instead of welding will result in less distortion.

A flat belt is used to drive the shaker mechanism on the fanning mill. Flat belts are cheap, low friction (compared to v-belts), and fun to use. Farmers used flat belts in the past, and may yet again in the future. There are a couple tricks to flat belts. First, the pulleys have to be crowned at the center. If your flat belt randomly jumps off one side or the other, crown your pulleys. To crown a pulley mount it on a bolt and chuck the bolt in a drill. Spin the pulley and hold it obliquely against a piece of sandpaper. Second, if the alignment of the two pulleys is off—by which I mean the two pulley axes are not parallel-- the flat belt will "climb to the higher side" and always fall off that side. Old leather belts work great as flat belts, and can be sewn, stapled, or glued with virtually any glue to make a belt out of a strip. Pulleys can be made in minutes from plywood, plastic, or wood sandwiched together to minimize splitting and warping. If you use a hole saw to make a pulley you get a center hole the size of the pilot bit for free. If the center hole needs to be countersunk (such as the shaker pulleys on the fanning mill), you may opt to countersink first and then hole saw the pulley out.

The blower on the fanning mill is designed to use a cantilever mounted bearing on a relatively sturdy drive side housing. This allows the light (non-drive side) cover of the blower housing to be removed and the apparatus cleaned and checked for interference, since the blower will still turn with the cover removed. This feature also allows access for cleaning and rodent and bug control.

When considering exercycles and bikes to use as power units for the grain bikes, any exercycle that uses bike parts will work. Flywheels are helpful, but make transporting the bike harder. Bicycles are more work to modify than exercycles, but make it possible to have higher quality components, gears, and a better power position. The thresher uses the most power and needs a high gear ratio (~ 1:4) in order to turn at 250rpm. In addition, the thresher should be a "fixed gear" so that the rider can turn the shaft both ways to clear the shaft should it get jammed with fibrous material. The fanning mill requires the least power and can have a single input gear with ~100 rpm. The fanning mill transmission allows the operator to select many possible gear combinations to tune the blower and shaker to the input power. The de-huller is fine without gears if used only for de-hulling, and also wants an input rpm in the ~100 rpm range. However, if the mill is going to be converted to a flour mill for making flour then I advise using a bike PTO with gears and a flywheel. Flour requires a lot of energy in a low speed high torque application of power. A flywheel makes a smooth pedaling motion possible and gears make it possible for young and old alike to make it work. We were tempted to use one deluxe bike PTO to power all four applications (thresher, fanning mill, de-huller, and flour mill) but because all the machines are used at the same time, too much time was lost switching the bike from one machine to the other and back again. It is an irony of our epoch that four bikes can be scavenged in less time than it takes to move one bike around.

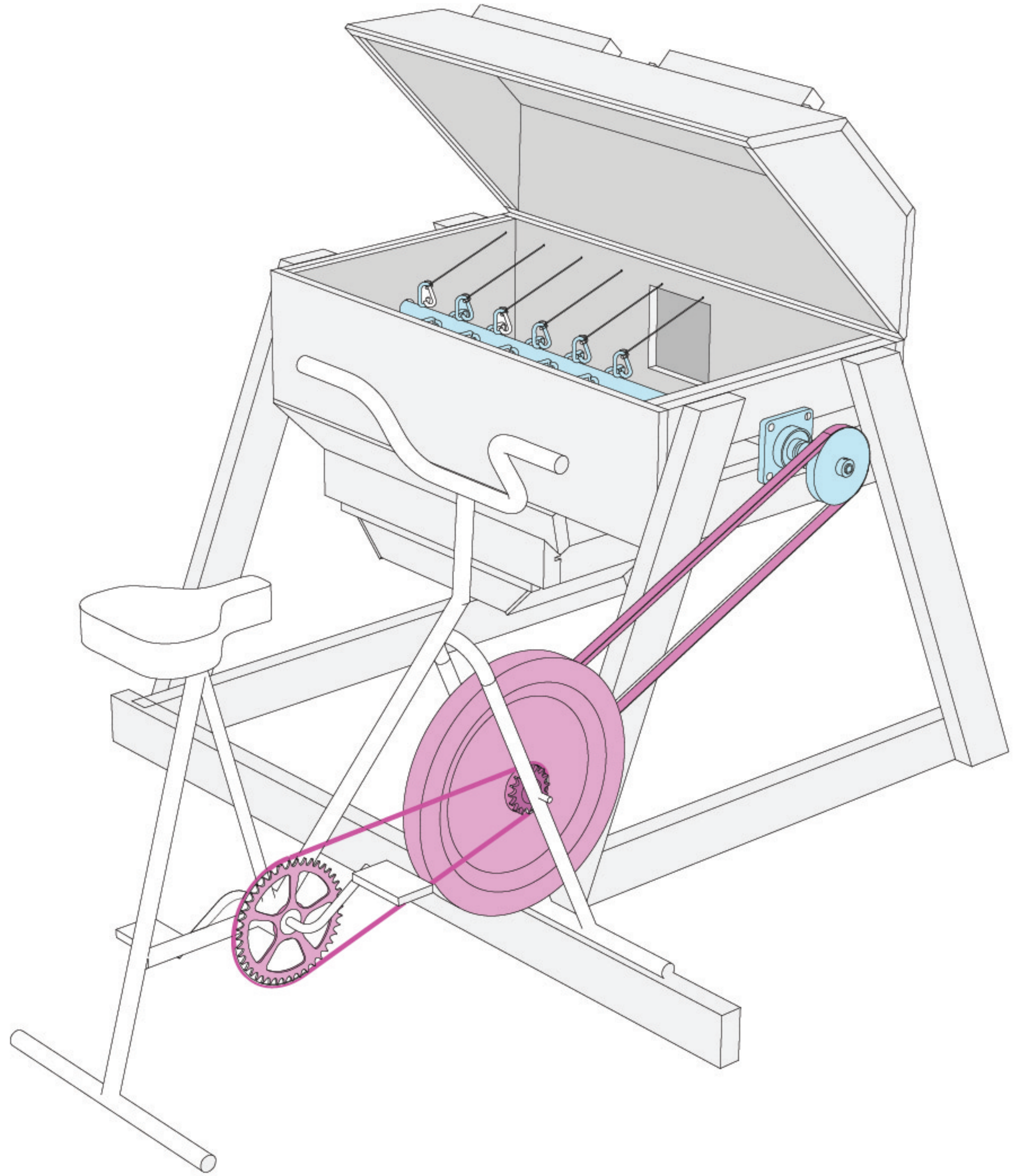
Thanks mostly to a grant from NESARE (www.nesare.org) and help from others these instructions are offered free to everyone. The instructions can't be sold, however, individuals and small shops are encouraged to make and sell the machines. Farmers and tinkerers will be able to improve the performance, cost, and ease of construction of these machines to everyone's benefit. More experiments and creativity in swipple design, blower design, and de-hulling pads will yield grain. Please share your improvements on this website!

Finally, in addition to thanking NESARE for the bulk of the grant money [$13,742] , I would like to thank the other individuals who donated money and priceless time to help: Bill Braun (Ivory Silo Farm) paid for half [$2000] of the original prototyping and provided the inspiration. Steve Baer (Zomeworks Corp.) donated money [$400] and expertise. John York did the calculations for the blower on the fanning mill and consulted on innumerable other technical details. Peter Dow drove down from New Hampshire to solve a problem with the de-huller. Josephine D'urso interned here in June, completed countless shop tasks and designed and built the tipping bucket for the fanning mill and the cowling for the de-huller (with the volunteer help of Kenneth Ferro). Emily Vogler and Olaf Bertram-Nothnagel, in addition to agreeing to work for pay, also poured uncompensated effort and intellect into each stage of the project. An anonymous scrap monger saves discarded bikes and excercycles for me. And all of the crops for testing the machines were grown by Chris Yoder (Vanguarden CSA), Hannah and Ben Wolbach (Skinnydip Farm), Noah Kellerman (Alprilla Farm), and Dee Levanti and Bill Braun (Ivory Silo Farm).

THRESHER

The Thresher is a bike powered gang of swipples (the part of a flail that hits the seeds) inside a drum. The swipples hit the seed heads or pods and break them apart so the seeds fall out. The design is based around using 1x10 finished lumber to construct the drum and also using about all the power a person can supply while biking. The swipples can be easily changed and are made from wire, bike spokes, wood, and plastic or metal chain depending on the crop. The size of the scalping screen (through which the threshed material falls) is also easily changed.

The Thresher can be used three ways: One, as a batch process where the whole drum is filled with plant material, processed, and then the fibrous remains are removed. Two, as a pass-through process where seed heads are fed in through the right top window, get processed as they move to the left, and the empty seed heads are tossed out the left side window. And Three, as a sheaf process, where sheaves of cut and aligned grain are held by their stalks with the heads thrust through a window on the side of the drum to be processed, after which the straw bundle is withdrawn, and a new sheaf introduced.

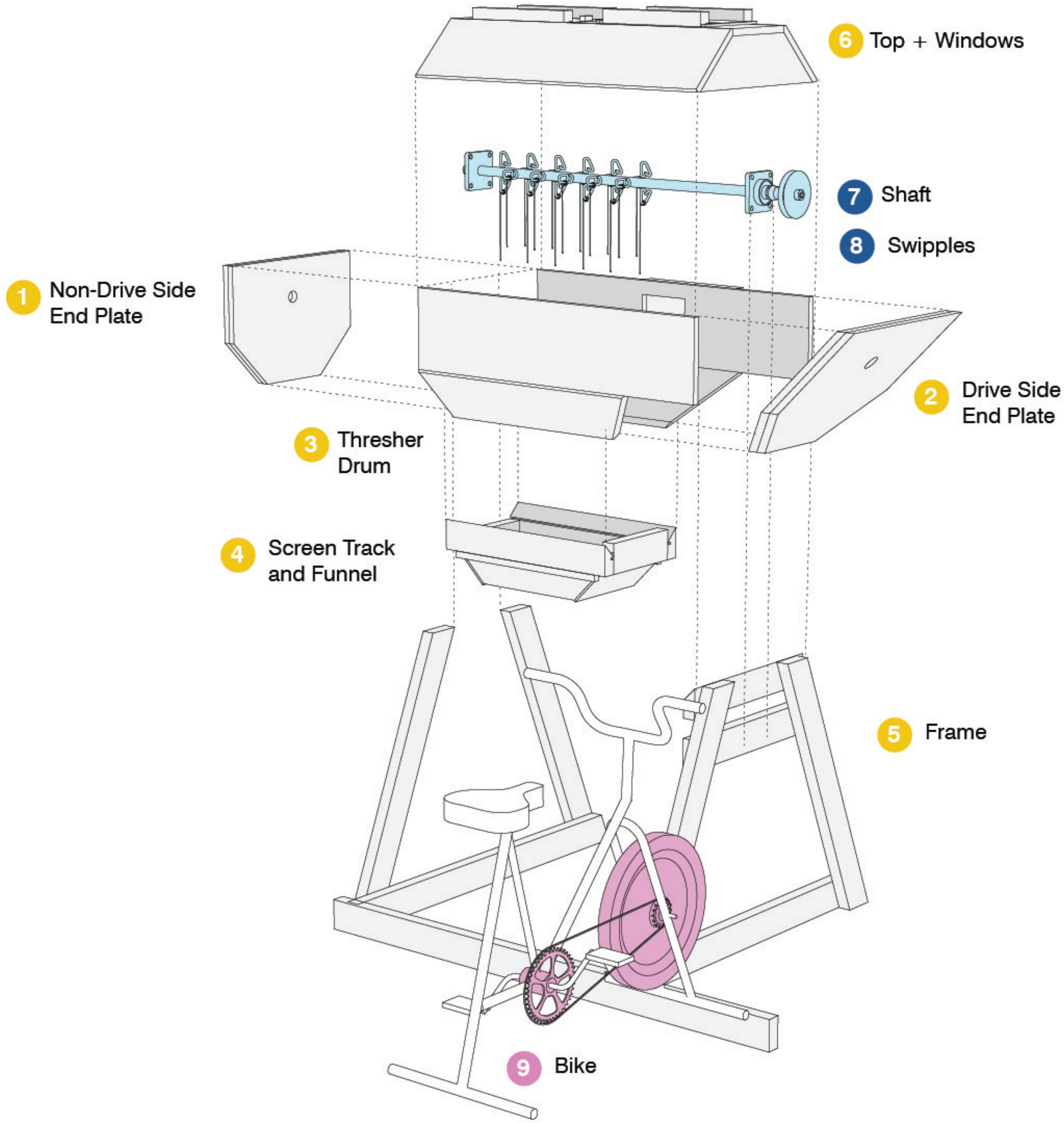


OVERVIEW OF STEPS

 WOOD WORK

 METAL WORK

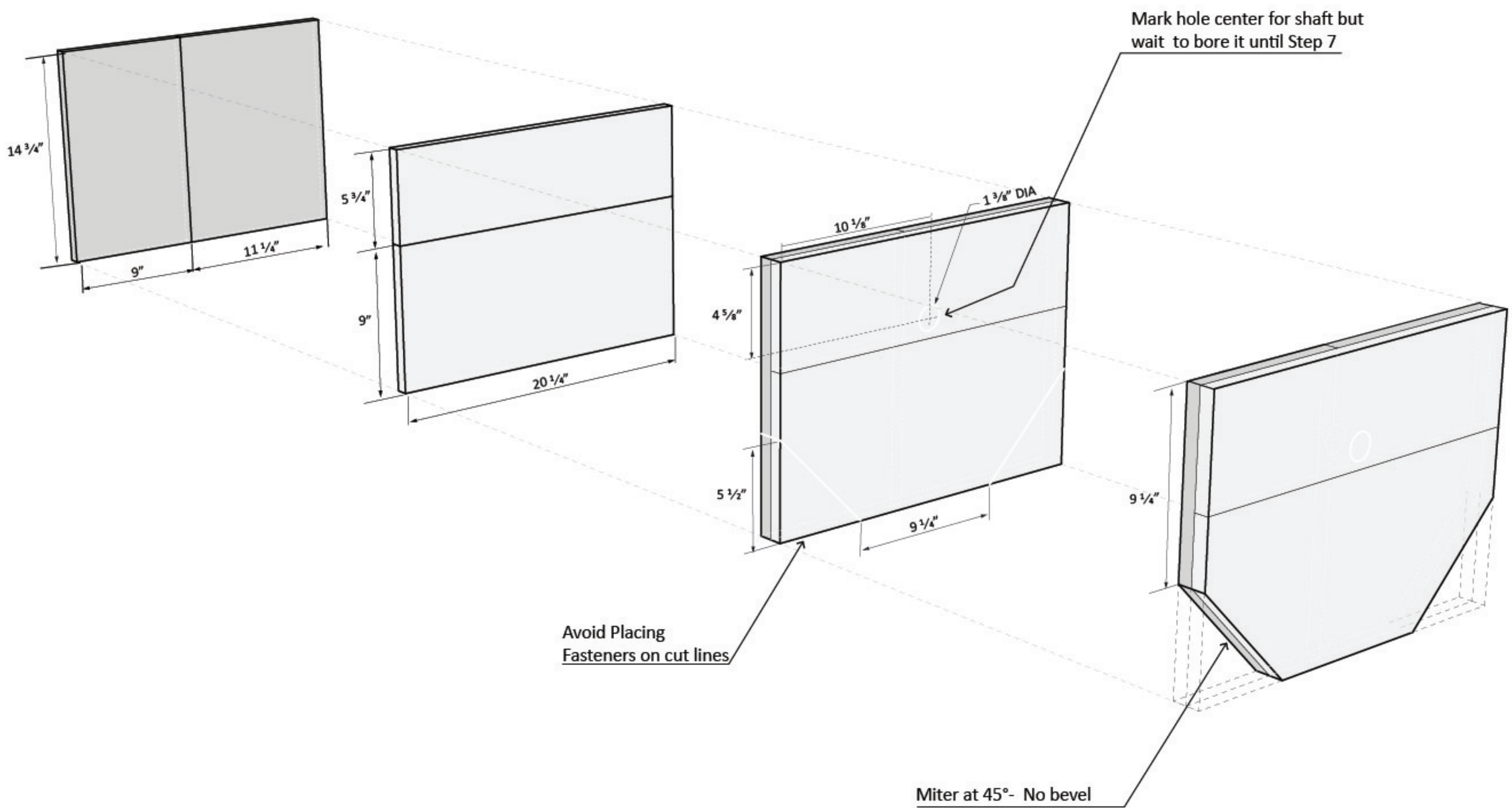
 BIKE WORK



STEP 1

NON-DRIVE SIDE END PLATE

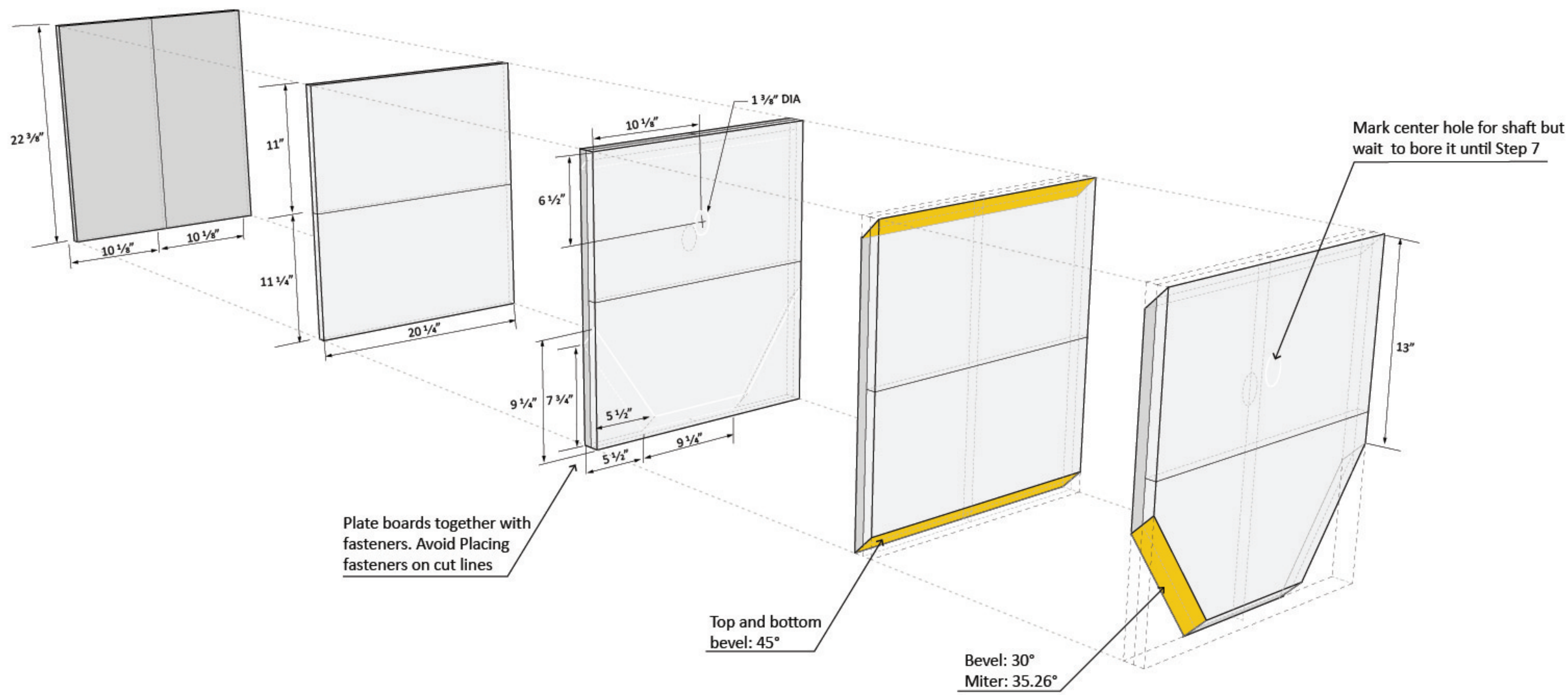
The end plates of the thresher drum are built up from two thicknesses of 1x lumber, cut out of 1x12. Since the end plates are too wide to be cut from a single 1x12 board, each thickness must be two boards jointed together. One of the end plates of the thresher drum is oriented square to the staves (on the non-drive side) and the other is oriented at 45° degrees to the staves (on the drive side). The square end plate is relatively easy to build, so build it first.



STEP 2

DRIVE SIDE END PLATE

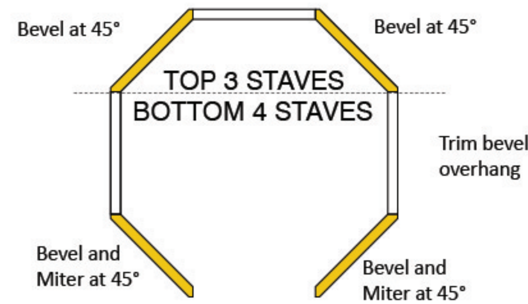
The angled end plate requires careful measuring and cutting. One trick for getting the angled endplate to turn out correctly is to plate up the shape as a rectangle with square cuts (avoid putting fasteners where cuts will occur). Then bevel the top and the bottom. Finally, cut the miters + bevels on the flared side

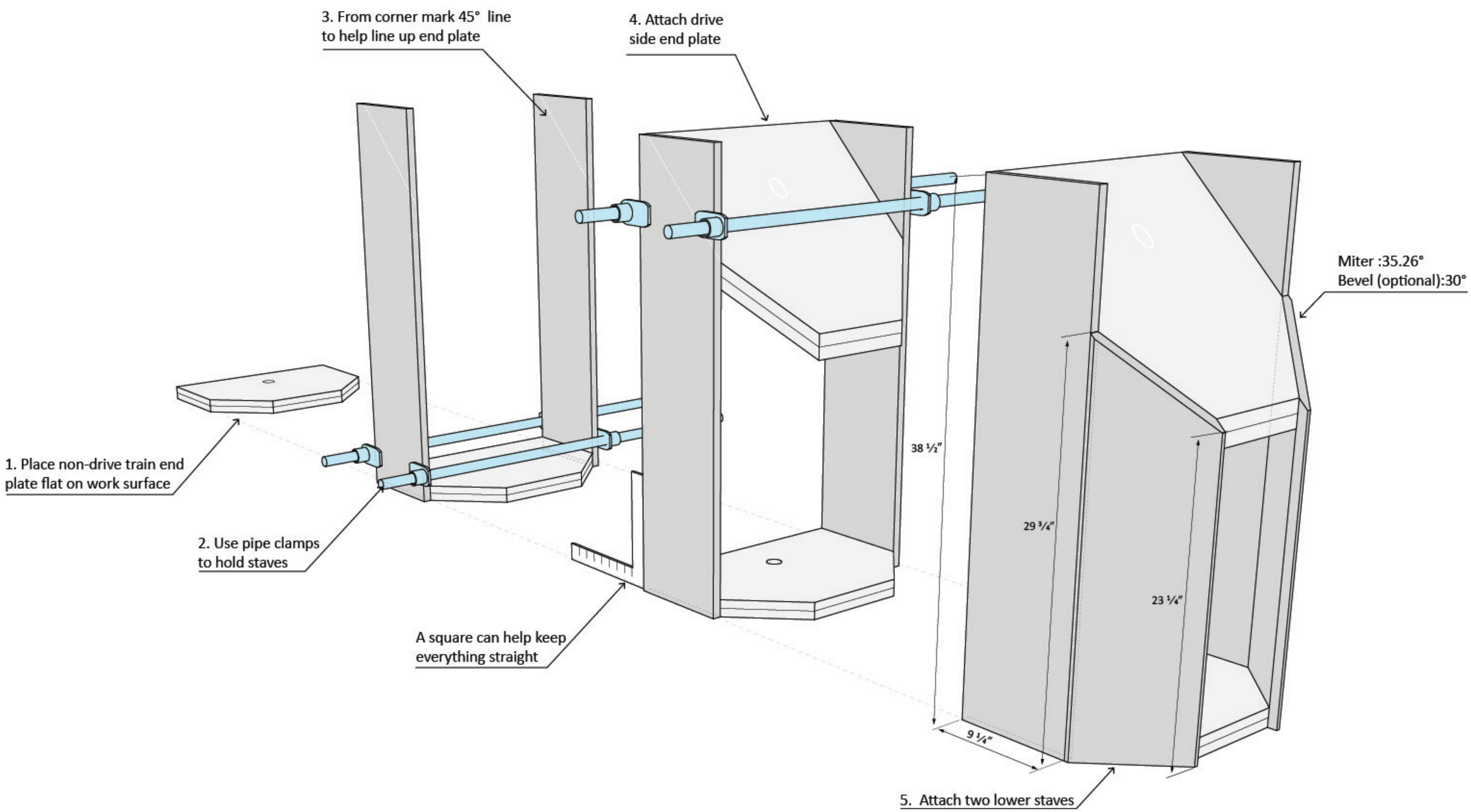


STEP 3

THRESHER DRUM

The shape of the thresher drum is almost octagonal. It is designed to be built with 1x10 finished lumber. The bevelled edges can be cut on the boards with a table saw or a skillsaw. If a skillsaw is used to cut the bevels, then a straight piece of wood should be clamped or nailed to the stave to guide the skillsaw. Make the 4 staves for the drum and the 3 staves for the top (see step 6) all at once. Then set aside the 3 top staves for step 6.



