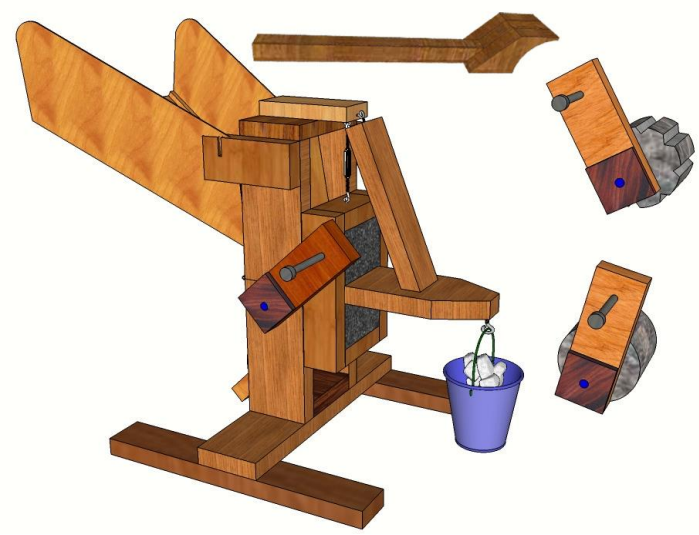
How to Build a Dry Biomass Grinder

Notes, Parts List and Drawings
Below are comments regarding construction and operation.



The biomass grinder was designed to grind dry biomass and to accomplish several goals. The objectives were the flexibility to grind a wide variety of dry biomasses, low-cost, easy to build using mostly hand tools, easy to operate, easy to maintain and require no welding.

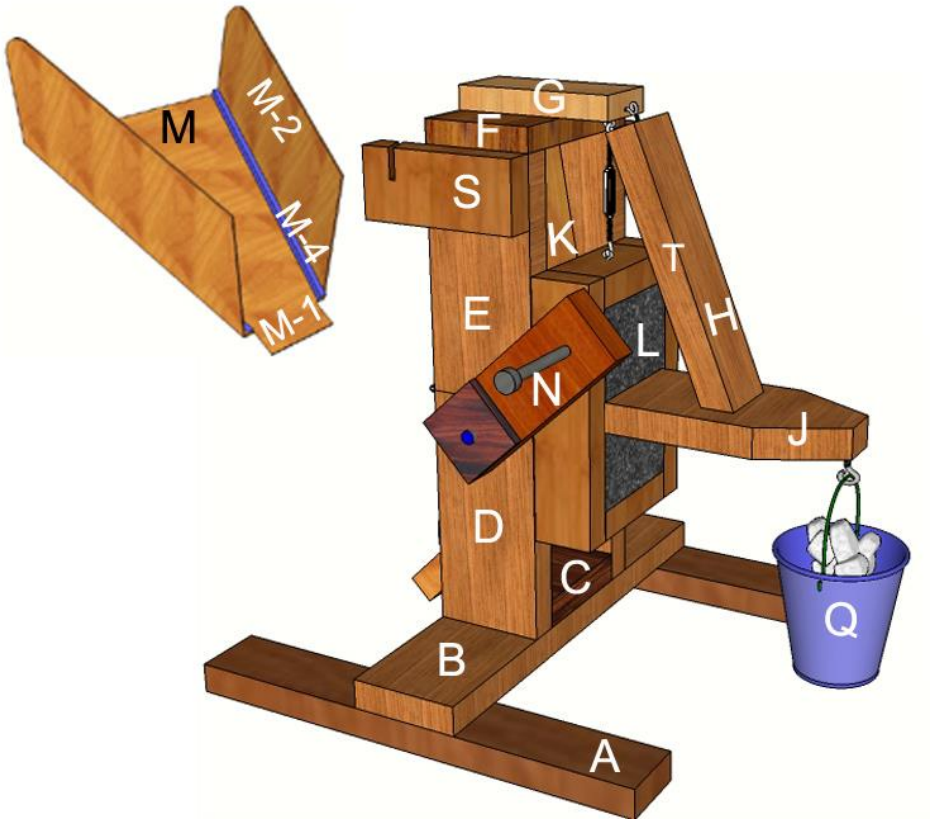
The grinding process is accomplished by rotating a concrete grinding head with its aggregate exposed against a matching concrete grinding cup with its aggregate exposed and introducing biomass in between the two surfaces. The grinding cup is supported with two degrees of freedom to absorb the movement from an out-of-round grinding head or the accidental introduction of small stones or stick into the grinding space. The grinding head is easily rotated using a hand crank at a slow speed (under 90 rpm). The unit can be powered from a bicycle, a foot powered treadle, a gasoline motor, or an electric motor. Grinding pressure is easily adjusted by the weight of a few rocks in a pail.