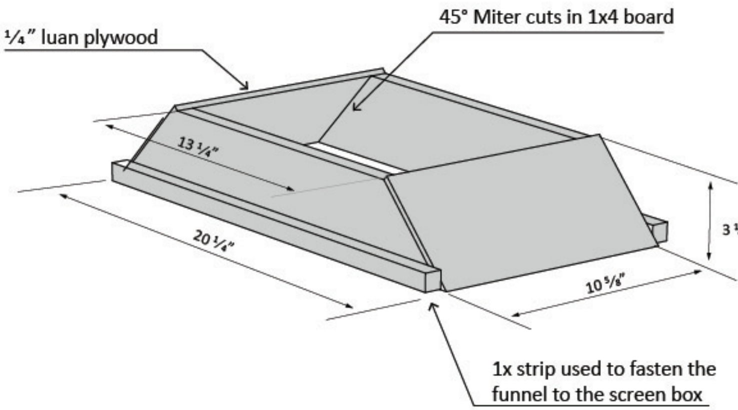


STEP 4

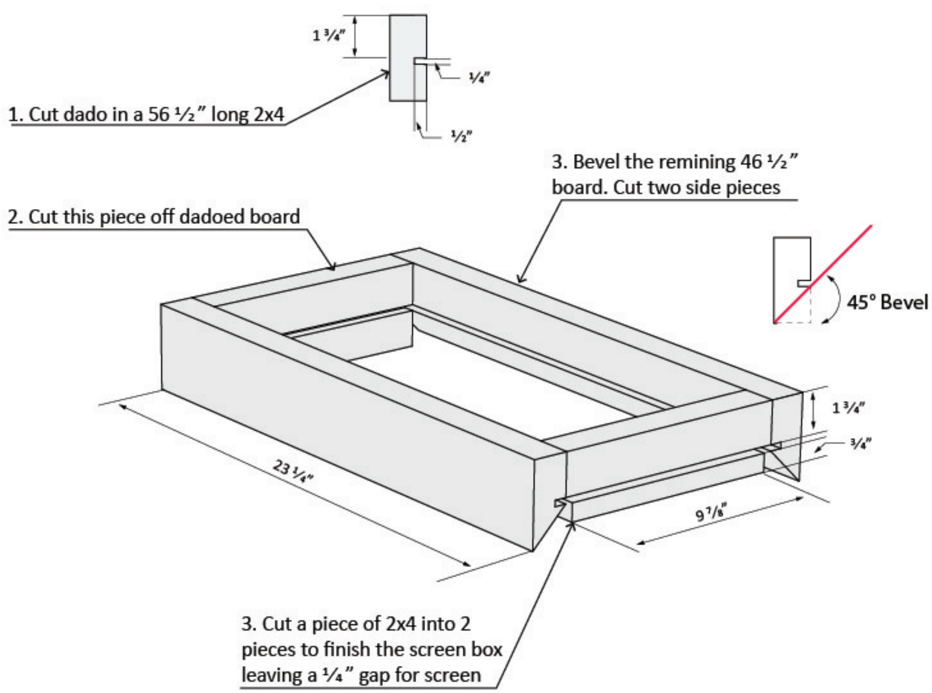
SCREEN TRACK + FUNNEL

The bottom is made up of 2 parts, the screen box and the funnel. It is easiest to construct it upside down. The screen should be cut to fit into the slot. In general the smallest screen that will pass the seeds is used.

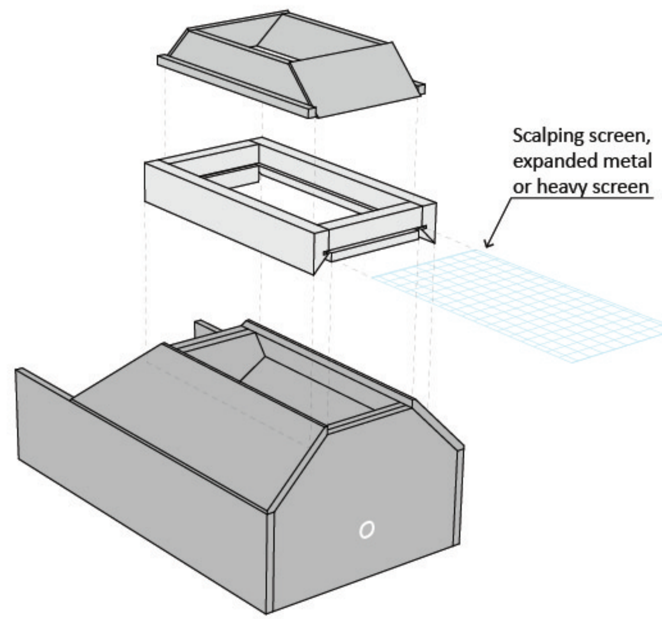
FUNNEL



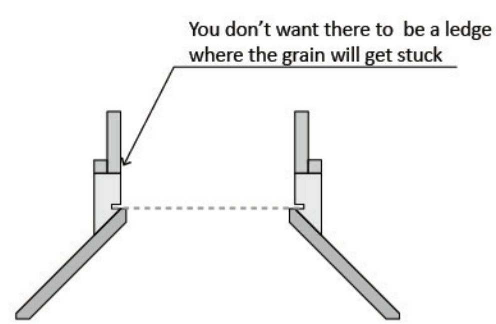
SCREEN TRACK



ASSEMBLE



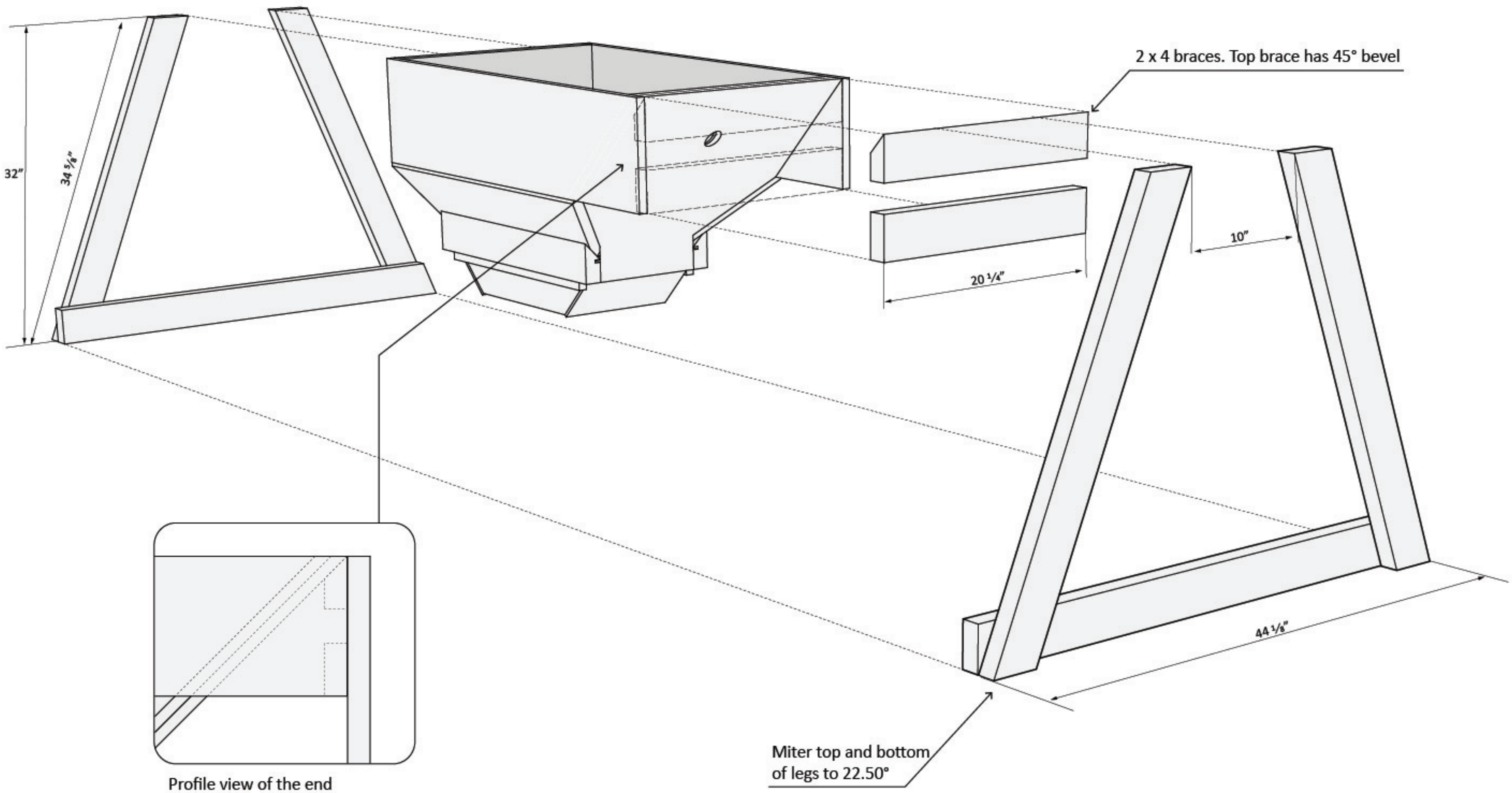
CROSS-SECTION



STEP 5

FRAME

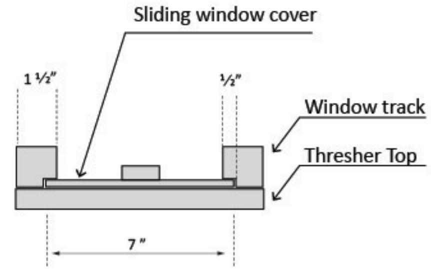
Once the thresher drum is assembled the 2x4 legs and bracing can be fastened to the drum so it will stand up.

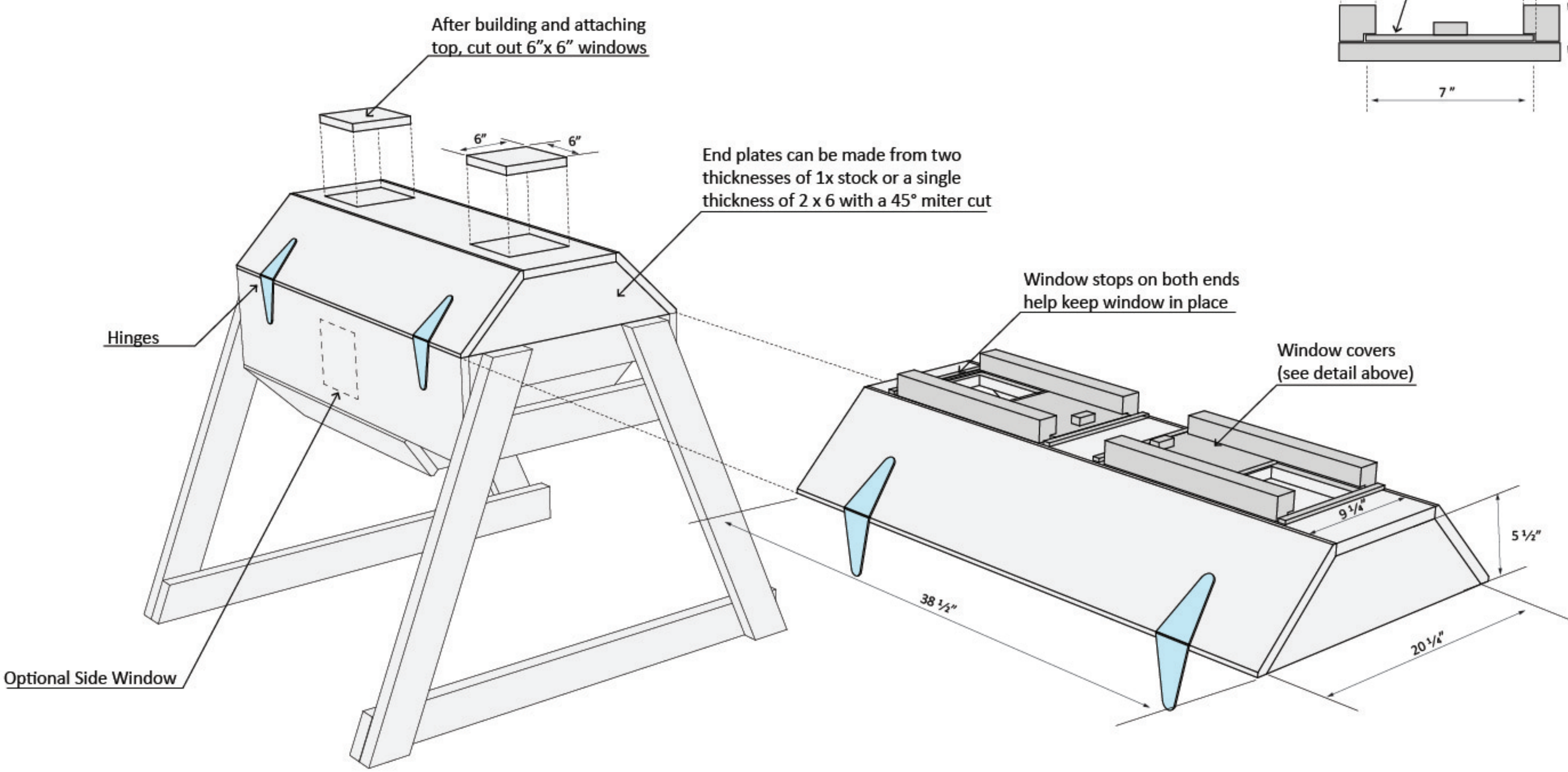


STEP 6

TOP + WINDOWS

The top is made out of 3 staves prepared in Step 3. The two windows on the top of the thresher make it possible to feed unthreshed grain heads (such as rye harvested with a sickle) through the right hand window and have them travel to the left through the thresher and be thrown out of the left hand window. The optional window on the side of the thresher can be built the same as the top windows and allows bumdles of stalks (such as rye harvested with a scythe and grain cradle) to be fed into the spining thresher and then withdrawn once threshed.





STEP 7

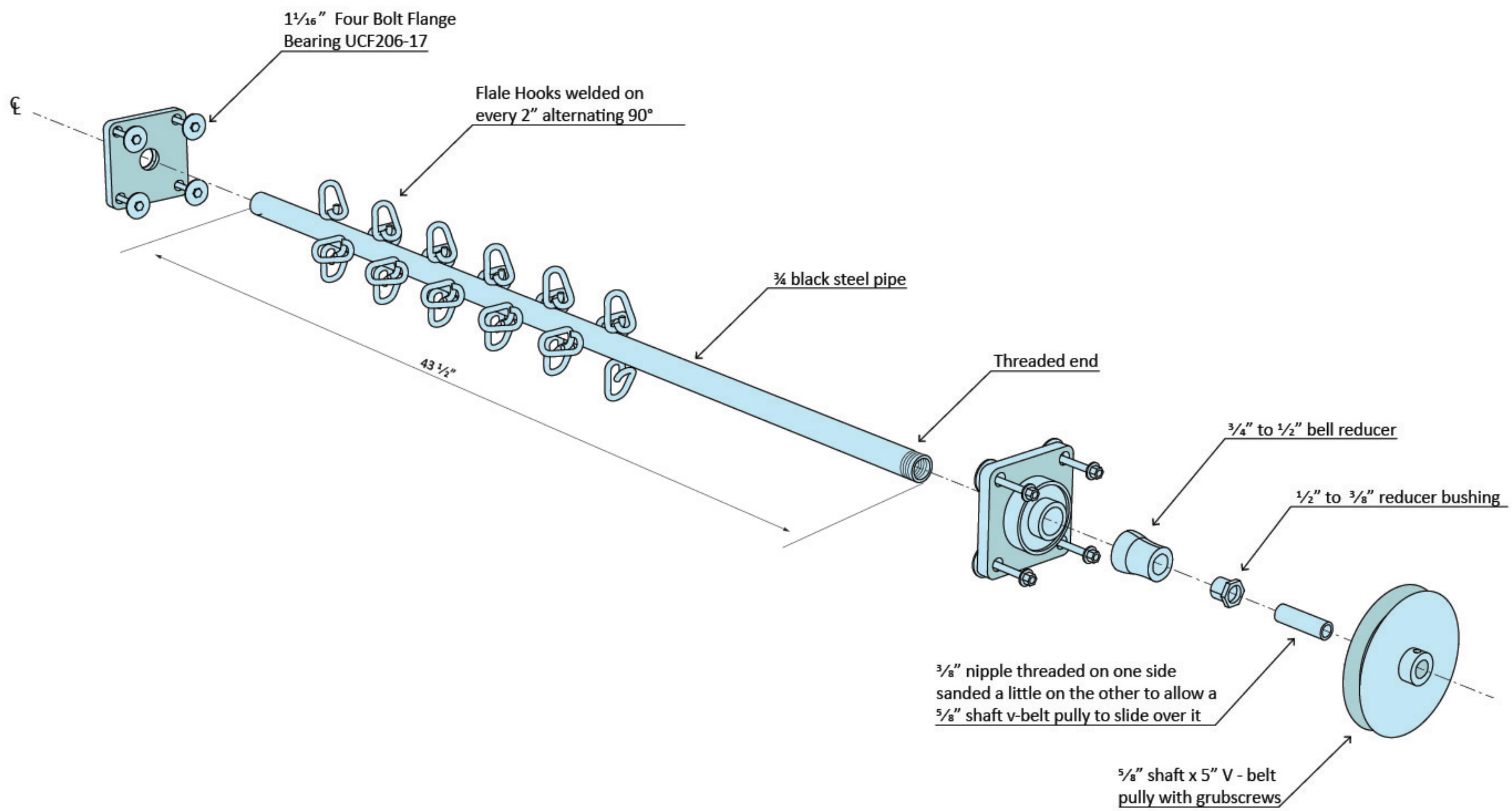
SHAFT

The shaft for the thresher is just a piece of ¾" schedule 40 black steel pipe. Select a piece that looks straight to the eye. The small imperfections in the straightness of the shaft will cause the whole thresher to shake and wobble a little, which helps the thresher work properly.

Bore the holes for the shaft in the end plates. With the thresher assembled and standing upright, the hole on the drive-side is made at a 45° angle to the end plate by holding the drill horizontal. Then cut the shaft to length. Since the shaft must be installed after it is made, it will need a mark where the first flail hook is welded to the shaft. The mark should be the farthest point on the shaft toward the drive side that still allows the shaft to be installed ("zig zagged" into place) in the thresher drum. The mark can be found by simply installing and uninstalling the shaft a couple times, and marking the point with a sharpie. The goal is to populate as much of the shaft as possible with flail hooks, so that the entire interior volume of the thresher drum is visited by a swipple. The area of the shaft that is left bare of flail hooks is over the angled endplate of the thresher drum. Grain heads in that area tend to fall down the incline into the path of the first set of flails.

Once the shaft is marked for flail hooks, the flail hooks can all be welded to the shaft. The flail hooks should be welded so as to minimize heat distortion (tacked and then back-step welded). The shaft with the flail hooks is installed, and then the bearings are slid over the pipe and bolted to the thresher drum. 1¼" fender washers are used against the wood. The shaft end might have to be sanded a little to get the bearing to slide over it.

Finally, the bell reducer, bushing, and nipple are threaded on tightly. The nipple may need to be filed a little for the v-belt pulley to slide on to it.

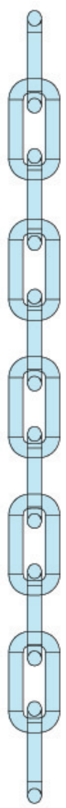


STEP 8

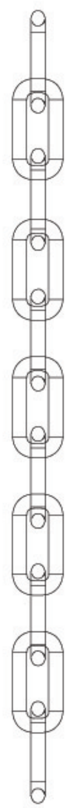
SWIPPLES

A swipple is the part of the flail that strikes the grain head or seed pod and knocks the seeds out of it. The Thresher is designed so the swipples can be easily changed. A very simple and inexpensive swipple can be made from a piece of wood and a length of wire. Or, a piece of chain, plastic chain, or wire can be used. The swipples mount on the flail hooks which are welded to the shaft. Below are the swipples we have tested and the crop they worked best on:

Deciding which swipples to use is easy. If the thresher fails to completely remove the seeds from the grain heads or pods, select a harder, heavier swipple. If the thresher breaks the seeds, select a softer, lighter swipple. If the grain heads are being fed continuously in to the thresher, the swipples can vary along the length of the thresher, beginning with lighter swipples at the entrance end and using heavier swipples at the exit end.

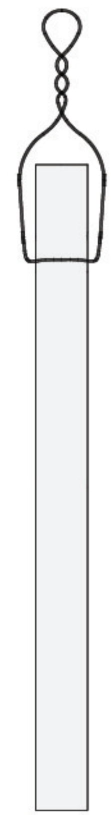


METAL CHAIN:
Worked OK on harder beans and rye but not as well



PLASTIC CHAIN:
Worked well on larger beans that weren't as dry

STAINLESS STEEL BICYCLE SPOKES (14G)
Worked well on dry black beans



HARDWOOD WITH WIRE LOOP:
Worked great on rye, wheat, rice, and lupine.

STEP 9

BIKE UNIT

Virtually any exercycle made with bicycle parts can be used to power the Thresher. Preferable is an exercycle with a large gear ratio (4:1 or larger), and a “fixed gear” (which means you can pedal backwards as well as forwards). A freewheel can be converted to a fixed gear by welding the freewheel shut or by removing the freewheel and installing a fixed cog and lock ring. A flywheel is optional. Some exercycles may need structural reinforcement.

The Thresher uses a v-belt transmission from the excercycle to the thresher shaft. The v-belt will slip if the shaft jams, and this is safer for both the machine and the operator. The v-belt pulleys can be purchased or made from wood.

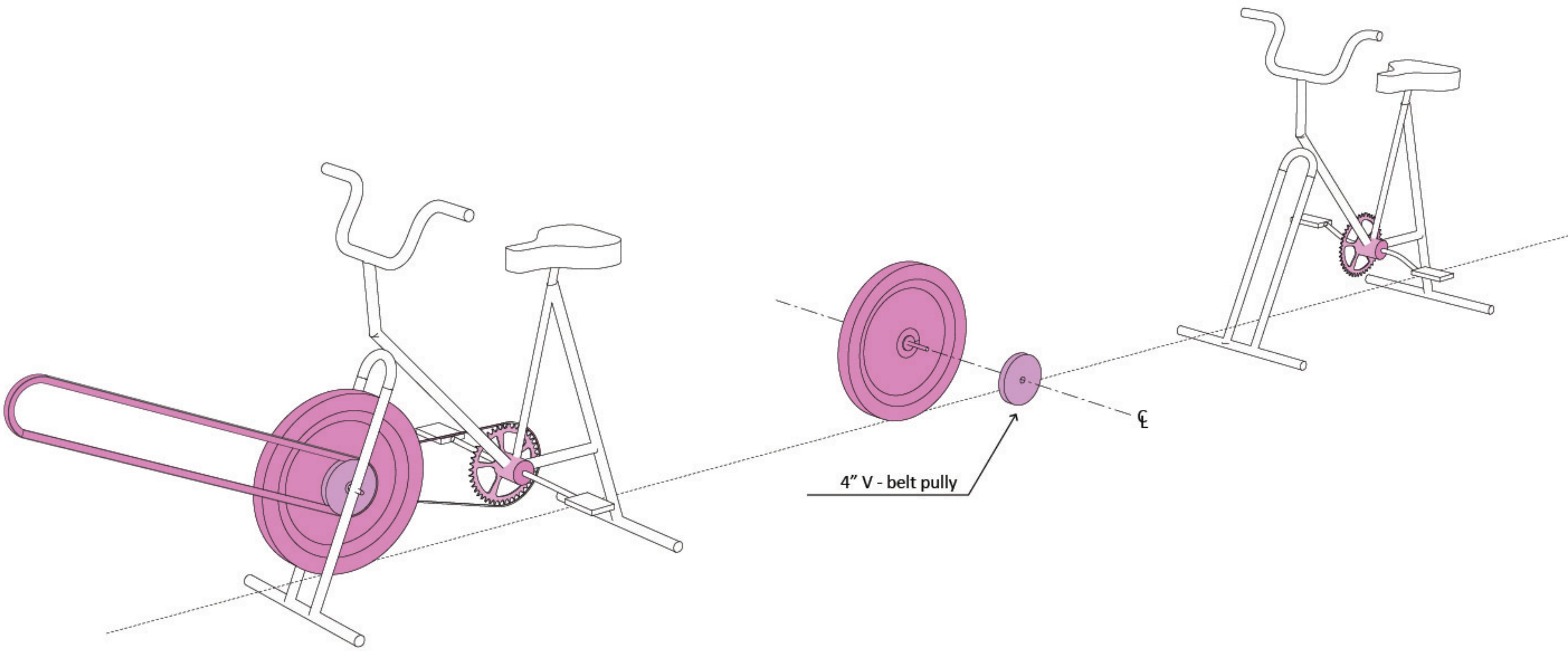
First, remove the flywheel from the exercycle. On the non-drive side of the flywheel (or wheel) hub mount a ~4” v-belt pulley. The center bore on the pulley has to be large enough to clear the bearing race covers on the exercycle's hub. If you use a metal v-belt pulley it will either need to be intended for a very large shaft (~1.5”), or you will need to modify the hole in the one you have. If the pulley is made from wood then drilling out the center to the correct inside diameter is easy.

The next challenge is locating, drilling, and tapping holes in the exercycle hub that allow you to mount the v-belt pulley precisely centered on the axle of the flywheel or hub. A compass divider helps.

For ease of future maintenance, the bottom bracket of the exercycle can be outfitted with a zerk fitting. Add structural elements to the exercycle if it needs it.

Drill quarter inch holes in the legs of the exercycle so that it can be screwed to the wood frame of the Thresher.

Reassemble the exercycle and mount it to the Thresher with the v-belt tensioned and aligned. Then screw down the legs of the exercycle.



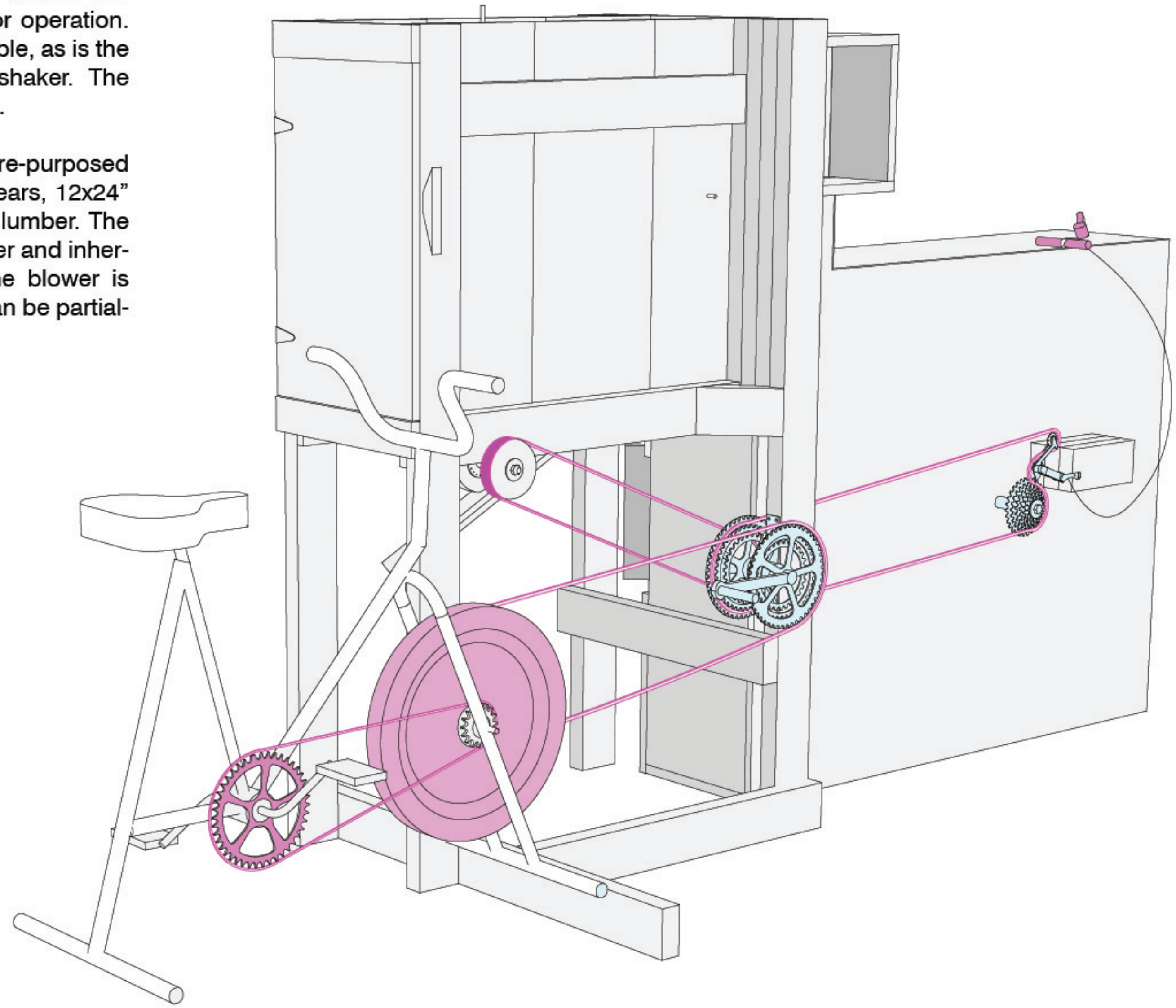
Questions + Comments + Donations -
Contact Lu Yoder - bravelittleship@gmail.com

This project was supported in part by the Northeast Sustainable Agriculture Research and Education (SARE) program (www.nesare.org). SARE is a program of the National Institute of Food and Agriculture, U.S. Department of Agriculture.

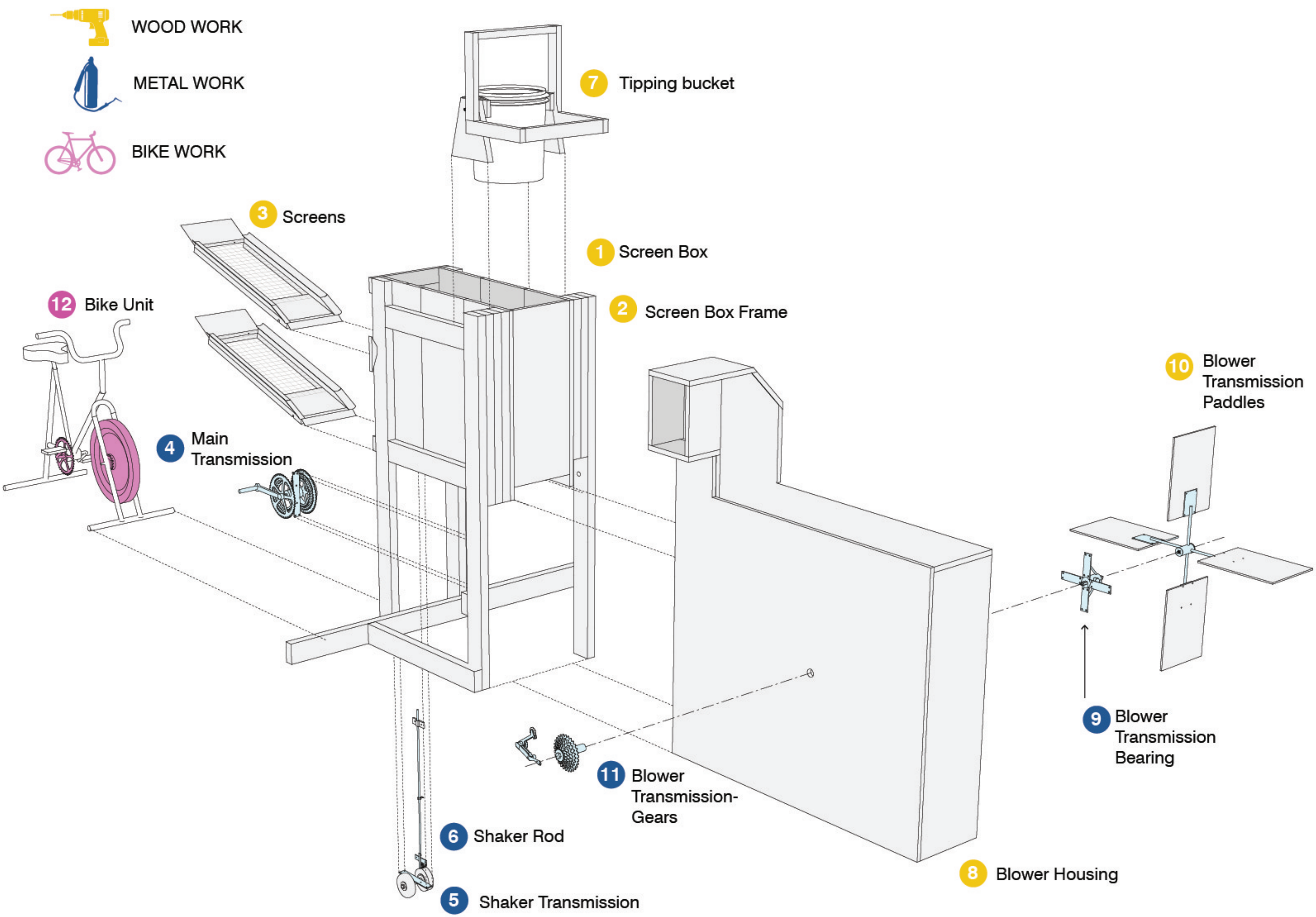
FANNING MILL

The Fanning Mill sorts and clean seeds. It first grades material by size with two (high pass and low pass) screens, and then winnows the remaining material in a vertical winnowing tower. The screen size is selected for the crop or operation. The tilt angle of the screens is adjustable, as is the rate and amplitude of the screen shaker. The speed of the blower is also adjustable.

The design is based around using re-purposed bike parts for the transmission and gears, 12x24" screens, and common 1x12 and 2x4 lumber. The blower is designed for maximum power and inherent turbulence. If finer tuning of the blower is needed (for small seed) the air inlet can be partially blocked (choked).



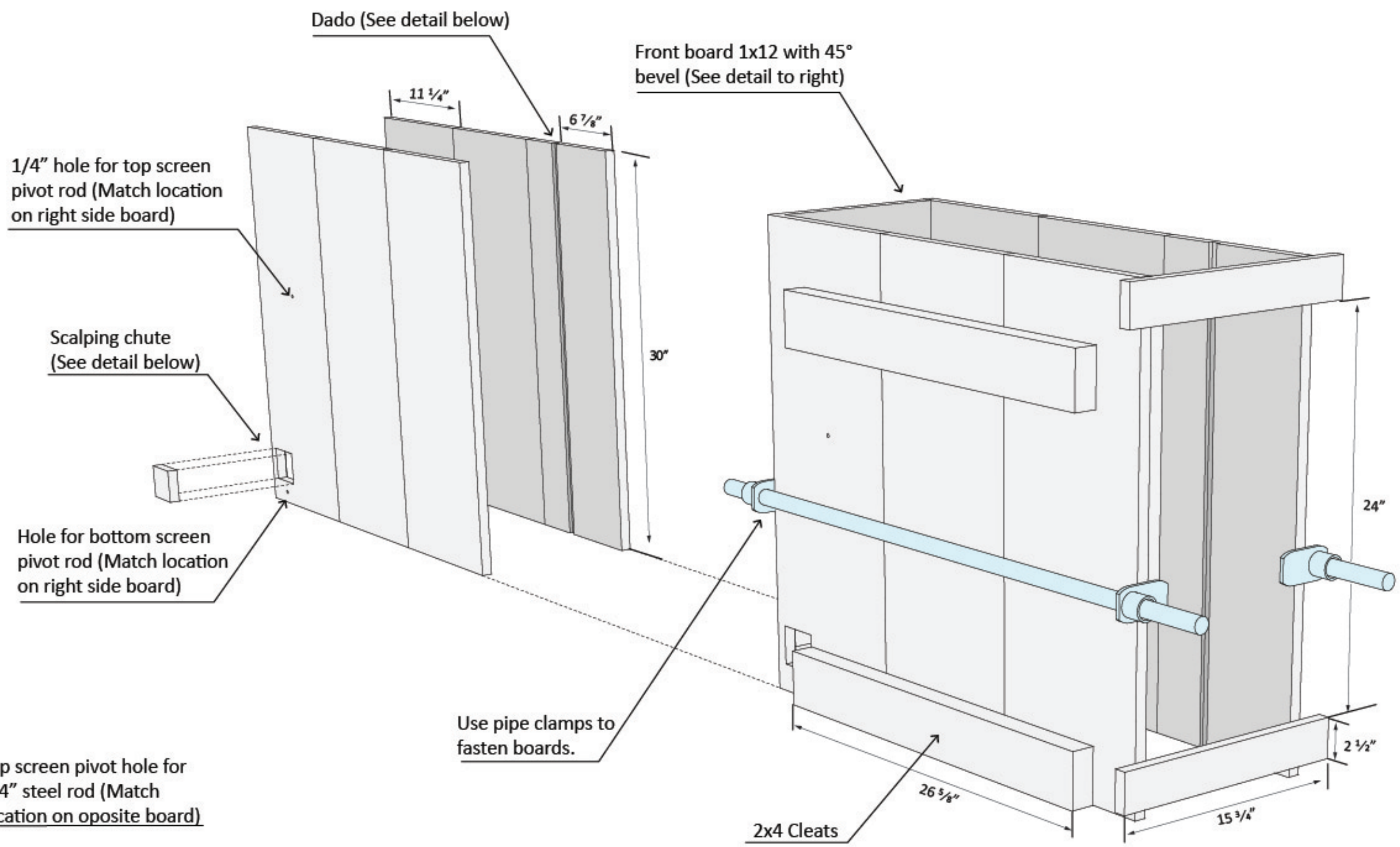
OVERVIEW OF STEPS

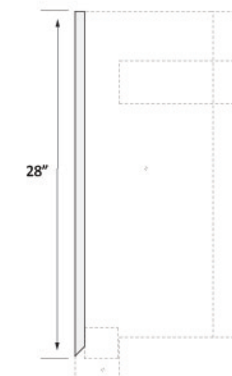


STEP 1

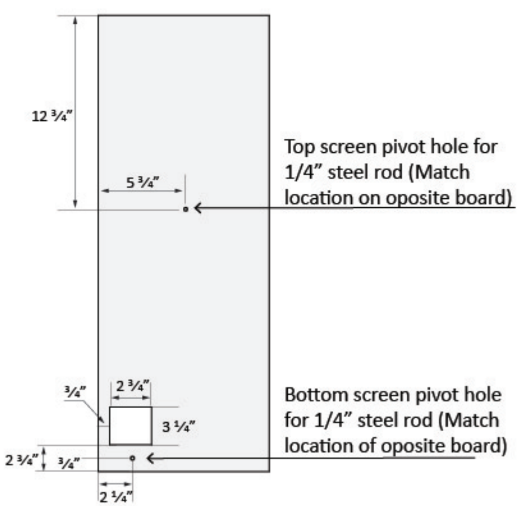
SCREEN BOX

The 1x12 sides of the screen box get cut to 30". Then the dado, the window for the scalping chute, and the holes for the pivot rod are added as shown. The sides are jointed together with the 2x4 cleats. It is a good idea to use pipe clamps to squeeze the edges of the 1x12 together so that no little gaps are left where seeds could get stuck or escape. Once the two sides are made, the front board can be made and attached, as well as the two back frame pieces.

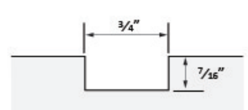




Front Board Detail



Scalping Chute and pivot rod hole detail

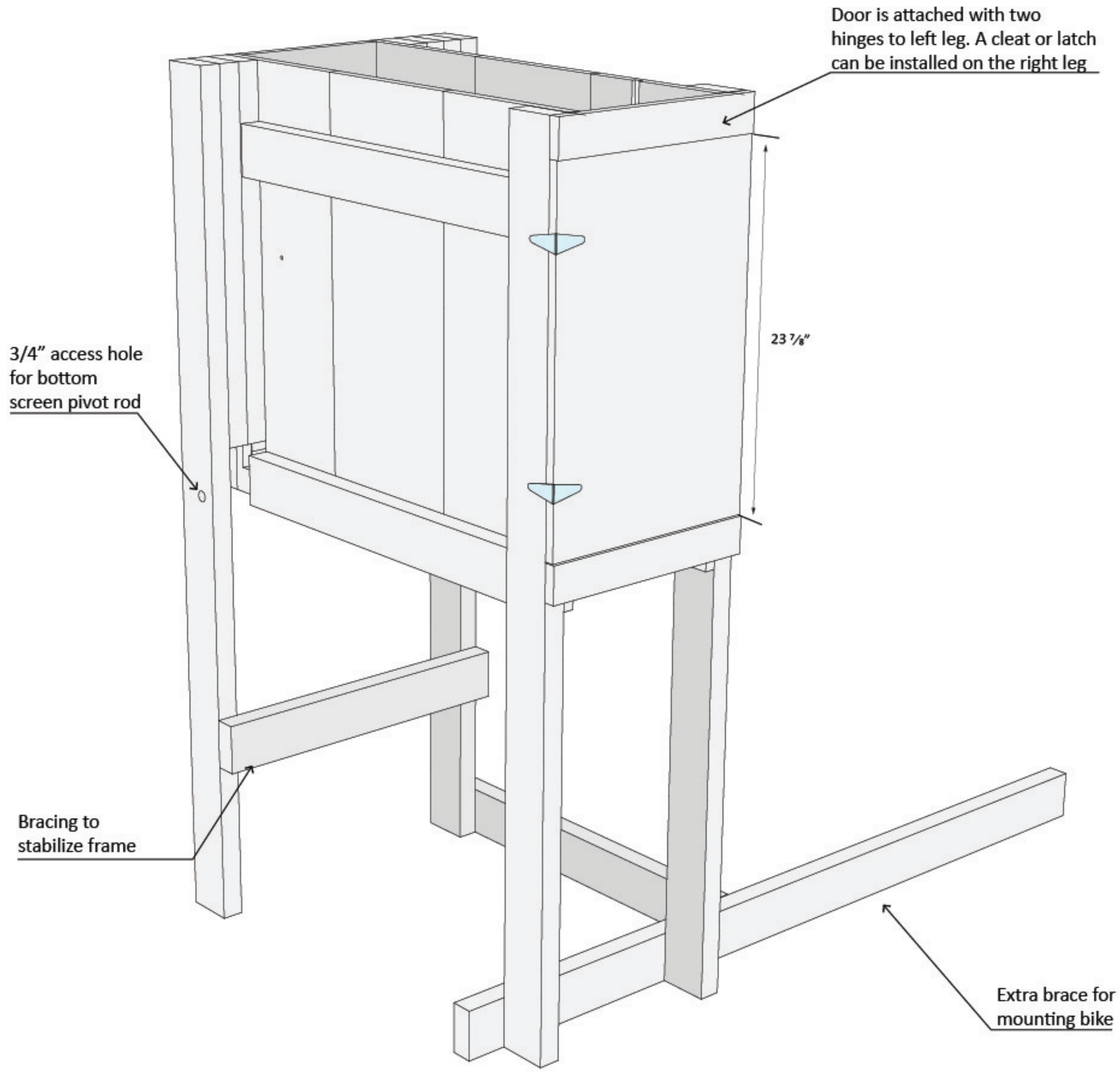


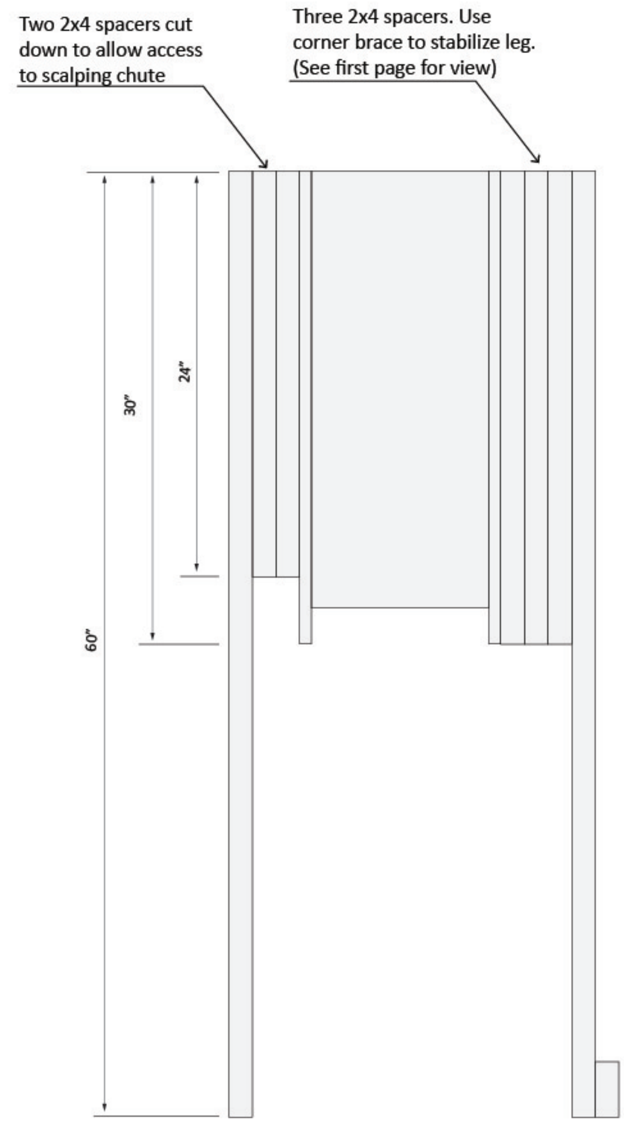
Dado Detail

STEP 2

SCREEN BOX FRAME

Next attach the 2x4 leg spacers and legs. Finally the bracing and back door can be attached. At this point the 1/4” rods that the screens pivot on can be installed, or that can be left for the metal working phase of the construction. The 2x4 spacers on the drive side of the screen box allow the main transmission to align. On the non-drive side, the spacers just allow room for the scalping chute.





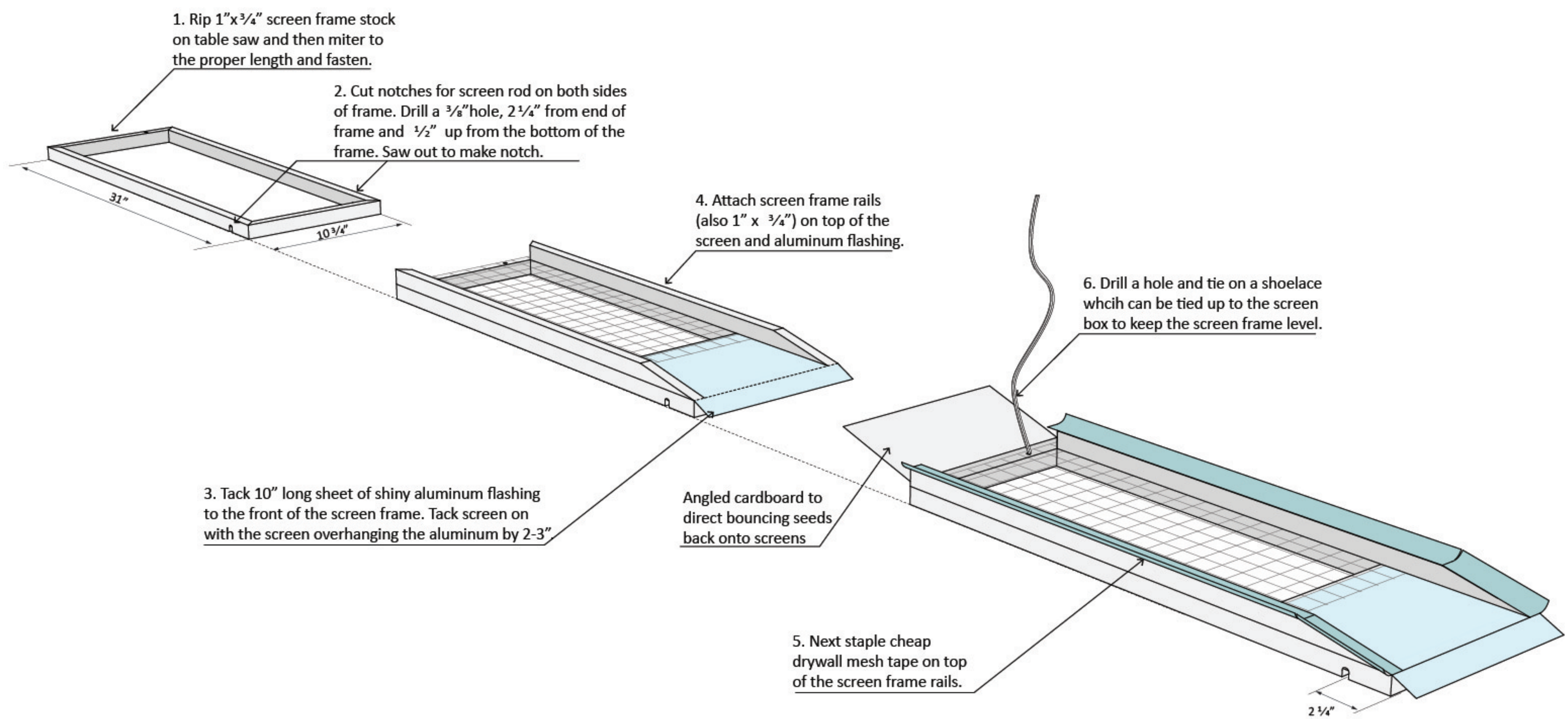
STEP 3

SCREENS

The screen frames are all the same size, so depending on how many different screens you plan to use, the parts for the screen frames can be mass-produced. Note that on screens used on the bottom level (grading screens) of the fanning mill it may be necessary to chisel off some wood from the left side of the screen frame rail so it is easier to put in and remove the screen from the frame box. When a screen is in use the proper angle of the screen in the screen box (for a given crop) will be determined by trial and error. Once a good angle is determined, the space in the screen box behind the screen needs to be filled with an angled piece of cardboard that directs bouncing seeds back on to the screen.

One good way to select screen size for a given crop is to take a sample of the crop and manually sift it with different screens until the correct screen is found. The exact type of screen and the exact shape of the seeds can make screen selection tricky and surprising.

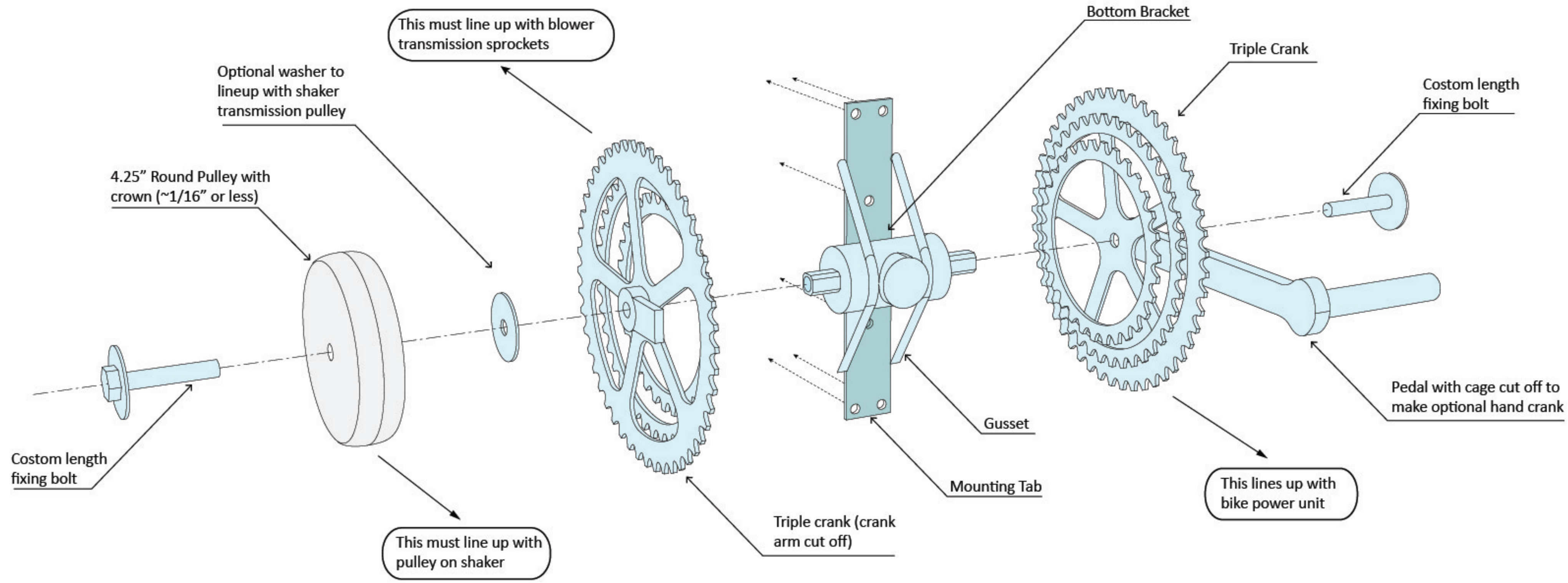
A 24”x 12” piece of screening is enough to build one screen. The purpose of the screen is to sort the seeds by size. The purpose of the shiny aluminum flashing is to allow seeds to slide easily down the non-shaking end of the screen and sail with some speed into the winnowing tower.