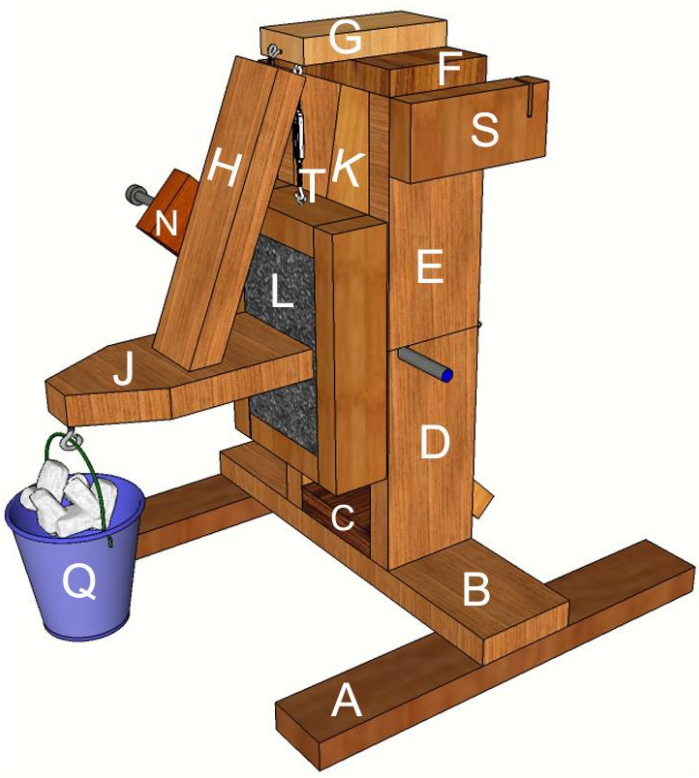
Two different grinding heads are available for flexibility in grinding various biomass materials. The grinder folds in half for storage and for a quick change in grinding heads without the use of tools.

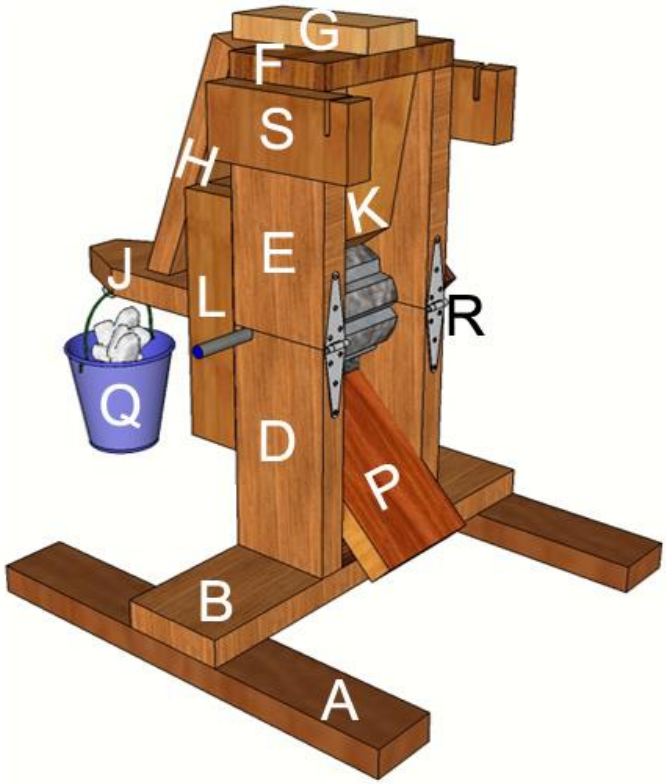
The grinder does a good job with soft biomass like peanut shells, leaves, grasses, dried banana fronds, etc. However, the grinder will not grind hard material like shelled corn or the like.