STEP 4

MAIN TRANSMISSION

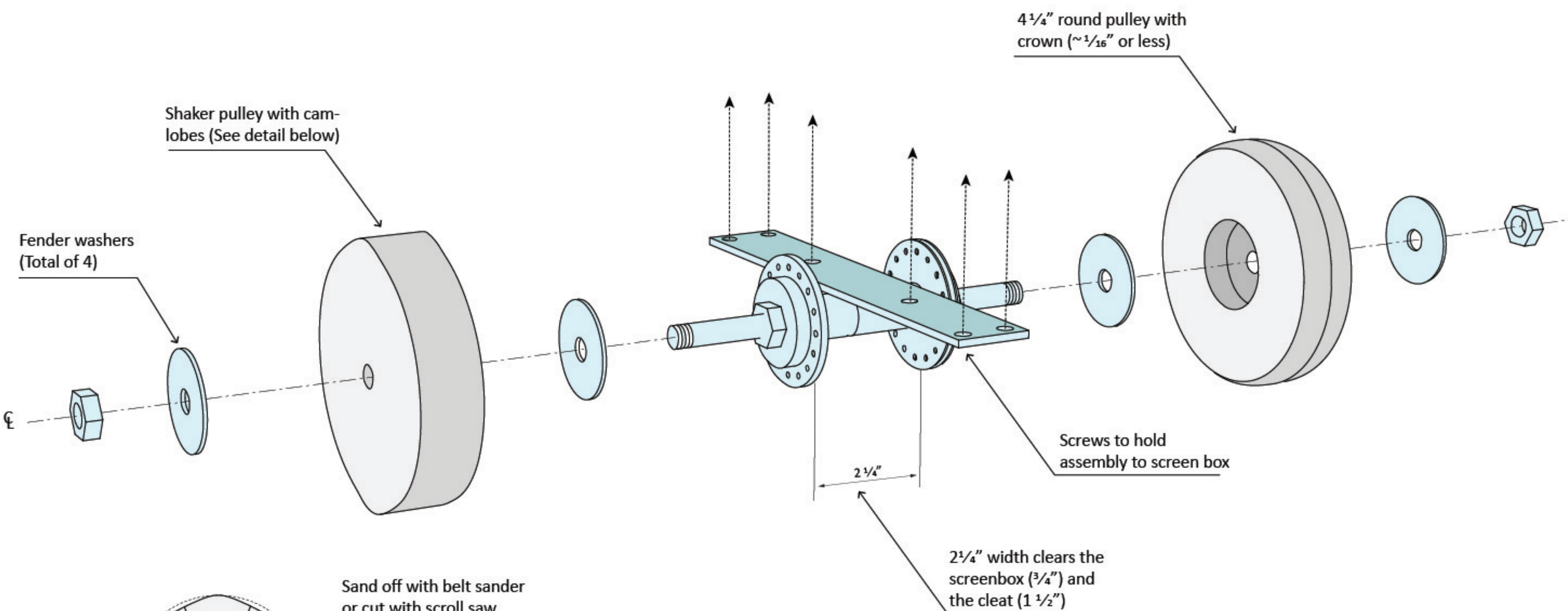
The main transmission is made from a couple of scavenged triple cranks and a bottom bracket. The bottom bracket is cut off the bike frame and taken apart. These instructions assume a bottom bracket spindle with threaded holes for the fixing bolts. If yours has threaded studs for fixing nuts, that's OK. To the bottom bracket shell attach some pieces of flat steel strap with mounting holes. Also, take the opportunity to weld the holes into the bottom bracket shut and install a zerc fitting for ease of lubrication in the future. Take care to protect the bottom bracket threads from weld spatter. Reassemble the bottom bracket. On to the right side spindle mount a triple crank with the crank arm and a pedal shaft (The pedal shaft is so you have the option of hand cranking the machine in addition to pedalling it). On to the left side spindle mount a triple crank with the crank arm cut off. A 4” diameter by 1” thick crowned flat belt pulley will also mount on this side. You will need to fabricate or buy a custom length fixing bolt to secure the left side assembly of pulley plus crank arm. The standard size female thread in a spindle is 8mmx1mm. If your spindle has a threaded stud, just weld an extension of threaded rod (3/8” for example) to it and use a fixing nut on the outside. Mount the transmission on the leg of the frame box, check the alignment of the flat belt pulley on the left side crank with the flat belt pulley on the shaker mechanism (see step 5). The transmission can be slid sideways to help the alignment, or a washer can be added between the crank arm and the pulley.

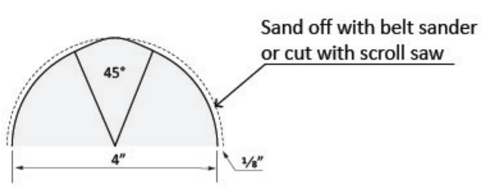


STEP 5

SHAKER TRANSMISSION

Begin by scavenging a steel front hub from a bicycle. Disassemble the guts from the hub shell and set them aside. Cut the hub shell with a grinder and tack weld it back together so that the inside width between the flanges is 2.25". Also tack-weld on a piece of sheet metal with holes as shown in the drawings. In order to keep the hub axis straight while it is welded, it might help to reassemble the axle guts before welding. If possible, avoid changing the axle length, as it will be helpful in the next steps to have the axle as long as possible. If the un-threaded part of the axle makes this impossible, consider using a different axle. When the welding is done, the hub will now mount nicely on the bottom of the screen box with the hub flanges snug around the bottom of the screen box. Next, measure the size and depth of a hole whose diameter clears the cones and locknuts of the hub, and will in depth allow the pulleys to be located within an eighth inch of the sides of the screen box. The pulleys are made from 1" thick plywood. If a scrap of 1" thick plywood can't be found, two sheets of 1/2" plywood can be laminated together, or pieces of lumber can be laminated together. The pulley circle is cut out with the center marked. The exact diameter of the pulleys is not important. Then the hole on the hub flange side of the pulley is bored, and then the rest of the pulley axis can be drilled out to the size of the front hub axle. The pulley is mounted on the hub in a sandwich of fender washers --that is-- fender washer, wooden pulley, fender washer, axlenut.



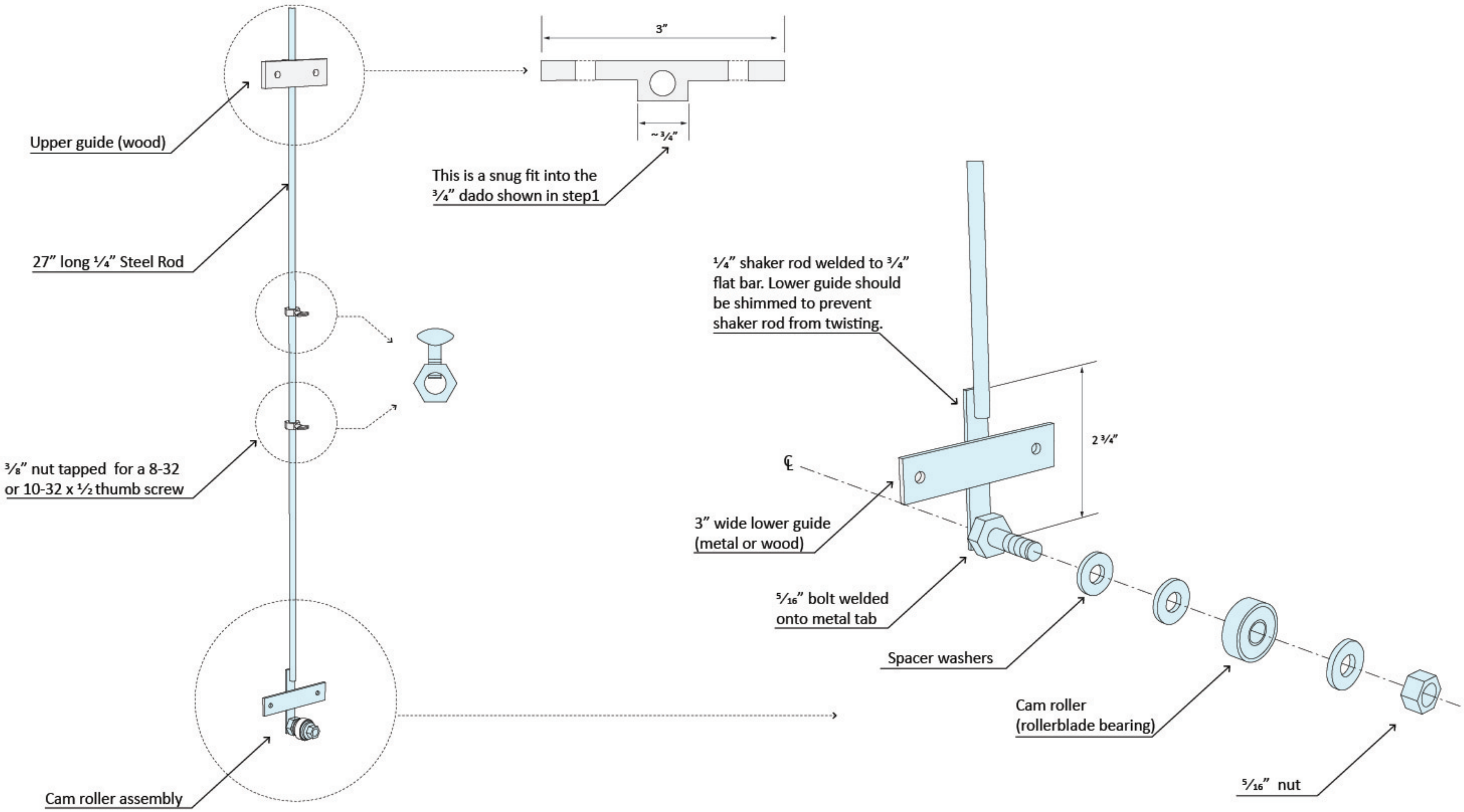


Shaker Pulley Detail

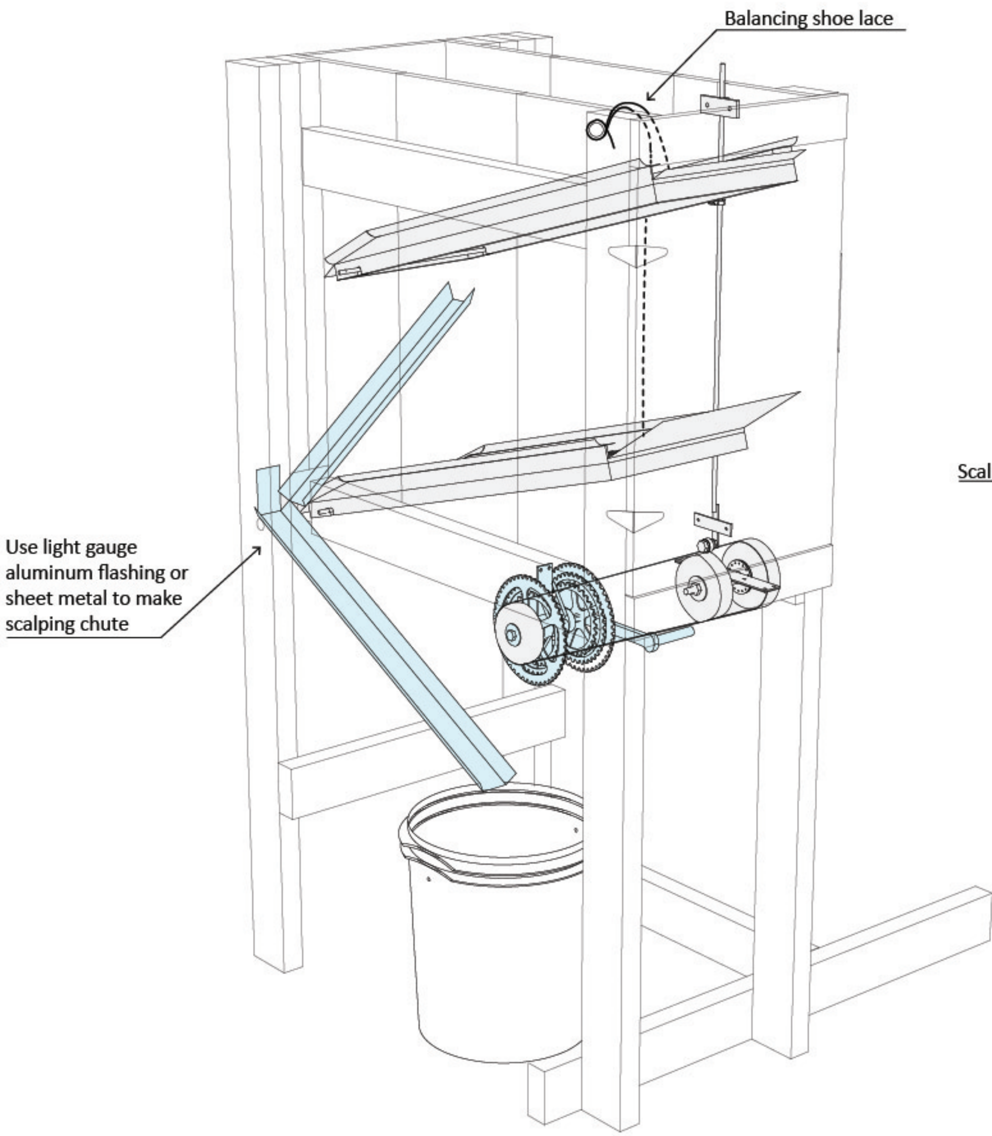
STEP 6

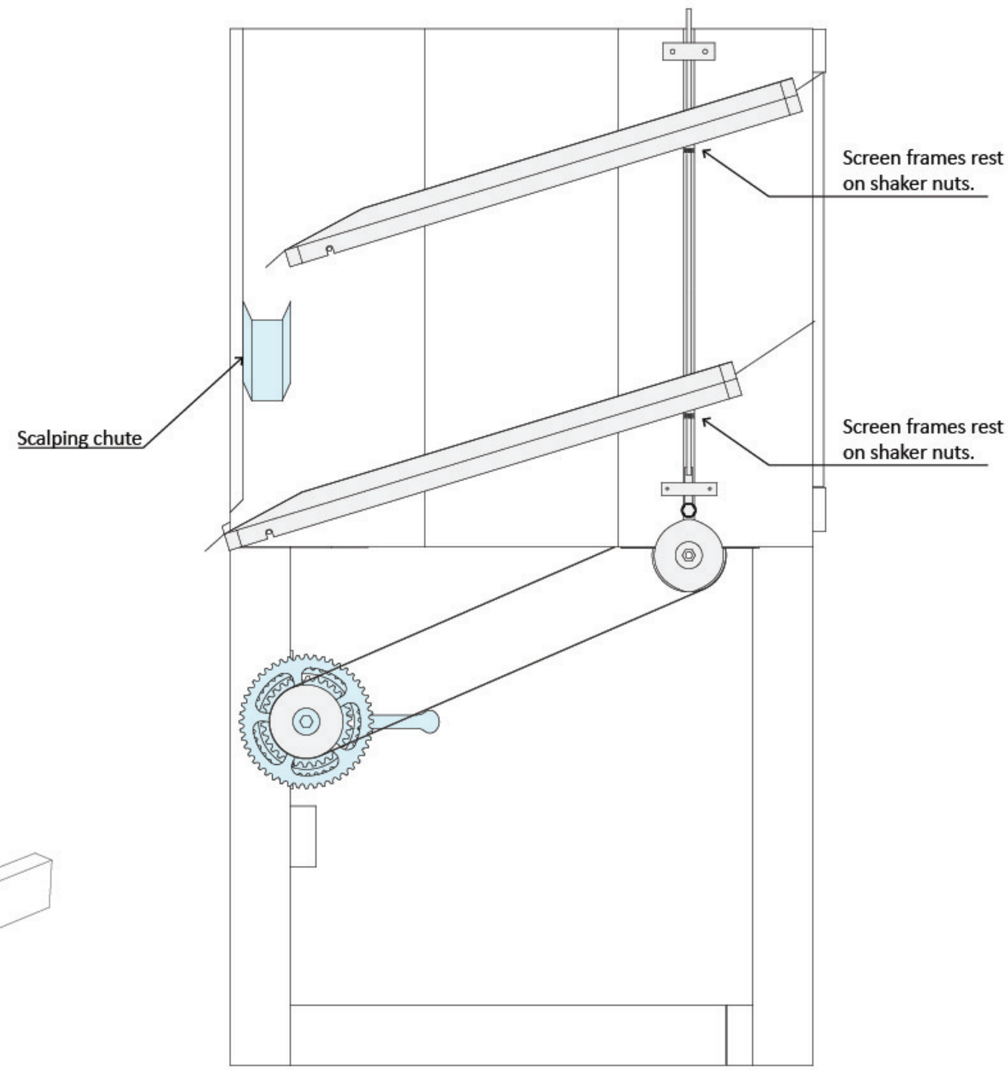
SHAKER ROD

The shaker rod is driven up and down by a roller blade bearing rolling on a rotating pulley with cam lobes. The screens in the screen box are bumped by an adjustable nut. The frequency of the shaking can be adjusted by varying the pulley sizes. The amplitude of the shaking can be adjusted by changing the size of the cam lobes. The guides are just bushings that hold the shaker rod in the dado on the screen box and can be made of wood or metal. The tab on the bottom of the shaker rod is only there to make welding a bolt on easier. The bolt could also be welded directly to the shaker rod.



SCREEN BOX ASSEMBLY

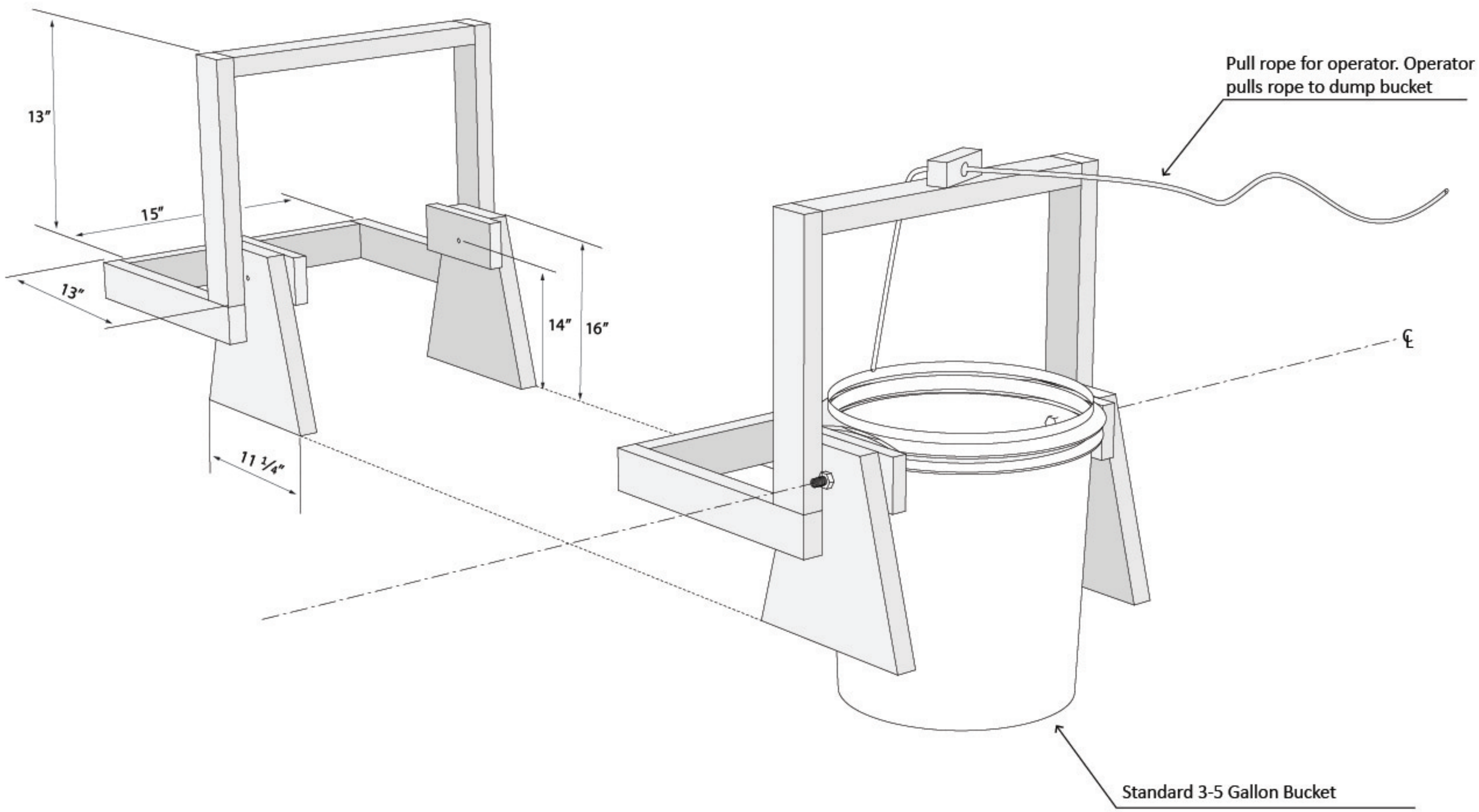




STEP 7

TIPPING BUCKET

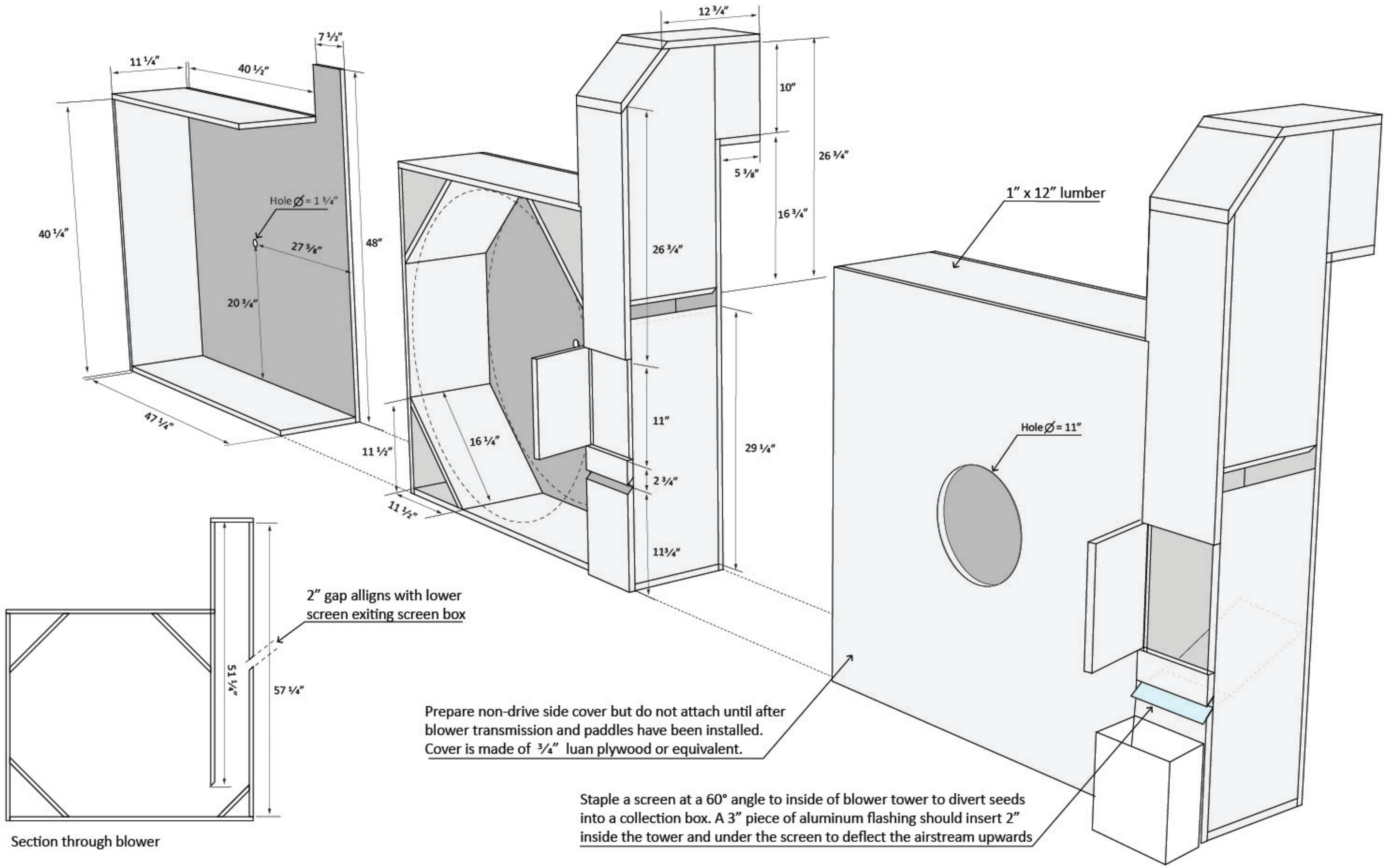
The last step to complete the screen box is to make a bucket and yoke so that a person operating the fanning mill can control the pouring of the material on to the top screen of the fanning mill. A suitable 3-5 gallon bucket is attached by two bolts to a rigid wood frame (made of scraps) that spans the top of the frame box. The yoke is designed to stabilize the loaded bucket and is allowed to slide a little along the top of the frame box so that the location on the screens where the bucket dumps the plant material is adjustable.



STEP 8

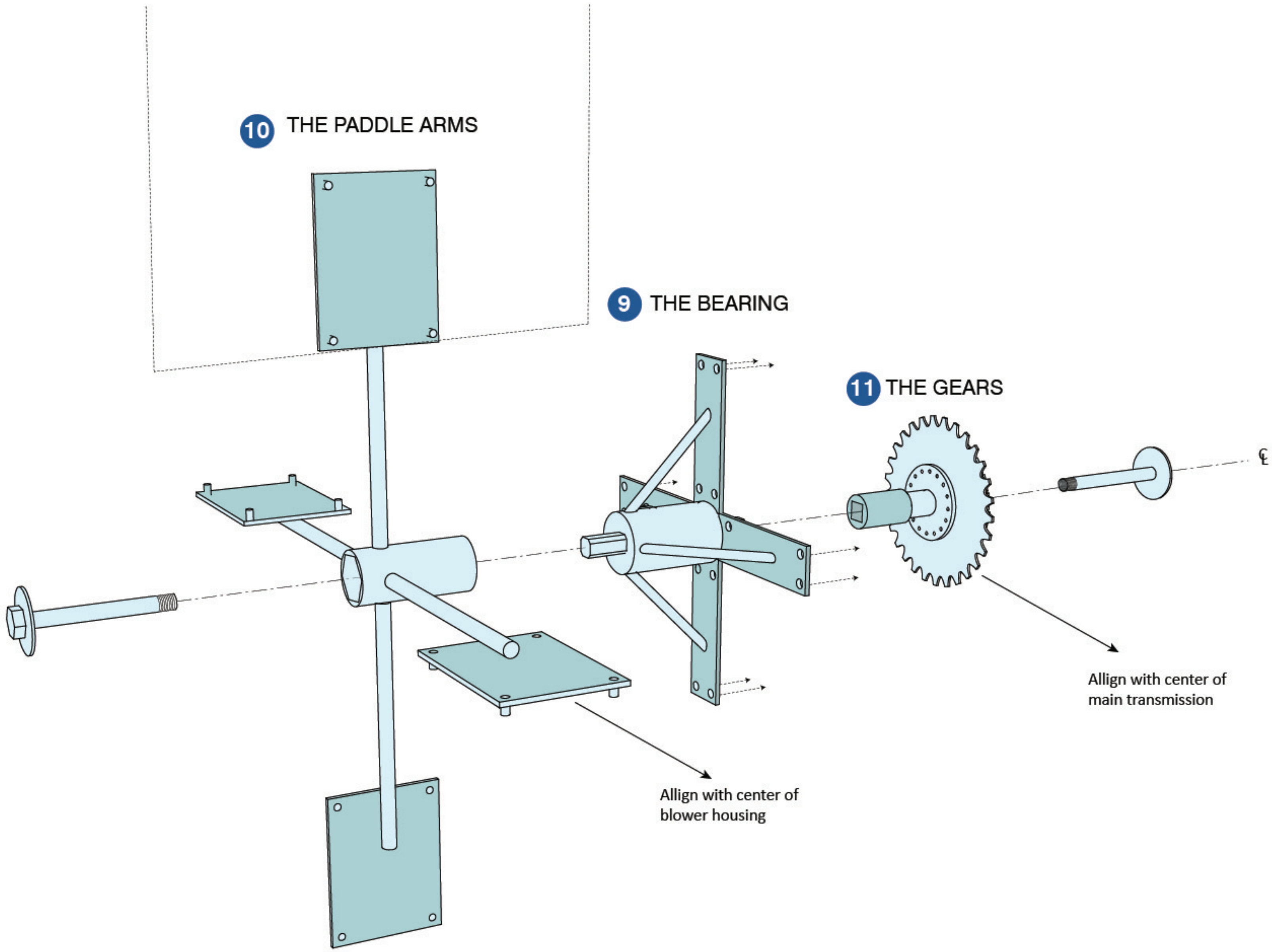
BLOWER HOUSING

Start by cutting out the drive side cover from a sheet of 3/4" plywood. Then attach the 1x12 frame pieces. The frame pieces that are along the back of the winnowing tower will need to mate face to face with the 1x12 on the front of the screen box, slots aligned for the bottom screen to pass through, so make sure those are smooth and flat. The pieces of wood (and small hinged door) that seal up the non-drive side of the winnowing tower should be assembled carefully so that air (or seeds) don't leak out. The design of the blower housing allows the non-drive side cover to be removed quickly and easily so that the inside if the blower can be cleaned, or a piece of debris obstructing the blower paddles can be removed.



BLOWER TRANSMISSION - OVERVIEW

The construction of the blower is described in 3 parts, first the bearing, then the paddle arms, then the gears. However, the alignment of the gears with the main transmission, and the alignment of the blower paddles with the blower housing, must be kept in mind during the construction of the three parts.

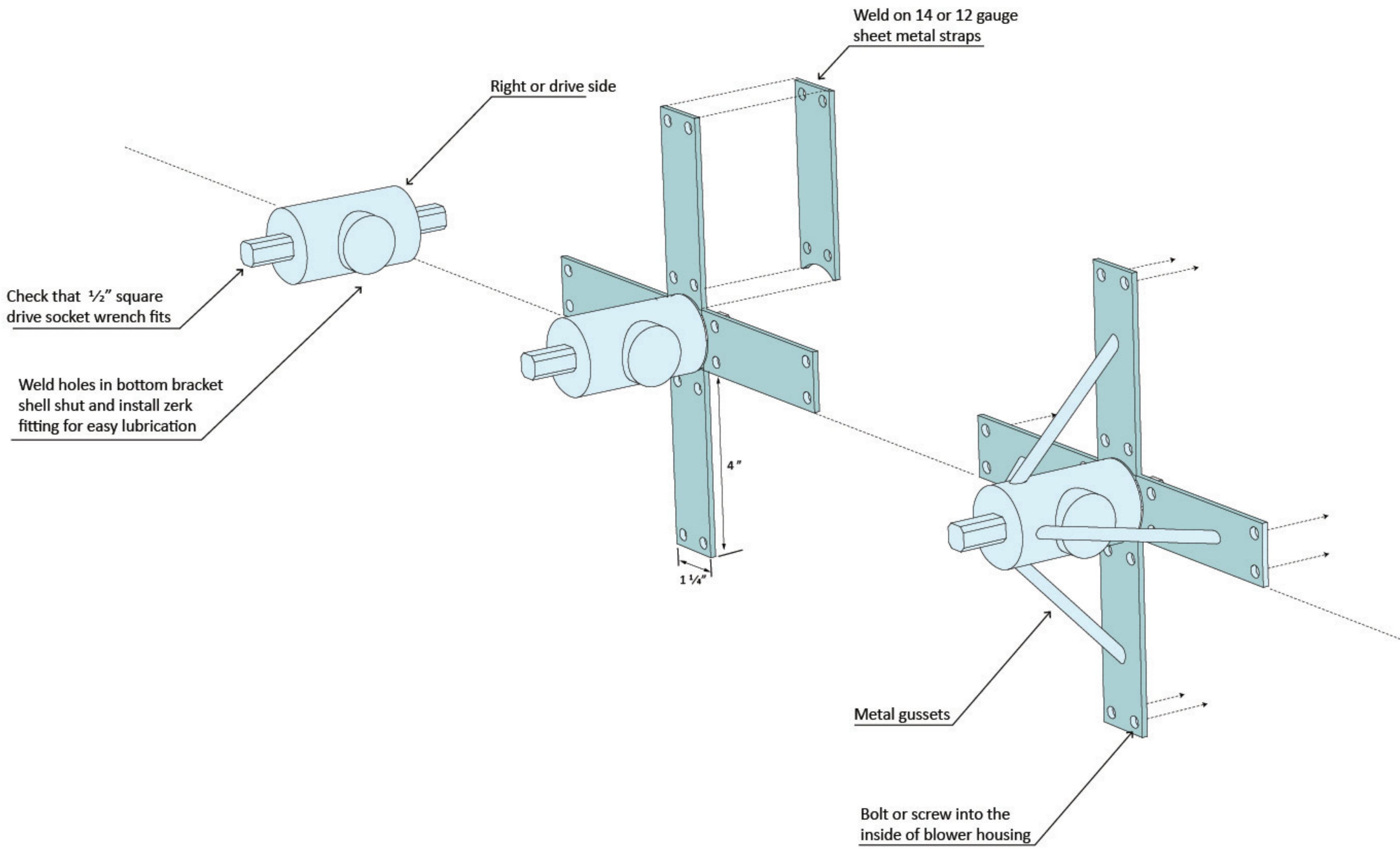


STEP 9

BLOWER TRANSMISSION - THE BEARING

First, a bottom bracket is cut from a bicycle and disassembled. Although there are different bottom bracket spindle standards, most spindles have a square tapered end. Check that a standard 1/2" square drive socket wrench socket slides on to your square tapered spindle. This is the trick that will make the whole part possible to easily build. Then, four sheet metal straps with mounting holes are welded to the bottom bracket (right side or drive side), along with some metal gussets to stiffen the assembly.

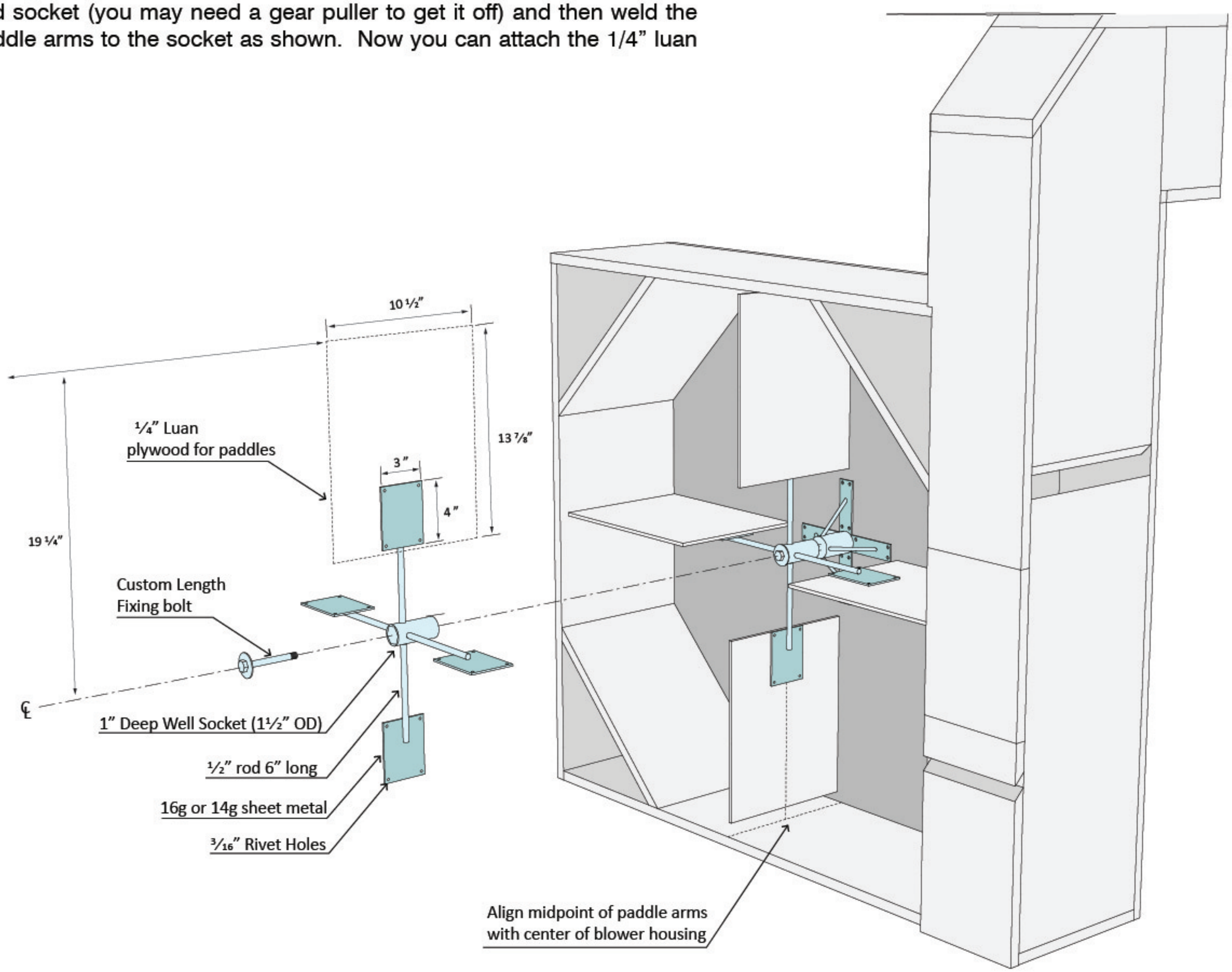
Take this opportunity to weld the holes into the bottom bracket shell shut, and install a zerk fitting for future ease of lubrication. Take care to protect the bottom bracket threads from weld spatter. Then reassemble the bottom bracket. The bottom bracket will now mount to the inside of the blower housing, with its right side spindle-end protruding through the hole in the blower housing. The left side spindle-end will be inside the blower housing.



STEP 10

BLOWER TRANSMISSION - THE PADDLE ARMS

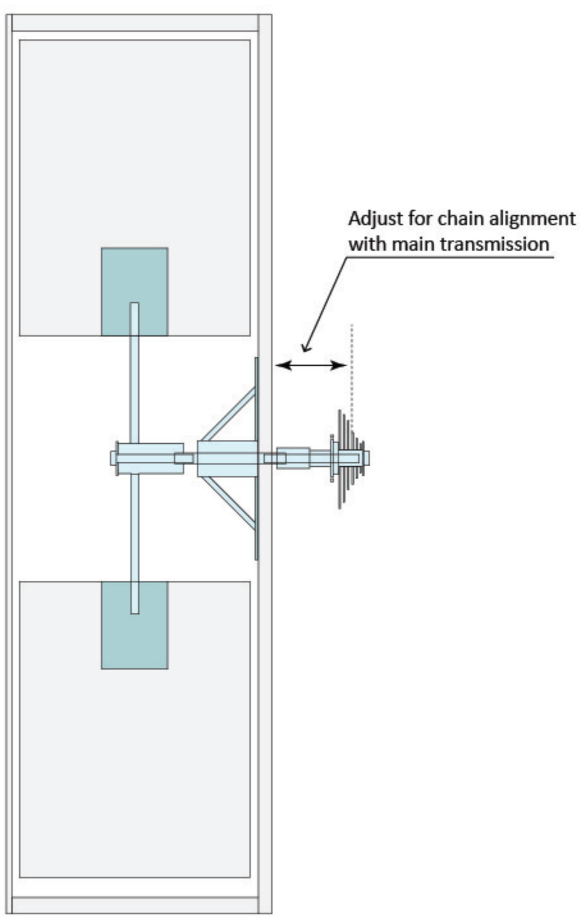
On to the left side of the spindle will mount the blower paddle arm assembly. Take a 1/2" drive by approx 1" deep well socket (approx 3" long) and make a custom fixing bolt (or threaded rod extension, if your spindle has a threaded stud- instead of a threaded hole) that allows you to mount the socket on the spindle where the crank arm would normally mount. Tighten the fixing bolt. Measure from along the socket and mark the point that corresponds to the center of the blower housing. Remove the fixing bolt and socket (you may need a gear puller to get it off) and then weld the paddle arms to the socket as shown. Now you can attach the 1/4" luan plywood paddles to the paddle arms with 3/16" aluminum rivets or small bolts. Or, you may want to wait to attach the plywood paddles to the blower assembly until everything is mounted so you can exactly center the paddles on the blower housing. Either way the finished paddle wheel can be spun and checked for clearance before the non-drive side plywood cover is attached.

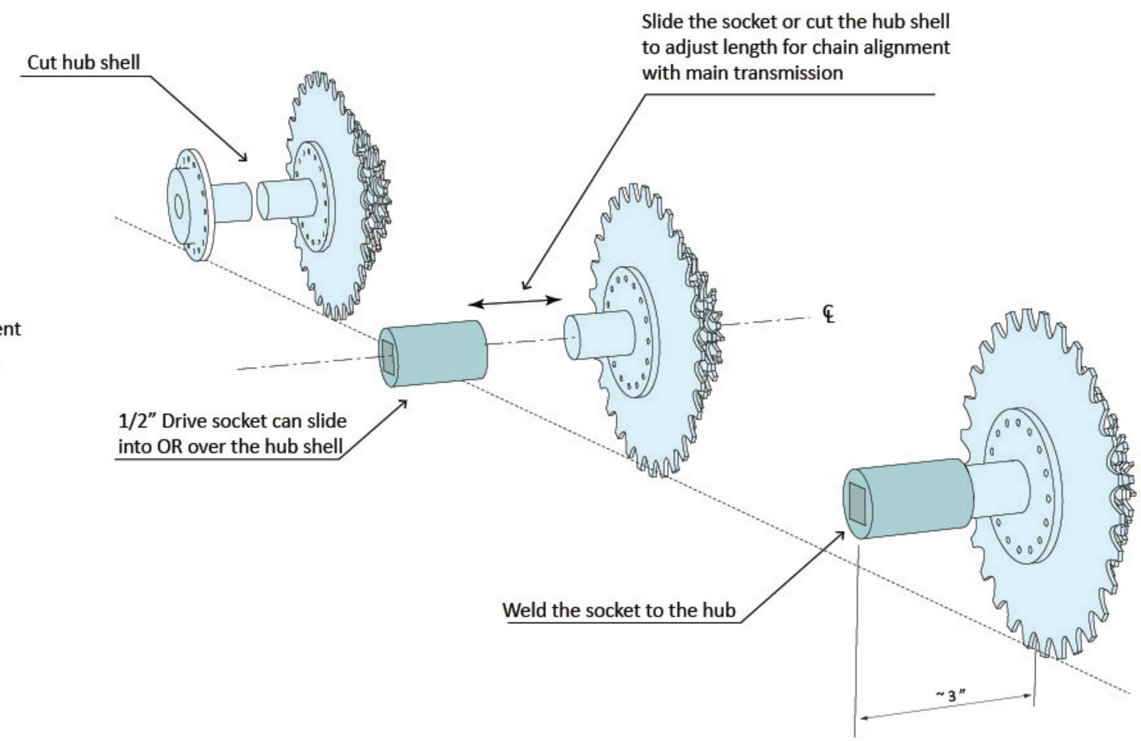


STEP 11

BLOWER TRANSMISSION - THE GEARS

For the gears, find a steel rear hub with a 5,6,or 7 speed freewheel. Remove the guts from the hub. Cut the hub shell just inside the left hand flange. Check that there is now a smooth bore inside the hub shell. There may also be a smooth bore on the outside of the hub shell. Now find a 1/2” square drive socket whose OD just slides inside the ID of the hub shell, OR whose ID just slides over the OD of the hub shell. This allows you to tack weld the socket to the hub shell and maintain a straight center axis. Now mount the socket on the spindle and figure out how far from the end of the spindle the freewheel must be to provide good chain alignment between the main transmission and the blower transmission. You can now slide the hub shell and freewheel on to the socket and tack weld them together. Try to use a minimum of weldment to minimize distortion. Finally, fabricate a fixing bolt the correct length to attach the gear assembly to the spindle.





STEP 12

BIKE UNIT

Virtually any exercycle made with bicycle parts can be used to power the Fanning Mill. If the exercycle has a flywheel it will work better because the blower will supply a more consistent air stream to the winnowing tower. Some exercycles may need structural reinforcement.

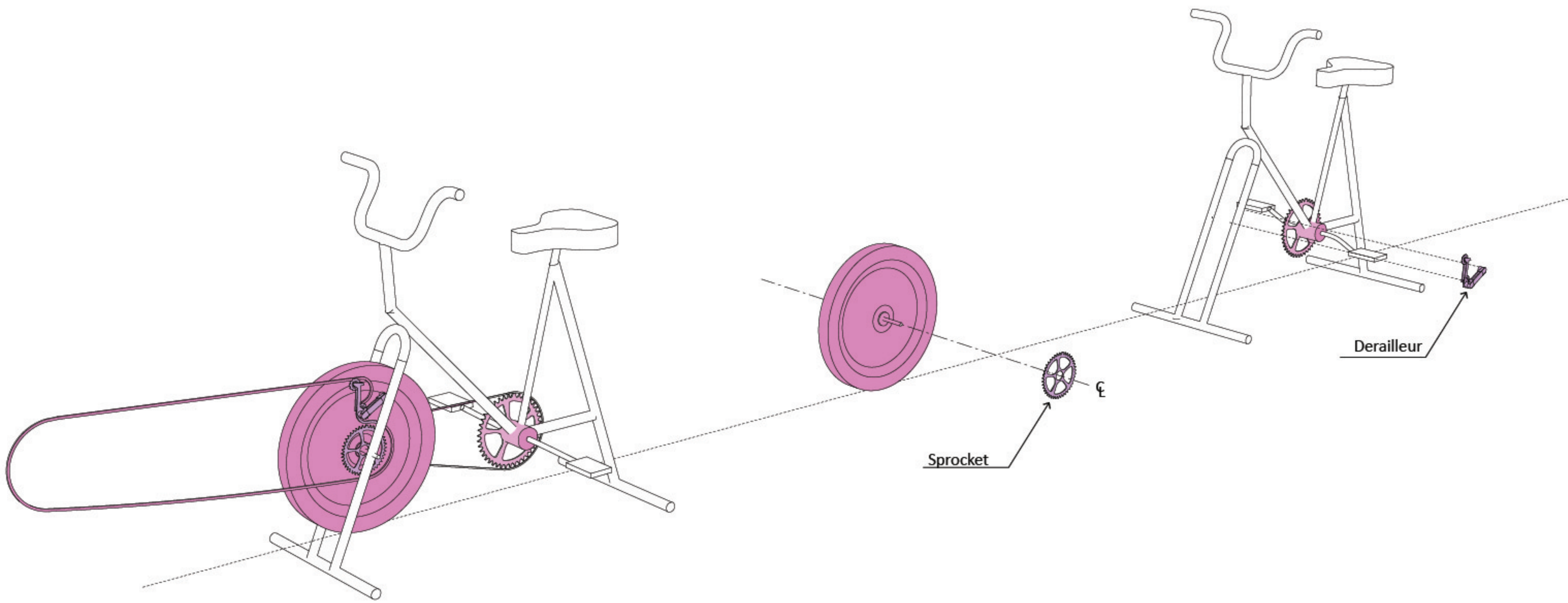
First, remove the flywheel from the exercycle. On the non-drive side of the flywheel hub attach a 20-30 tooth bike sprocket as follows: Depending on what is used for a sprocket, the center may have to be removed (with a blow torch, hole saw, or grinder) so it clears the hub parts. Then three holes should be drilled in the sprocket through which screws (eg 10-32) will thread into corresponding holes drilled and tapped in the cast iron of the flywheel hub. The challenge is locating, drilling,and tapping these holes while keeping the sprocket precisely centered on the axle of the flywheel. A compass divider helps.

For ease of future maintenance, the bottom bracket of the exercycle can be outfitted with a zerk fitting.

An old rear derailleur should be welded upside-down to the non drive side to act as a chain tensioner and chain alignment guide.

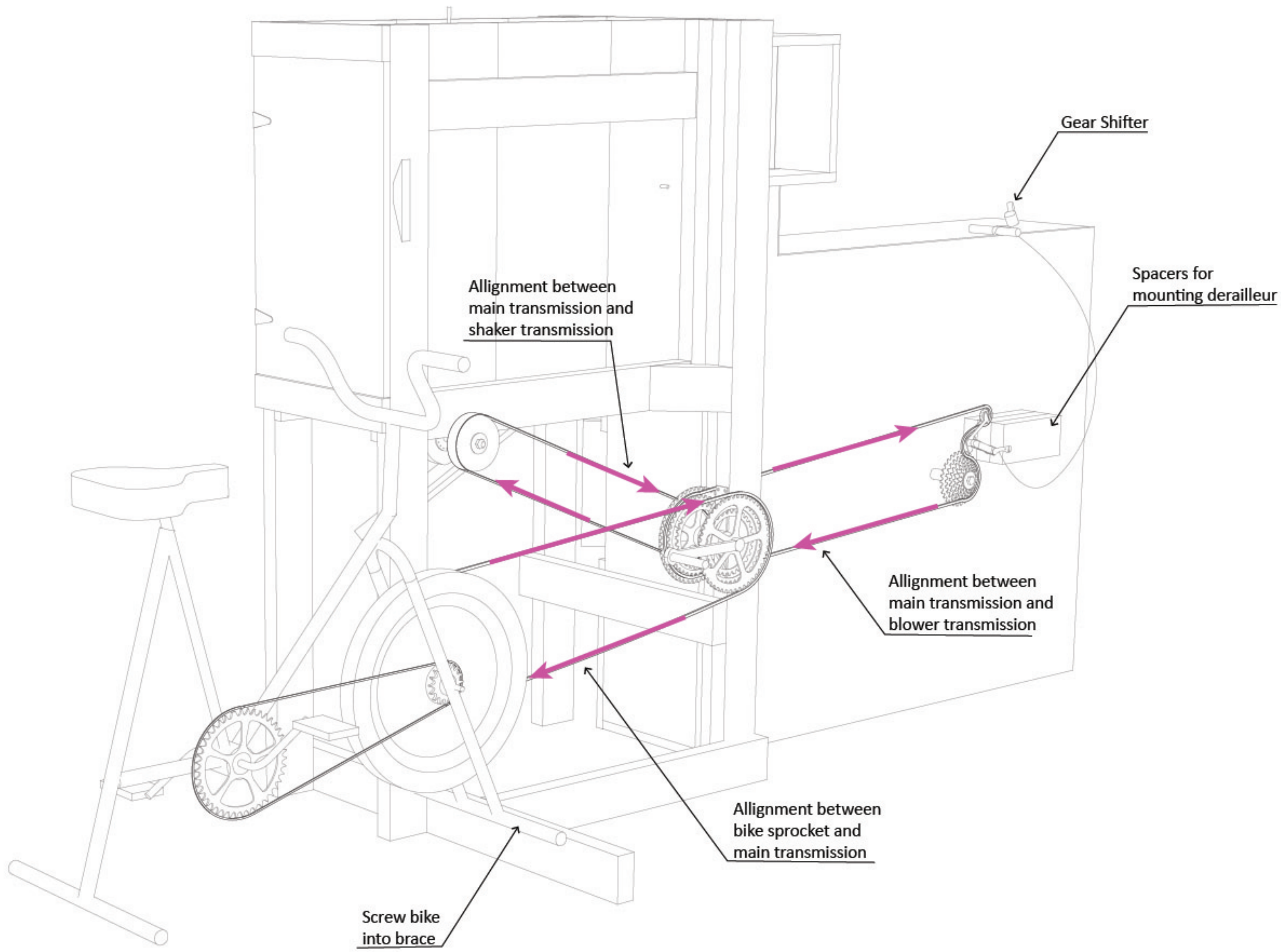
Drill quarter inch holes in the legs of the exercycle so that it can be screwed to the wood frame of the fanning mill.

Reassemble the exercycle, screw it to the fanning mill, and install a bicycle chain from the exercycle's non-drive sprocket, through the upside-down derailleur, and over to one of the chain rings on the fanning mill's main transmission.



POWER ASSEMBLY

The bike unit, main transmission, shaker transmission, and blower transmission are aligned and connected to each other. The bike unit is screwed down to the wood frame of the screen frame. Bike chain connects the left side of the bike wheel to the right side of the main transmission--select any one of the three chainrings. Then a second bike chain connects the left side of the main transmission to the blower transmission. Here gearing can be selected to achieve the desired speed of the blower, and hence strength of the air current in the winnowing tower. Finally, a flat belt connects the main transmission flat belt pulley to the shaker transmission flat belt pulley.



OPERATIONS

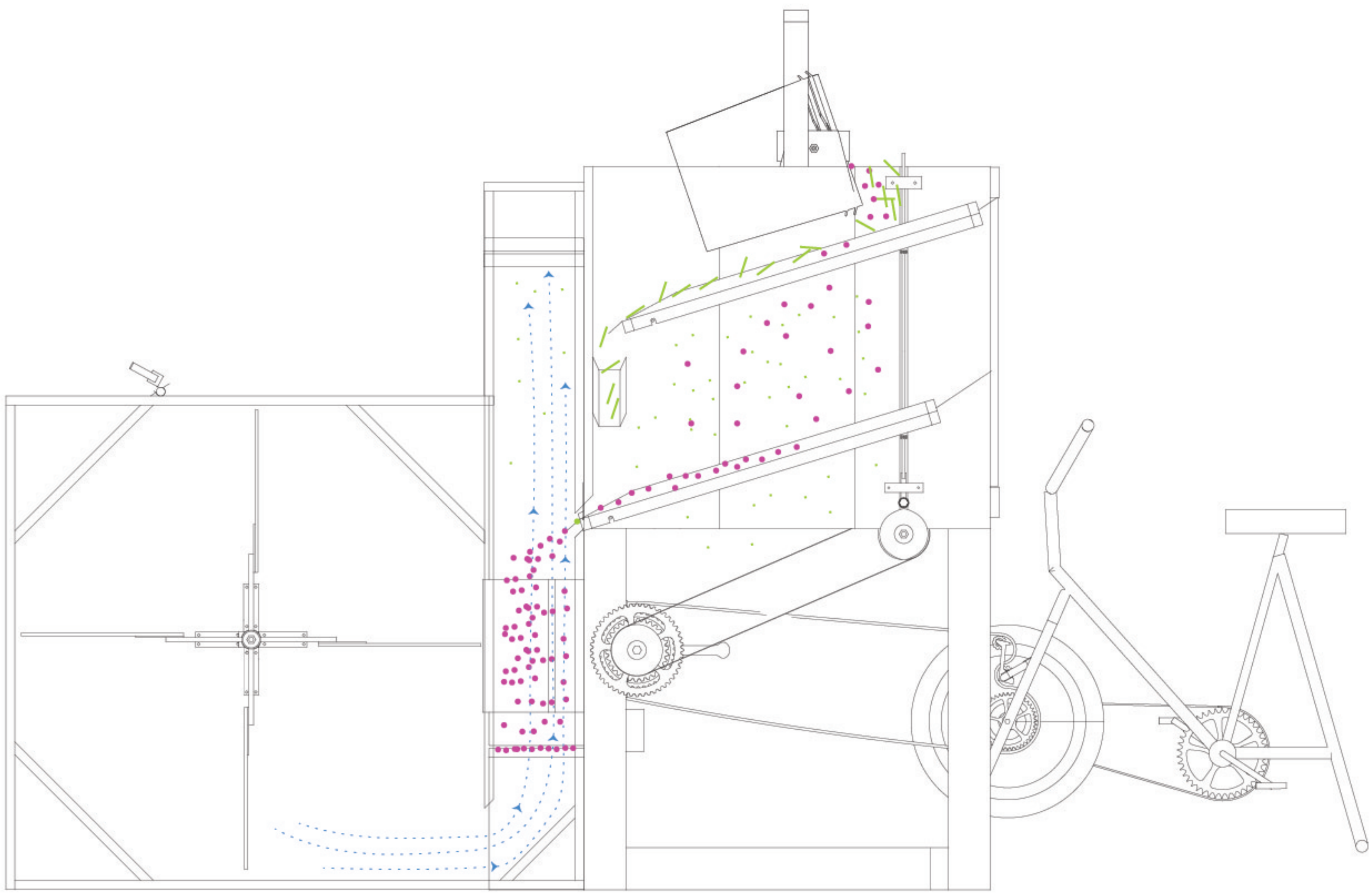
The fanning mill can be used to sort, clean and grade many kinds of seeds. The operator selects the screen sizes, screen tilt angle, and blower strength for the specific crop being processed.

Top Screen (scalping screen, or large screen): This screen is selected to allow the desired seed size to pass through it, while sending larger items (larger seeds, seed heads or pods, and debris) to a chute.

Bottom Screen (grading screen, or small screen): This screen is selected to allow all debris smaller than the desired seed to pass through (fall on the ground) while the desired seeds slide down into the winnowing tower.

The angle of each screen is adjustable. The angle of the screen is adjusted by loosening the set screw on the adjuster stop, sliding it up or down to the new position, then tightening the set screw. The angle of each screen is chosen so that the material slides down the screen when the screen is shaking, but not so fast that the screen fails to sort the material. Once the angle is selected, the open space between the rear of the screen and the back door of the screen box must be filled with a piece of cardboard that directs bouncing seeds back on to the screen.

(continued on next page)



OPERATIONS (cont.)

General note about screens: Screen selection is tricky. There are different types of screen, and even between two screens of the same size there may be a different amount of crimping in the wire that changes the way the screen interacts with the seeds/debris. In general, for the top screen select the smallest size that does the job, and for the bottom screen select the largest size that works. Specifically, a quick test by throwing a handful of the seeds/debris to be threshed on a screen and checking if the seeds find their way through the openings is a good start. There are also types of perforated metal and expanded metal. These have the advantage that perforated metal does not catch bits of fiber the way a wire screen does. However, perforated metal is usually more expensive than screen. The commercial screens for sorting seeds often use flat sheet metal with slot shaped holes punched out. Finally, the size screen used on the thresher will affect the screen selection and performance of the fanning mill. It is important to use the smallest size screen or expanded metal on the thresher that allows all the seeds to fall through it.

The frequency with which the screens shake can be adjusted by changing the pulley size on the shaker flat belt or by making a cam-pulley with more or fewer lobes.

Once sorted in the screen box, the desired seeds enter the winnowing tower, where they fall down through a column of air which is blowing up. The good seeds (that are heavy) fall down into a collection tub. The lighter chaff and bad seeds (that are light) get blown up and out of the winnowing tower on to the ground. The strength of the blower can be adjusted by changing gears on the blower transmission. To tune the blower, increase the blower strength while holding a hand in front of the winnowing tower until good seeds get thrown against your hand; then decrease the strength of the blower a little. The rider can also adjust the blower strength by pedaling faster or slower. Finally, for winnowing small, light seeds it may be necessary to reduce the strength of the blower by partly covering the air inlet hole on the blower housing.

Some crops require two passes through the fanning mill. For example, rice is first passed through to separate the seeds from the chaff. Then the seeds are de-hulled. Then the de-hulled seeds are passed through the fanning mill again to separate the grains of rice from the hulls. On the second pass, it is not necessary to use the top screen.

On some crops debris tends to pile up on the screen or at the passage between the screen and the winnowing tower. On small batches of seed it is possible to just open the back door of the screen box and manually clean the screen or shake it to shake down stuck material. On larger batches tuning the screen angles, changing the type of screen used, and tuning the size of the screens (both in the fanning mill and in the thresher) can solve most problems.

When done using the fanning mill it must be opened up and thoroughly cleaned of all debris and seeds. Leaving seeds around in the machine will encourage rodents to move in, contaminate the machine with rodent urine and feces, and chew up the wooden parts. Store the fanning mill inside protected from rain, sun, ground moisture, rodents, and insects.

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Questions + Comments + Donations -
Contact Lu Yoder - bravelittleship@gmail.com

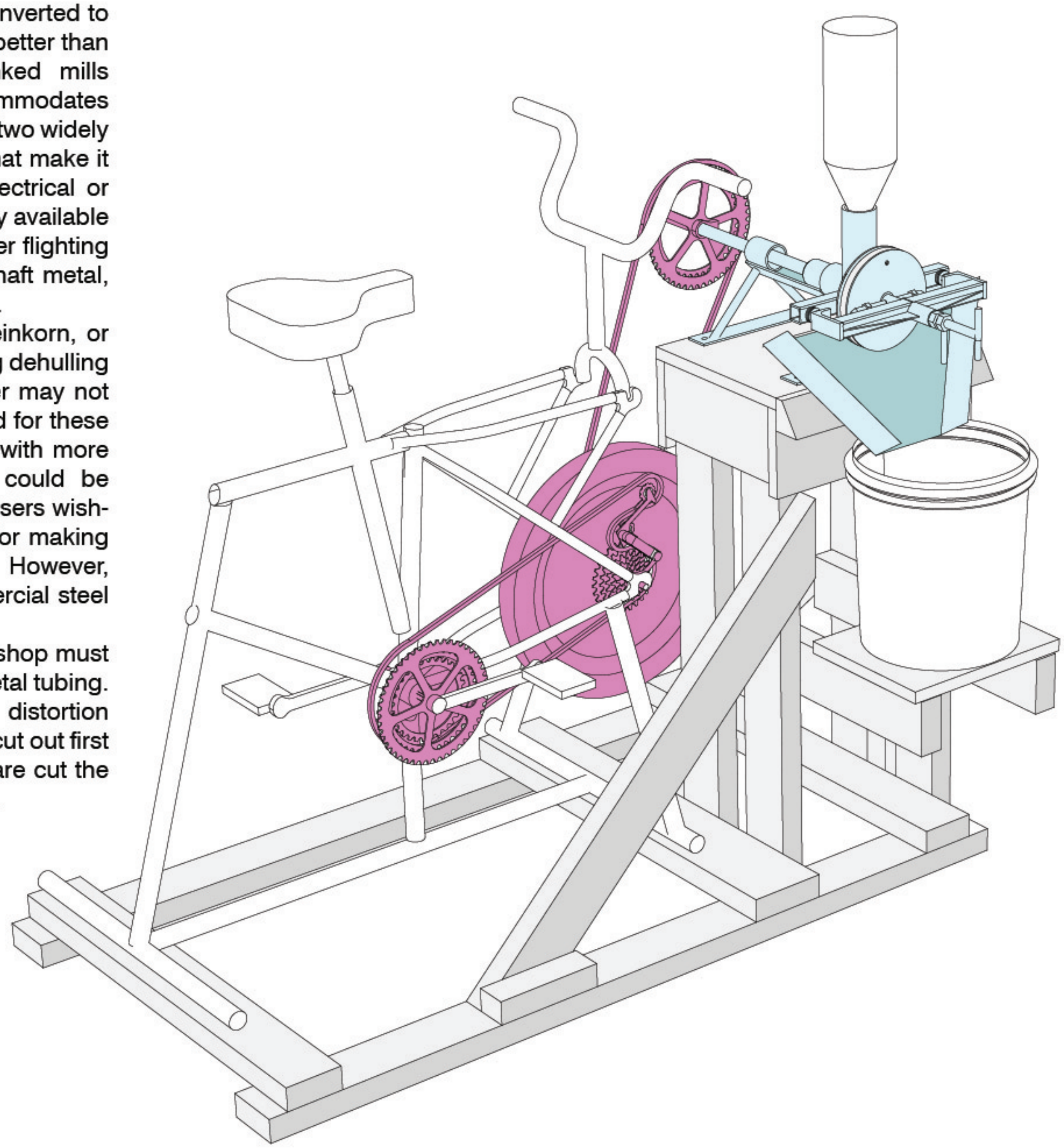
This project was supported in part by the Northeast Sustainable Agriculture Research and Education (SARE) program (www.nesare.org). SARE is a program of the National Institute of Food and Agriculture, U.S. Department of Agriculture.

THE DEHULLER | MILL

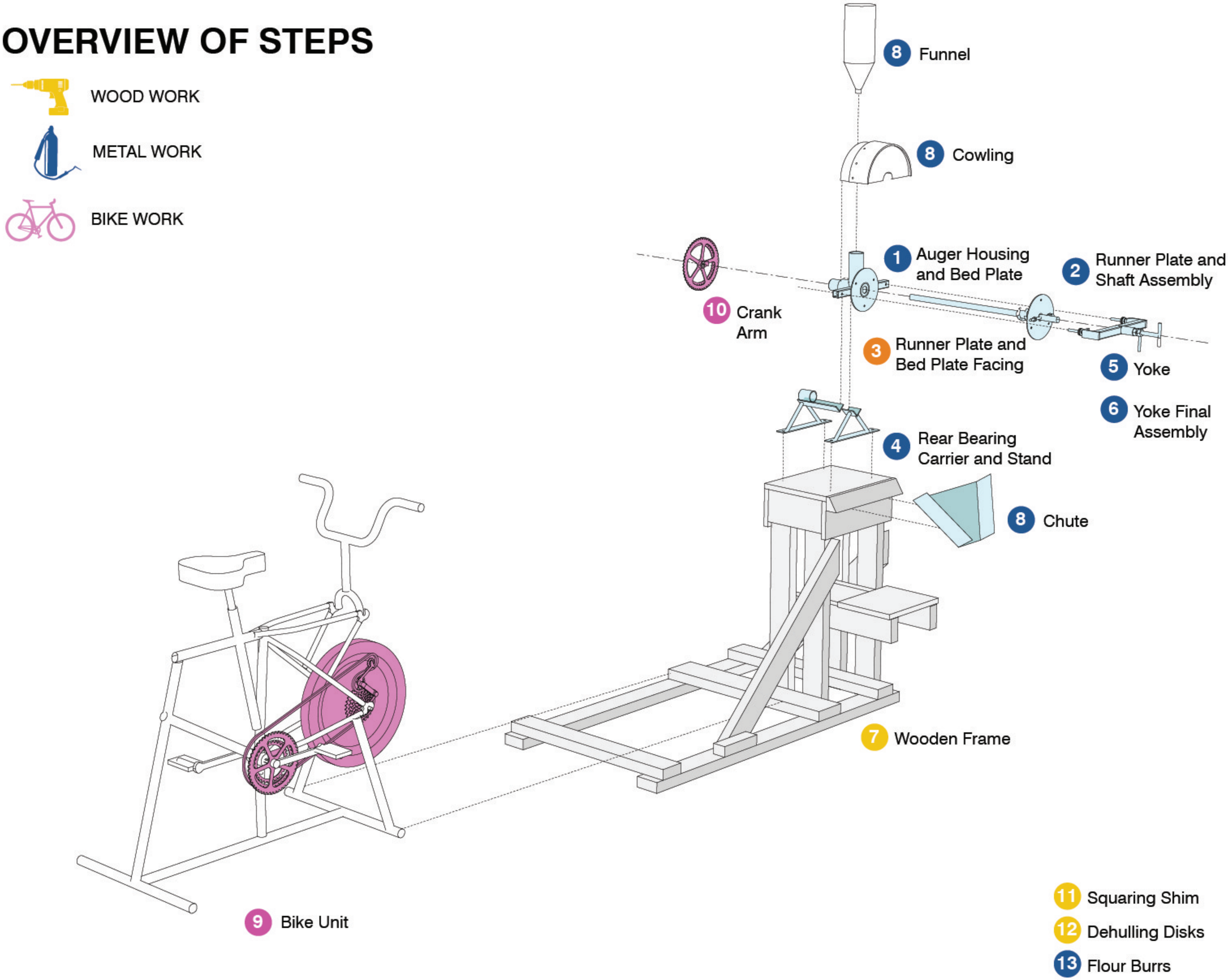
Here are plans for a horizontal shaft mill intended for dehulling grains. It can be easily converted to a flour grinding mill. This simple mill is better than the available inexpensive hand cranked mills because it uses ball bearings and accommodates a larger dehulling disc. In addition it has two widely spaced bearings and a stable design that make it better for the use of bike power or electrical or mechanical power. The mill uses readily available 1 3/8" x 3/4" sealed bearings. The auger flighting is made from a straight piece of key shaft metal, heated and bent around the auger shell.

For users wishing to dehull rice, einkorn, or emmer, instructions are given for making dehulling pads. For barley and oats this dehuller may not work, as much more scouring is needed for these two crops. However, it is possible that with more aggressive dehulling disks, this mill could be made to work for barley and oats. For users wishing to mill flour, instructions are given for making crude steel burrs with an angle grinder. However, in most cases the user can buy commercial steel or stone burrs and fit them to the mill.

Building the mill is not difficult. The shop must be equipped to make square cuts on metal tubing. Welding techniques that minimize distortion should be used. All of the parts can be cut out first and then fabricated. Once the pieces are cut the actual fabrication time is only five hours.



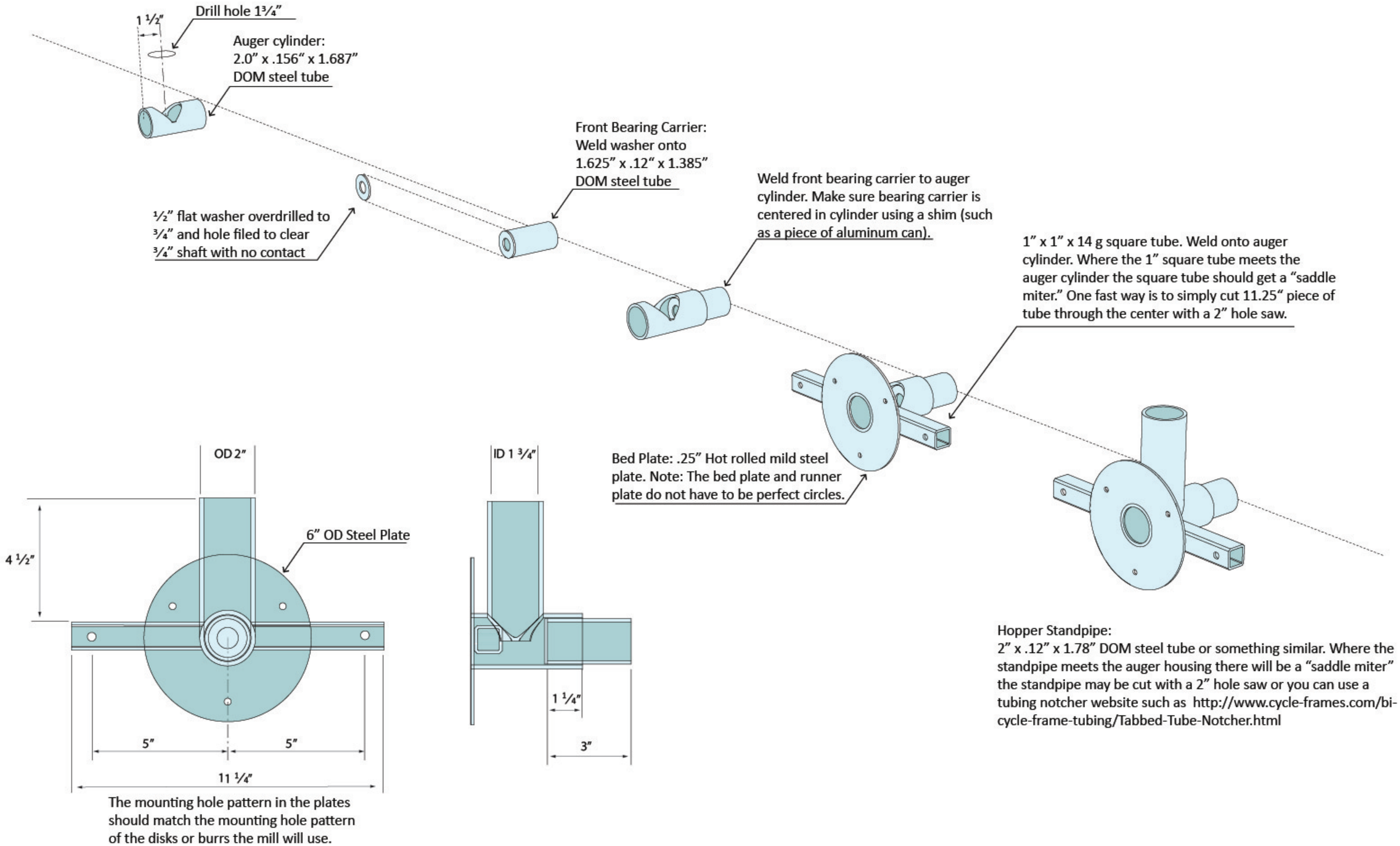
OVERVIEW OF STEPS



STEP 1

AUGER HOUSING AND BED PLATE

Whether the mill is intended for dehulling, flour, or both, the runner plate and the bed plate will need to be true and square to each other so that as the runner plate rotates the gap between the two plates remains constant. This requires making square cuts in the metal parts and welding the parts together square with a minimum of weld distortion.



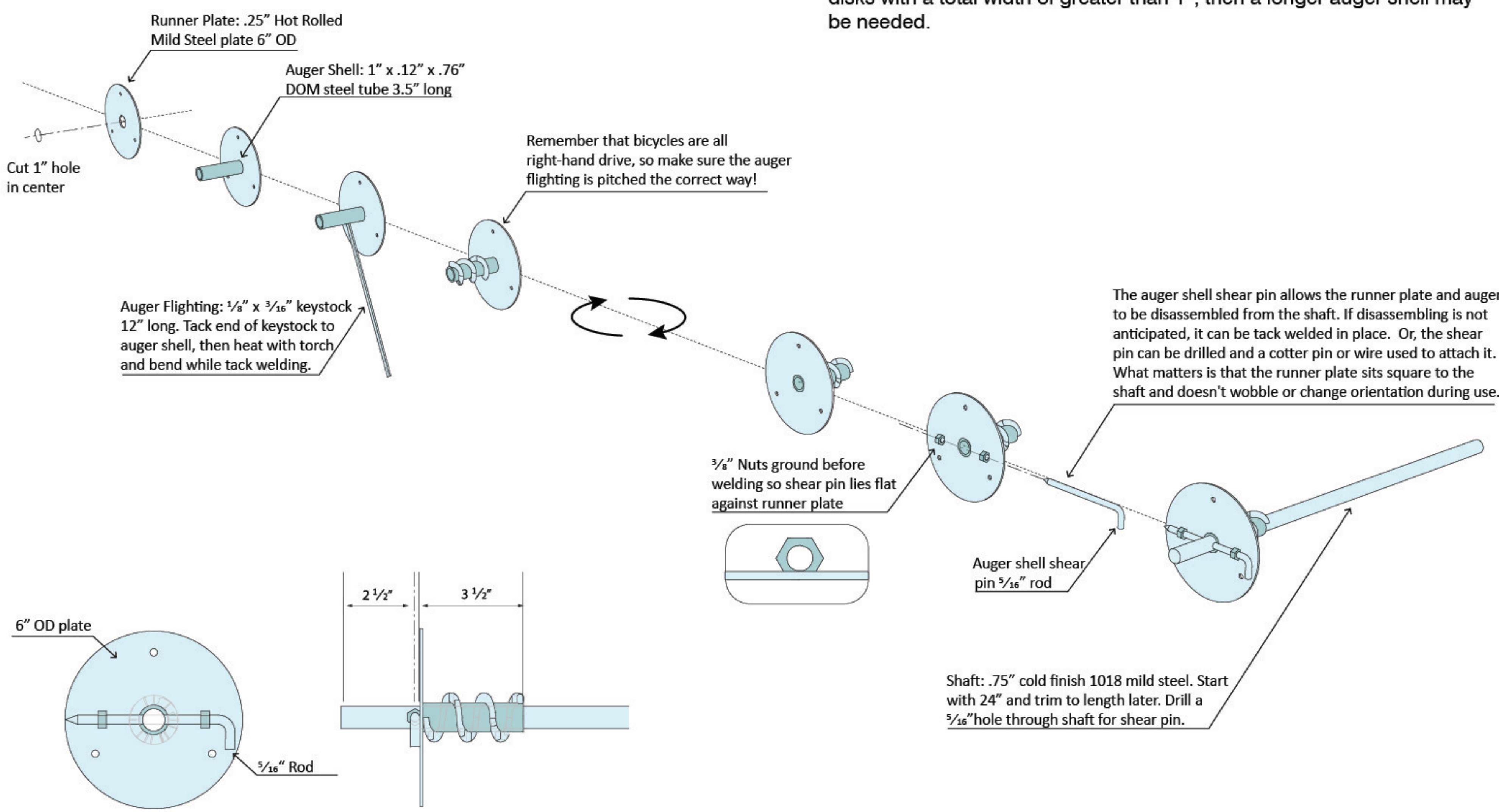
STEP 2

RUNNER PLATE AND SHAFT ASSEMBLY

Wrapping the auger flighting around the auger shell is easily done with a welding or brazing torch and a pair of pliers. The straight flighting-stock (key-stock or a small piece of sheet metal) is tacked to the shell and then heated and bent. Every half turn or so it is tacked to the auger shell and the process continues until all the flighting is attached.

Important!: Remember that as the shaft turns the auger must move grain toward the runner plate! The bicycle power unit will always turn one way (right-hand drive), so the orientation of the mill to the bike must be designed before the auger is made.

Also, the correct length of the auger shell and its flighting will depend on the width of whatever disks (dehulling disks, steel flour burrs, stone burrs) are sandwiched between the plates. If you anticipate using burrs or disks with a total width of greater than 1”, then a longer auger shell may be needed.

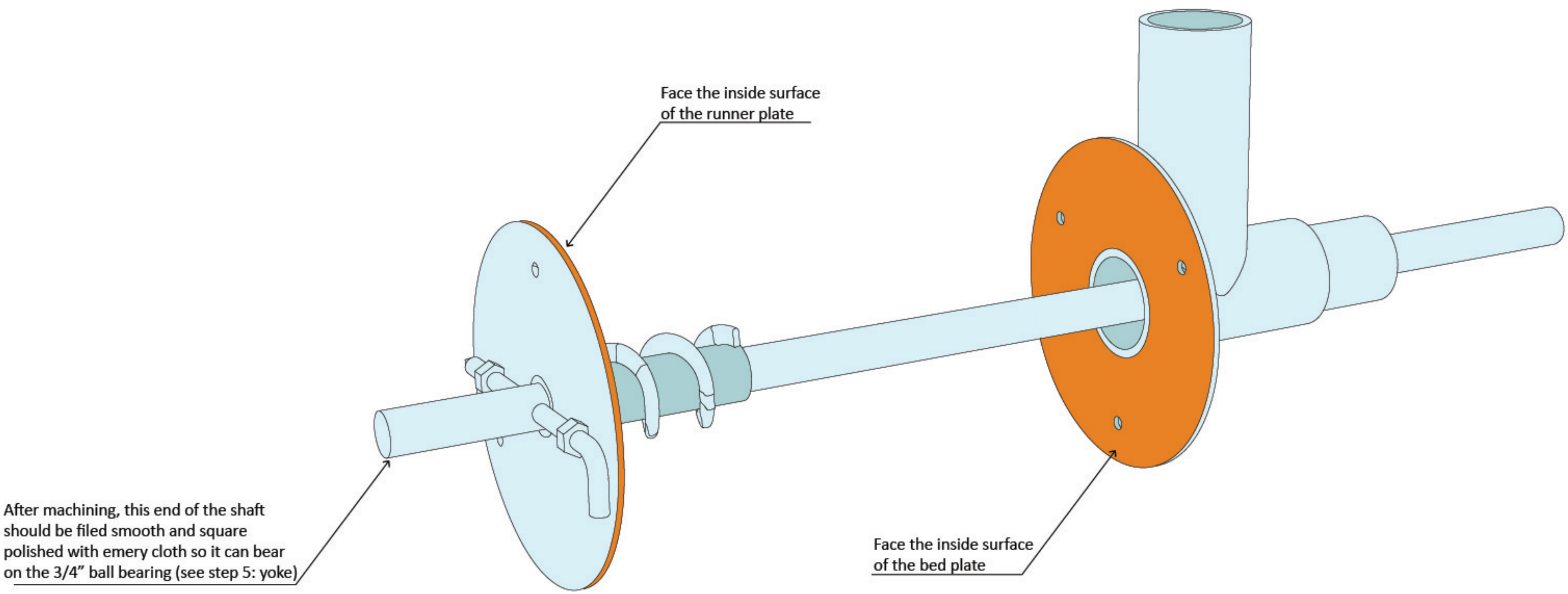


The mounting hole pattern in the plates should match the mounting hole pattern of the disks or burrs the mill will use.

STEP 3

RUNNER PLATE AND BED PLATE FACING

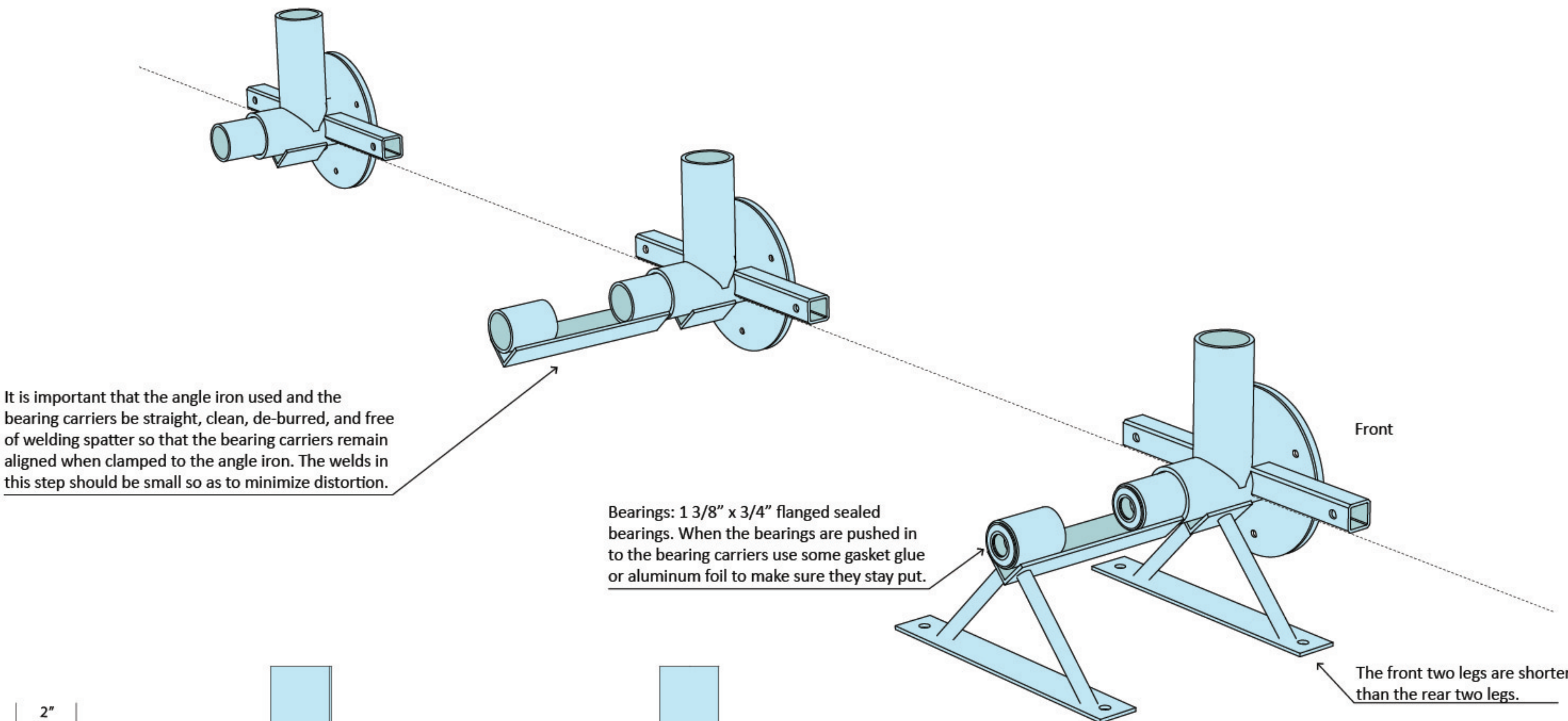
At this stage, the shaft assembly with the runner plate, and the auger cylinder assembly with the bed plate, can be taken to a machine shop and the working faces of the two plates can be faced on a lathe. The facing pass will make them true and square to the shaft center and the bearing carriers. Later, when the whole mill is assembled, a shim can be "run in" to remove any remaining lack of square (step 9: Shim).

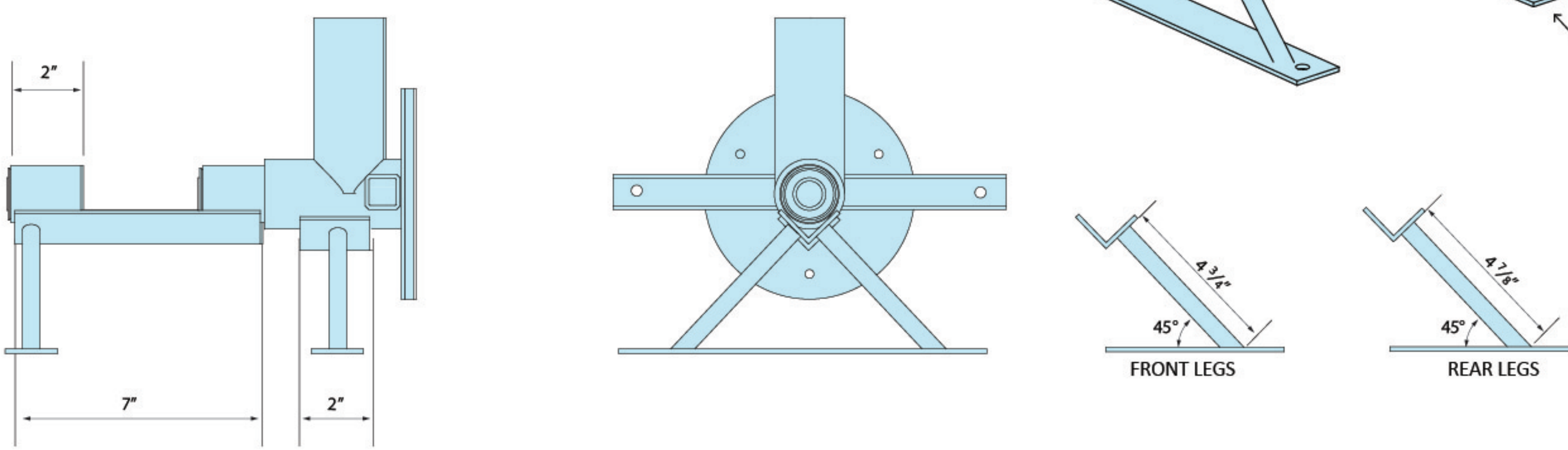


STEP 4

REAR BEARING CARRIER AND STAND

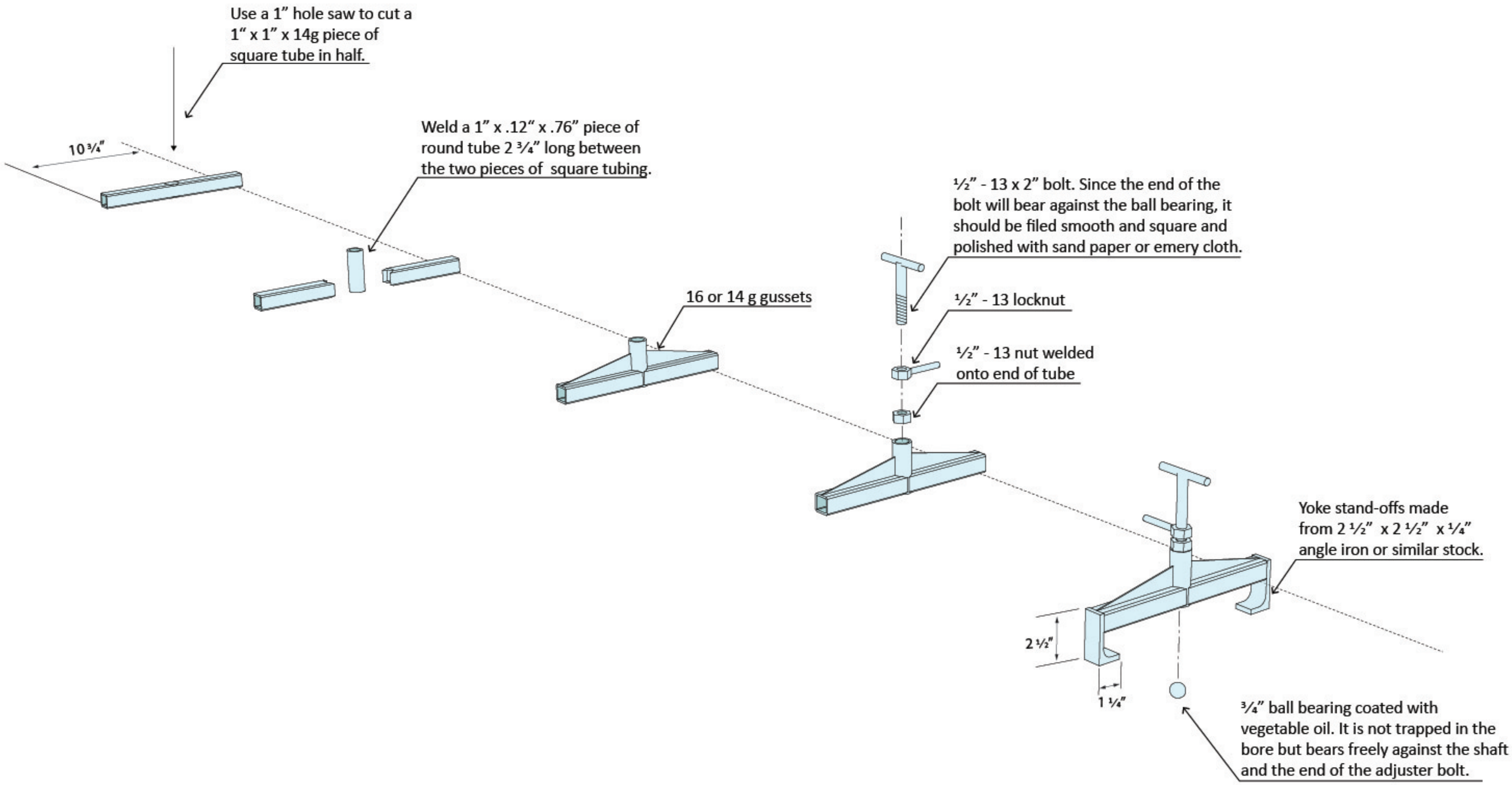
Now all that remains to build the auger cylinder housing is the rear bearing carrier and the stand. To attach the rear bearing carrier so that it is co-axial with the front bearing carrier, a piece of straight, clean, angle iron is used.





STEP 5

YOKE

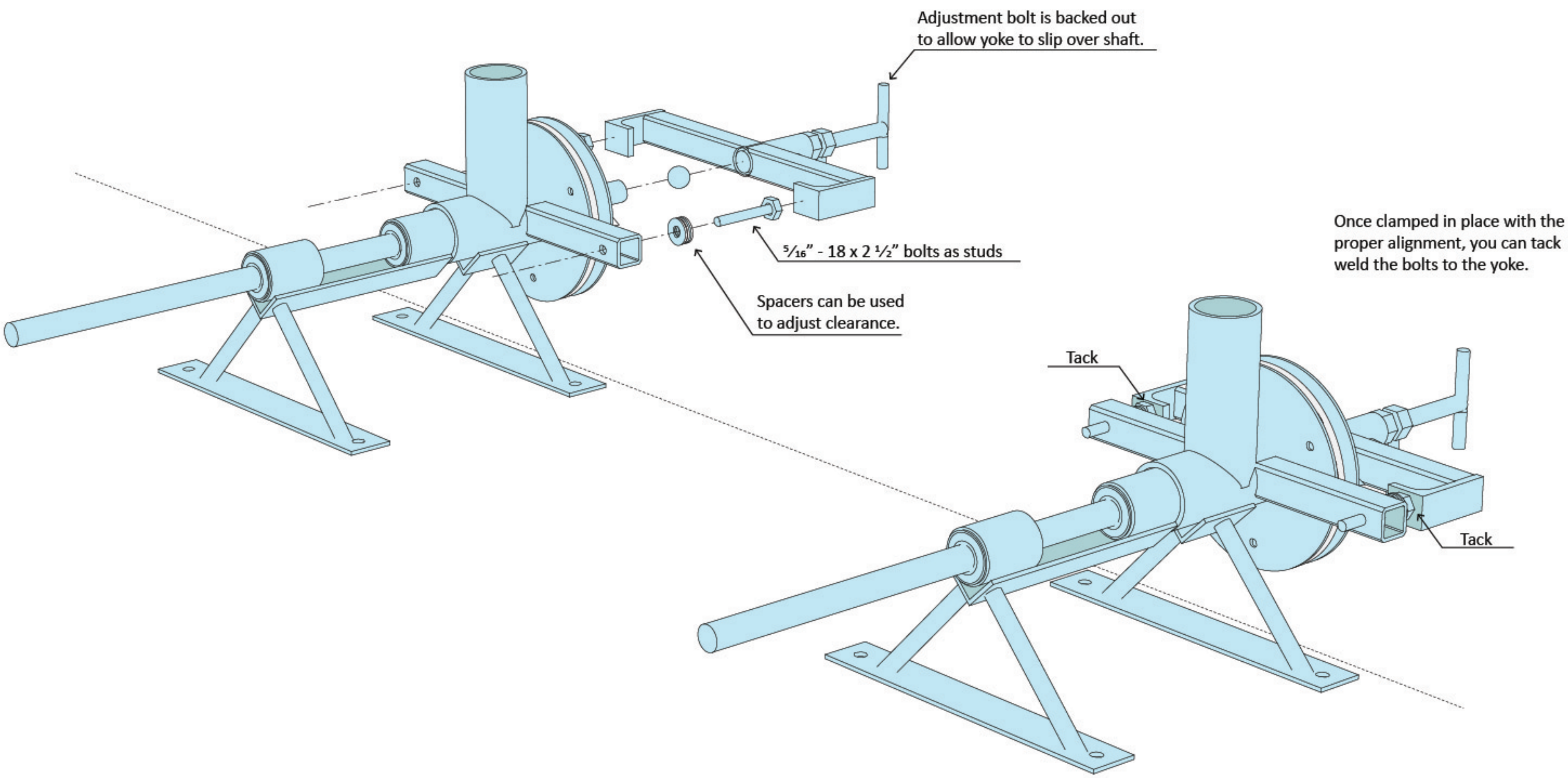


Use a 1” hole saw to cut a 1” x 1” x 14g piece of square tube in half.
10 ¾”
Weld a 1” x .12“ x .76” piece of round tube 2 ¾” long between the two pieces of square tubing.
16 or 14 g gussets
½” - 13 x 2” bolt. Since the end of the bolt will bear against the ball bearing, it should be filed smooth and square and polished with sand paper or emery cloth.
½” - 13 locknut
½” - 13 nut welded onto end of tube
Yoke stand-offs made from 2 ½” x 2 ½” x ¼” angle iron or similar stock.
2 ½”
1 ¼”
¾” ball bearing coated with vegetable oil. It is not trapped in the bore but bears freely against the shaft and the end of the adjuster bolt.

STEP 6

FINAL ASSEMBLY

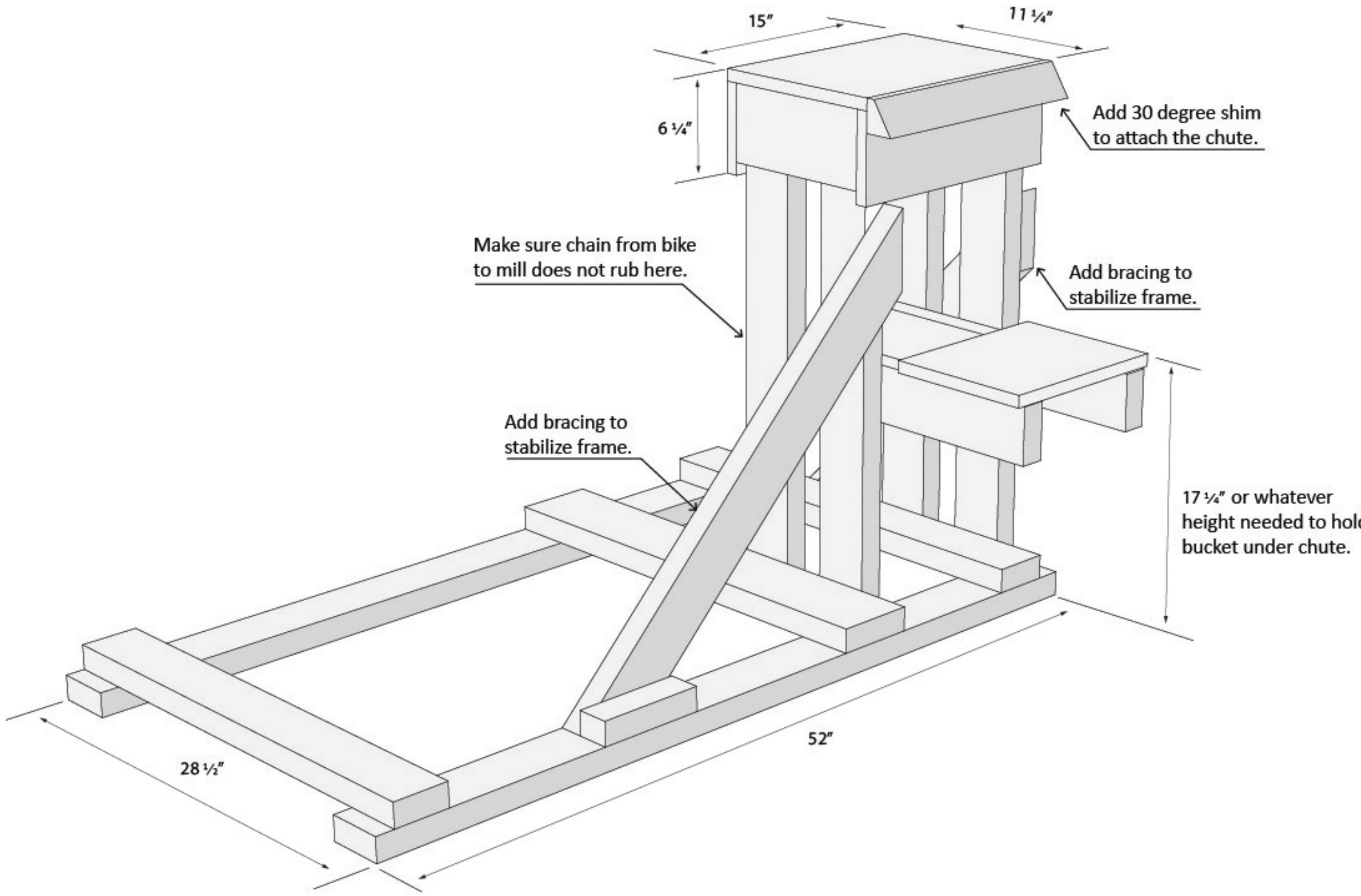
Assemble the auger housing, bearings, and shaft (use flat plywood disks or metal shims to space the runner and bed plates apart so that the auger shell inserts all the way into the auger cylinder but doesn't rub). Assemble the yoke on the end of the shaft (with 3/4” ball bearing inserted) with the two studs. Clamp the assembly in place and tack the studs to the yoke as shown below. Mark the left and right sides of the yoke with a center punch (so it can be re-assembled the same way every time). Disassemble and weld the studs to the yoke.



STEP 7

WOODEN FRAME

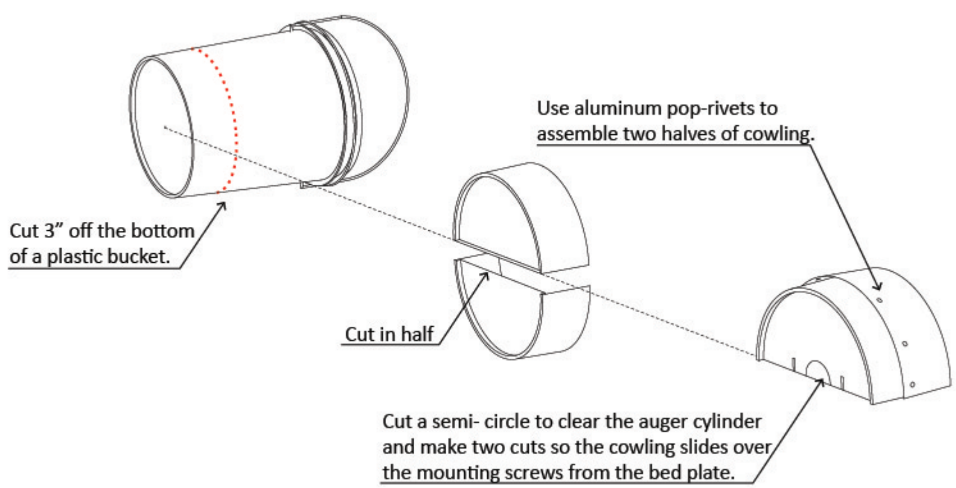
The frame below makes a steady platform to mount both the bike and the mill. The rider faces the mill and can use their hands to pour grain into the hopper or poke the hopper with a stick to keep the grain feeding evenly. The wooden frame can be built from standard 2x4 and 1x12 lumber, palette wood, or any lumber scraps available. The dimensions given worked for the particular exercycle we were using. You may need to vary the dimensions to suit your exercycle.



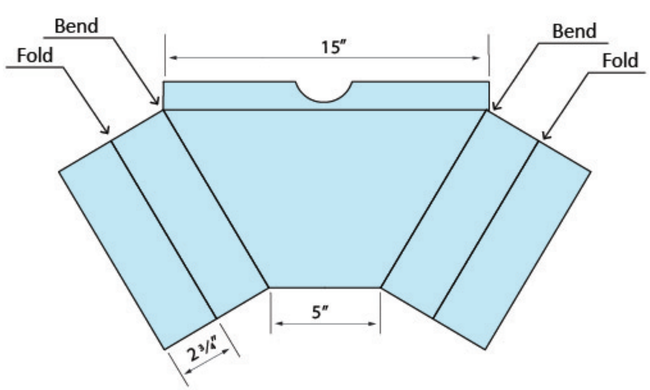
STEP 8

CHUTE + COWLING + FUNNEL

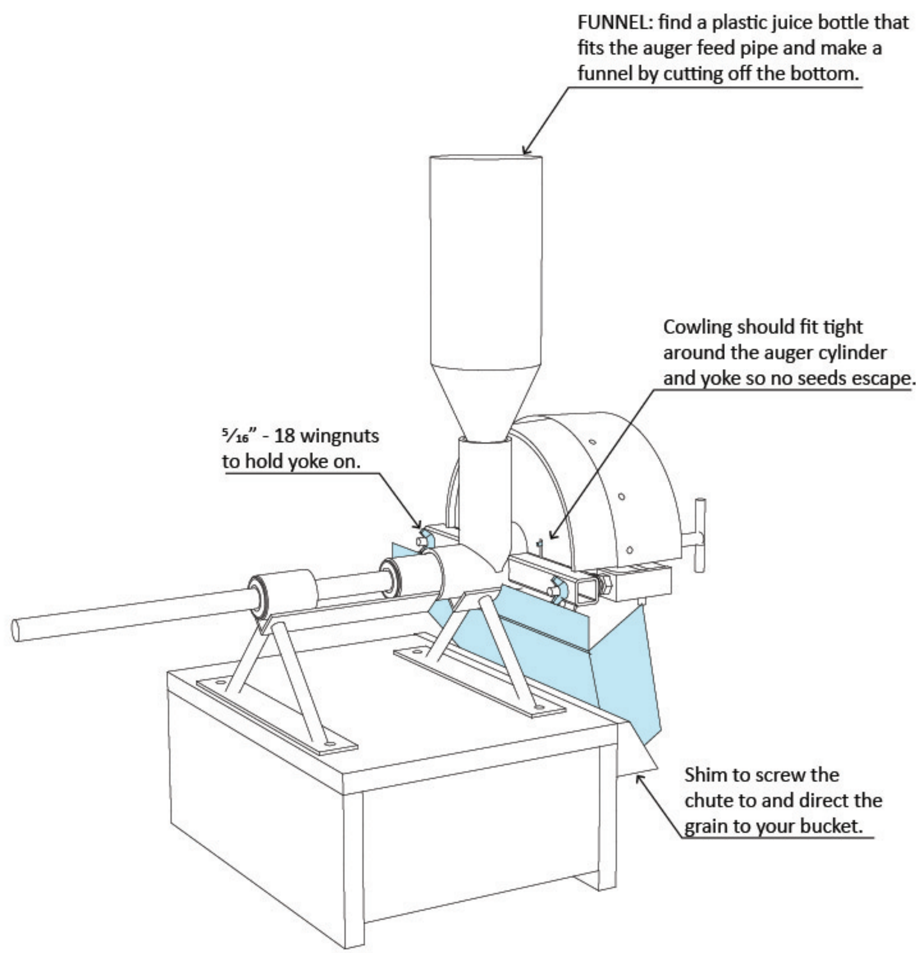
COWLING



CHUTE



ASSEMBLY

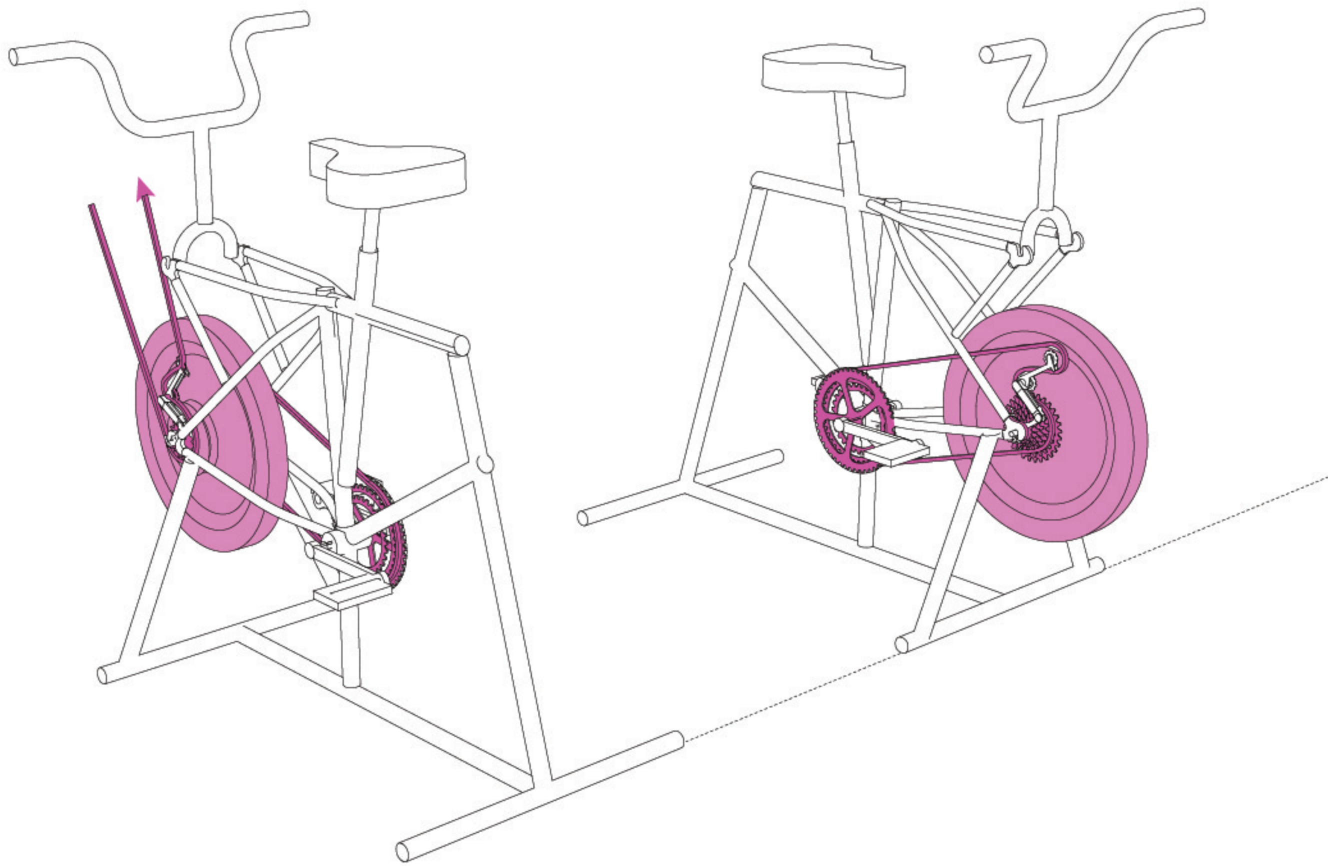


STEP 9 BIKE

Pictured is a method for taking two discarded bicycle frames and making a single stationary bicycle PTO with a flywheel (from an exercycle) and gears. Notice that the drive and non-drive side are reversed. This means some cold setting of the rear triangle may be necessary to accommodate the rear gear cluster. This PTO has the advantage that good components, gears, and a good rider position (power position) can be used. For grinding flour this is great because it takes a lot of power to make flour. Also, dehulling requires less power and a higher rpm, so gears are helpful if the plan is to switch back and forth between dehulling and flour milling.

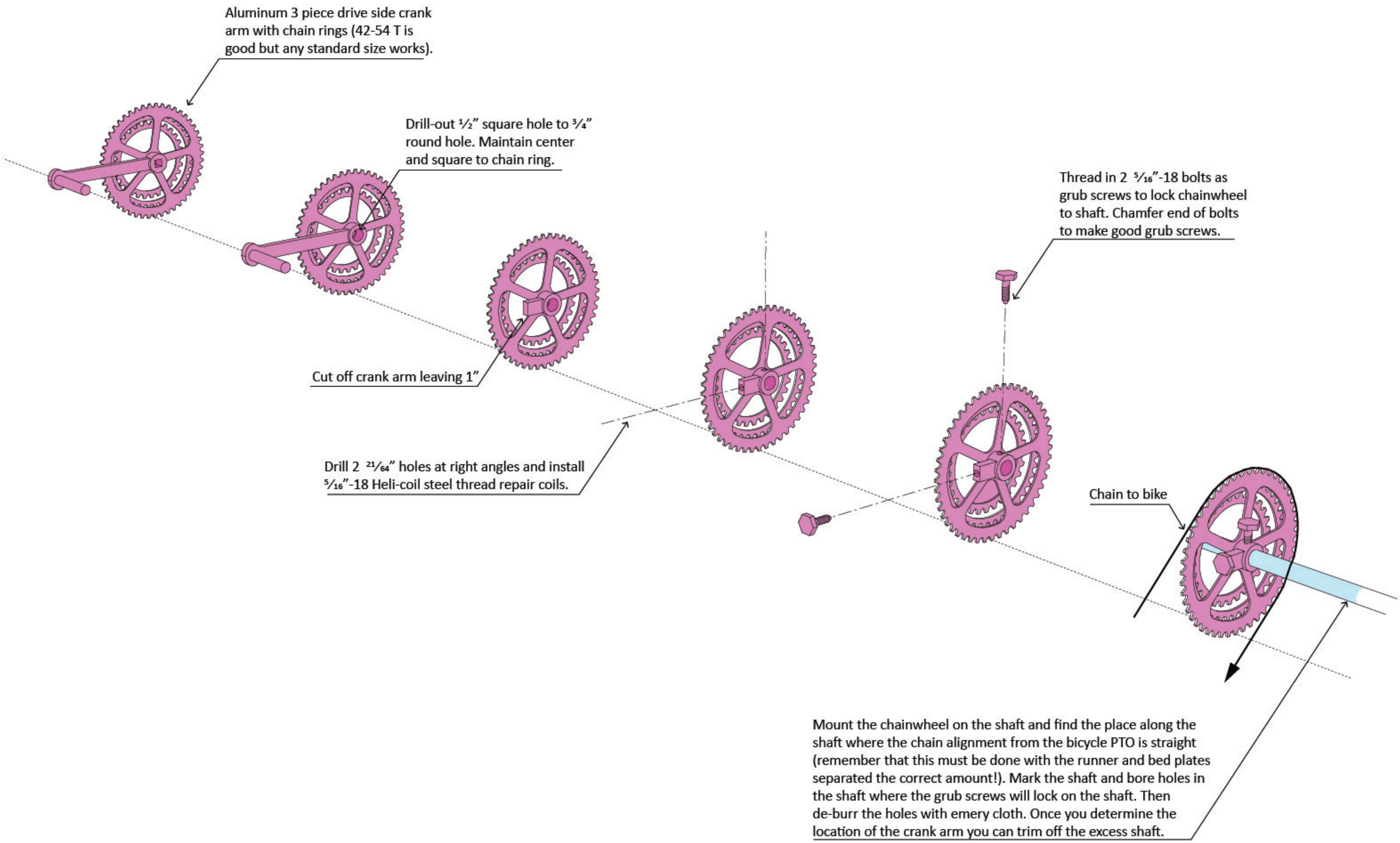
Originally we toyed with the idea of having one bicycle PTO that could be moved from machine to machine. This ended up not working well, as too much set-up time is lost between processes. Obviously this bicycle PTO takes much longer to build than the simple modifications to an exercycle detailed in the previous Grain Bike plans (Thresher, Fanning Mill). It is included because exercycles are sometimes harder to find than bicycles, and some bicyclists will insist on higher performance components and a better riding position than offered by old exercycles.

The choice to use a standard (upright) bicycle position rather than a recumbent position is because the upright position allows the rider/operator to use their hands to feed or adjust the machine being used.



STEP 10

CRANK ARM

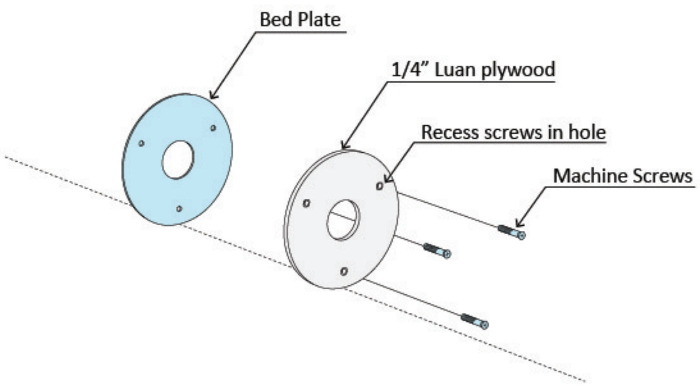


STEP 11

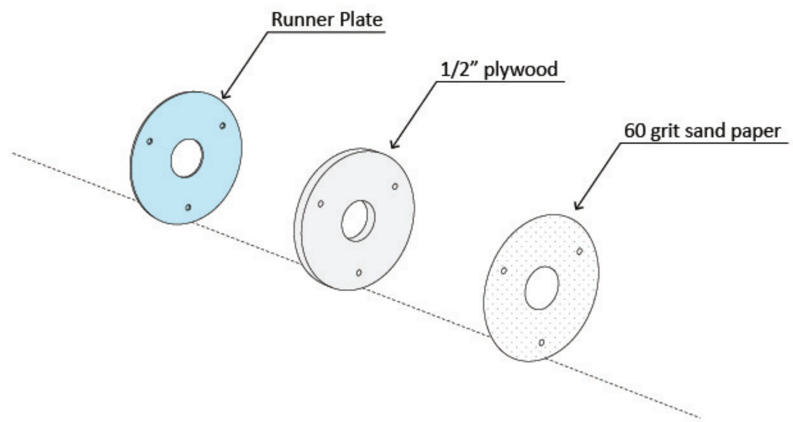
SQUARING SHIM

With the mill assembled and mounted on the frame with the bicycle, one last step can be performed to square up the two plates for precision operation. A 1/4" plywood (such as luan) disk (6" OD) is bolted to the bed plate with machine screws that are recessed in the plywood 3/16". A runner disk of 1/2" plywood is prepared with 60 grit sandpaper glued to it, nice and flat. The mill is assembled and operated so that the sandpaper "runs in" the shim. It usually takes a few minutes of sanding and blowing out the dust until the sanding disk touches the shim over its whole surface. Now the two faces are exactly square. The shim will live on the bed plate sandwiched between the bed plate and what ever bed disk (dehulling or flour burr) is in use. In order to record the shim's orientation make a "timing mark" on the shim and the bed plate.

SHIM



RUNNER DISK



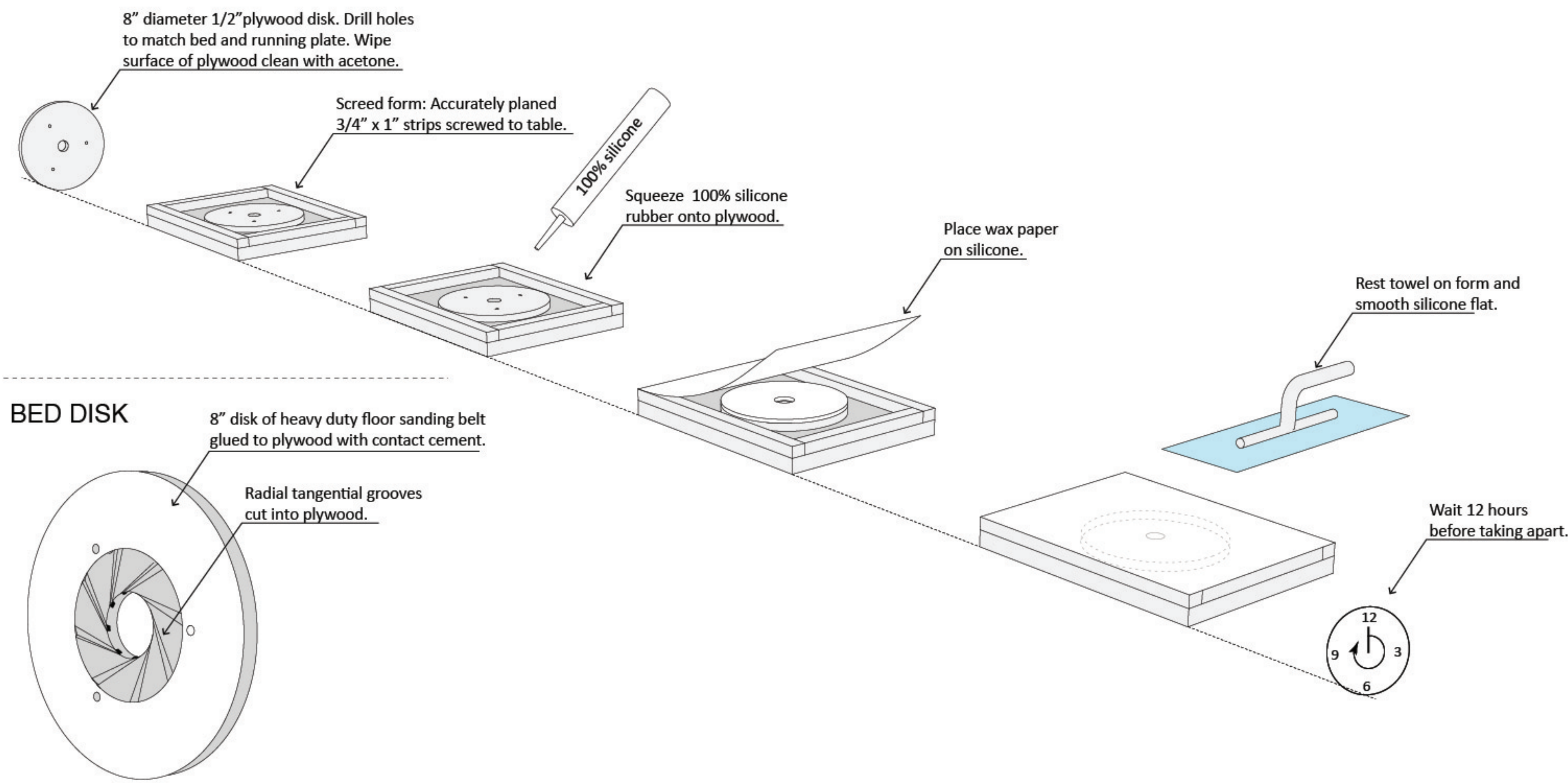
STEP 12

DEHULLING RUNNER DISK AND BED DISK

The runner disk for the dehuller is made by casting a 1/4” thick layer of silicone rubber (use 100% silicone with no additives) on to a flat disk of 1/2” plywood. To cast the silicone rubber nice and flat a screed form is set up around the plywood disk. The silicone is squeezed on to the disk and then a piece of wax paper is laid on top of the silicone and it is towelled flat through the wax paper with the trowel always touching the screed form as a guide for flatness. A good trick to know when tooling silicone is that a wet surface or an ice cube will tool the material without sticking to it. The water left behind does not damage the cure (it actually helps it cure faster). It is reasonable to anticipate that a couple of tries will be required before a good silicone casting is produced. Luckily the cost of making several tries is small.

The bed disk for the dehulling disks is a flat plywood disk with a piece of heavy duty floor sanding cloth (80 grit) glued to it. A series of “radial-tangential” grooves are cut in the plywood to create flumes that admit more grain between the disks. These flumes are made with an angle grinder, wood carving dremel, or chisel and mallet. The flumes have a vertical side and a tapered side. The vertical side is the trailing edge in the direction of travel. The tapered side is the leading edge in the direction of travel (“relative to the spinning runner disk, the bed plate “travels” the other way), and the tangential incline of the flumes is away from the direction of travel. Since plywood wears quickly, eventually the user will want to make a steel bed disk from 1/4” or 3/8” steel plate. Then, instead of sanding cloth, the surface of the bed disk can be made rough by grinding, scoring, etching or blasting.

RUNNER DISK



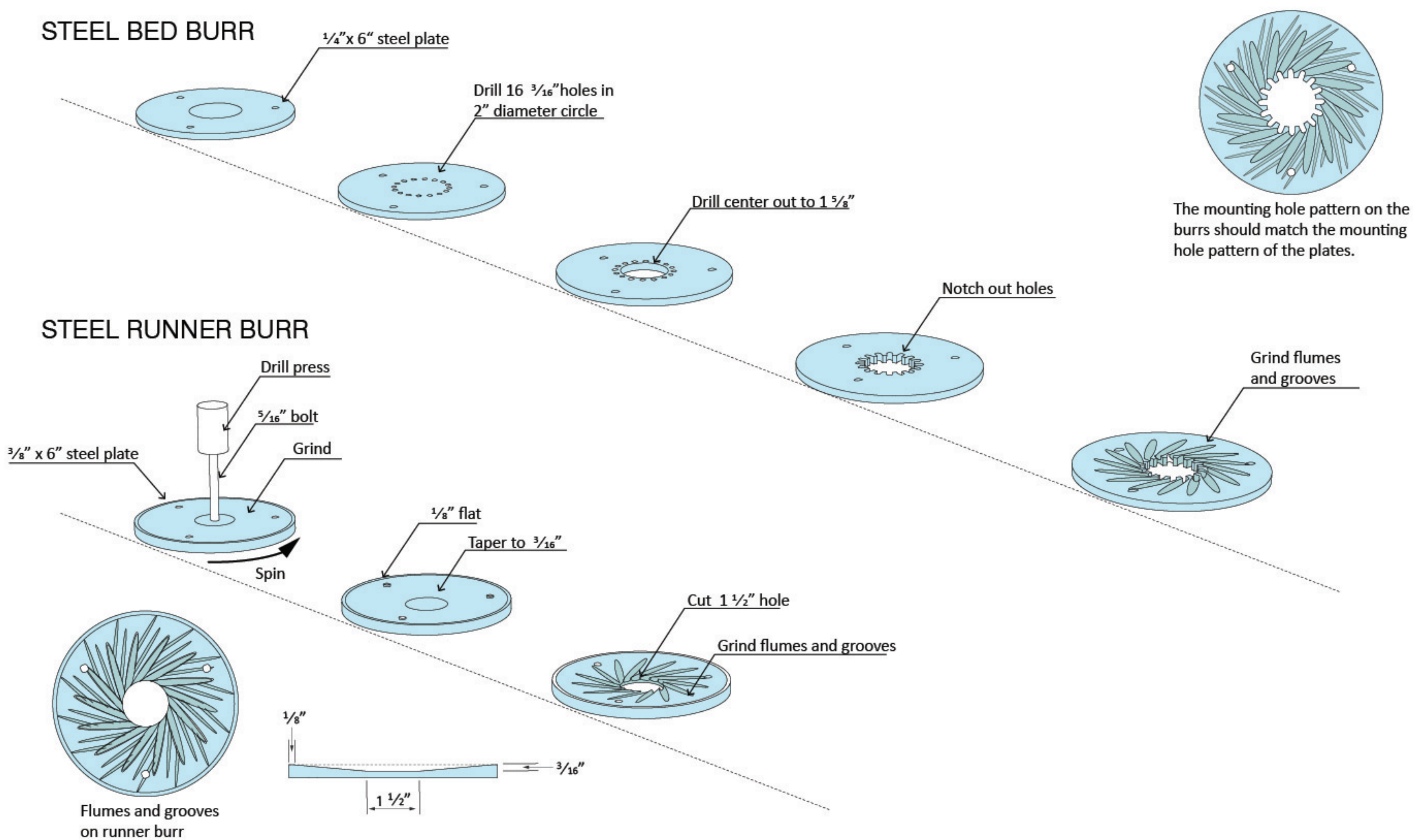
STEP 13

FLOUR BURRS

Steel or stone flour grinding burrs can be bought and mounted on the bed plate and runner plate. Or, steel burrs can be fabricated. The trick to fabricating steel burrs is that one of them, in this case the runner, is dished so that the two burrs only interfere (touch) at the outside edge. To dish the runner burr, cut out a 6" disk from 3/8" steel plate. Make a 5/16" hole in the center of the plate and use a 5/16" bolt with the head removed to mount the plate in a drill press or drill (clamped in a vise). Spin the disk and grind it with an angle grinder until the center (where the diameter equals 1 1/2") is 3/16" lower than the outside edge. Then drill a 1 1/2" hole in the center so the runner burr can mount around the auger shell. The bed burr is a 1/4" steel disk with the center drilled out to 1 5/8". Then a circle of sixteen 3/16" holes is drilled around the center hole of the disk and each hole is turned in to a notch with a jig saw. These notches let more grain between the plates.

Finally, on both burrs a series of flumes and grooves are ground with an angle grinder. The pattern of the flumes and grooves is "radial-tangential" and the flumes grooves should be deeper and wider toward the center and taper toward the outside edge with no groove at all in the outside 1/8" of diameter.

The shop made burrs are easy and cheap to make, however, they don't work as well as high quality commercial burrs.



OPERATIONS

When dehulling, the mill is sensitive to the adjustment of the gap between the runner disk and the bed disk. To properly tune this gap for a batch of grain, start with the gap too wide (1/8"-3/16", depending on the size of the grains). Operate the mill until grain starts falling out from between the disks. Tighten the adjustment bolt on the yoke in small increments until the grain falling out of the mill is dehulled. The hulls should be rubbed off in flakes; if the hulls are falling out as fine powder, then the gap is already too small. If some of the grain is not being dehulled, then the gap is too wide. Note that there is a time lag between when the gap is adjusted and when the grain exiting the mill shows the effects of the adjustment. Therefore, it is necessary to make a small incremental adjustment and wait to see its effect. Once the proper adjustment is obtained, the locknut on the yoke is tightened to hold the adjustment bolt in place. Then any grain in the collection bucket can be added back in to the mill for re-processing. Sometimes a batch of grain contains kernels of widely varying size, making it impossible to properly adjust the gap. Then it is necessary to either make 2 passes through the dehuller, with a smaller gap on the second pass, or to grade the batch of seeds in to two batches of more uniform kernels. For rice, 99% dehulled is ok for eating. However, 95% dehulled is unacceptable for eating and 90% dehulled is a nuisance to eat.

Sustainable Agriculture Research & Education

Questions + Comments + Donations -
Contact Lu Yoder - bravelittleship@gmail.com

This project was supported in part by the Northeast Sustainable Agriculture Research and Education (SARE) program (www.nesare.org). SARE is a program of the National Institute of Food and Agriculture, U.S. Department of Agriculture.

Open-Source, DIY Seed Cleaner Plans

Released for the benefit of small independent seed producers.

This design combines traditional zig-zag aspirator design with a 'swirl chamber' just below take-off to allow repeated sorting of each seed as it is poured though.

Suitable for small seed (poppy, amaranth) to medium seed (squash, sunflower)

Construction cost was less than 5 GBP using scrap materials.
Using purchased materials cost would be under 50 GBP.

Remember though that this is only designed for small-scale batches: lots of a few grams to 10kg or so. Bigger than that you'll need a different solution because the square-rule law applies - if you double the size you'd need 4 x the suction!

If you make one, please email us a picture of yours! We'll put them up here.

[Courgettes & Summer Squash](#)

[Cucumbers, Achocha & similar things](#)

[Fennel](#)

[Flowers](#)

[Grains](#)

[Herbs](#)

[Kale](#)

[Kohl Rabi](#)

[Leaf Greens for Cooking](#)

[Leeks](#)

[Lettuces](#)

[Melons & Watermelons](#)

[Mustard Greens (for cooking)](#)

[Onions - normal](#)

[Onions - special types](#)

[Oriental Greens for cooking & salads](#)

[Parsnips, Root Chicory & Root Parsley](#)

[Peas](#)

[Pumpkins & Winter Squash](#)

[Radishes (salad, & cooking types)](#)

[Salad Vegetables](#)

[Sweet Corn](#)

[Swedes](#)

Important - read the link above before you make one.
Basically you can make one for your own use,
but you have to tell people where you got the plans (including a link to us),
and can't sell copies of the machine for a profit.
You are free to adapt the plans and improve it - but the same rules then apply to the new design.

Thanks! Ben.

[SweetPeppers]
[Tomatoes: Bush Types]
[Tomatoes: Vines - Cherries]
[Tomatoes: Vines - Larger]
[Tomatilloes & Groundcherries]
[Turnips]
[Unusual Tubers: Oca & Yacon]

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