To simplify construction, we specifically eliminated the need for sizing grates typically used in a hammermill or other grinders to control particle size. Instead, we reprocess the biomass to achieve the correct particle size. If you are not happy with the particle size the first time through the grinder, simply run it through again. The process runs

quickly, and it takes very little time to reprocess. The smaller the particle size becomes, the faster the material moves through the grinder.

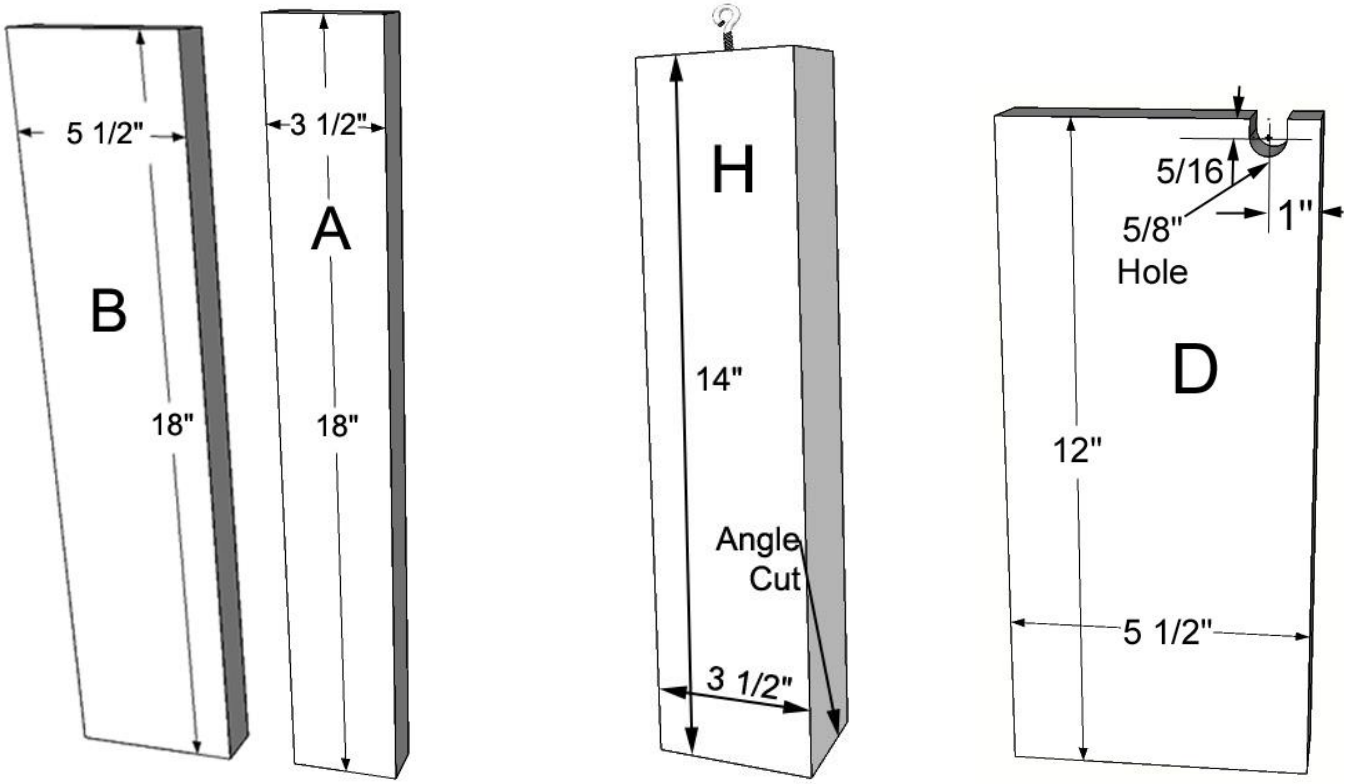


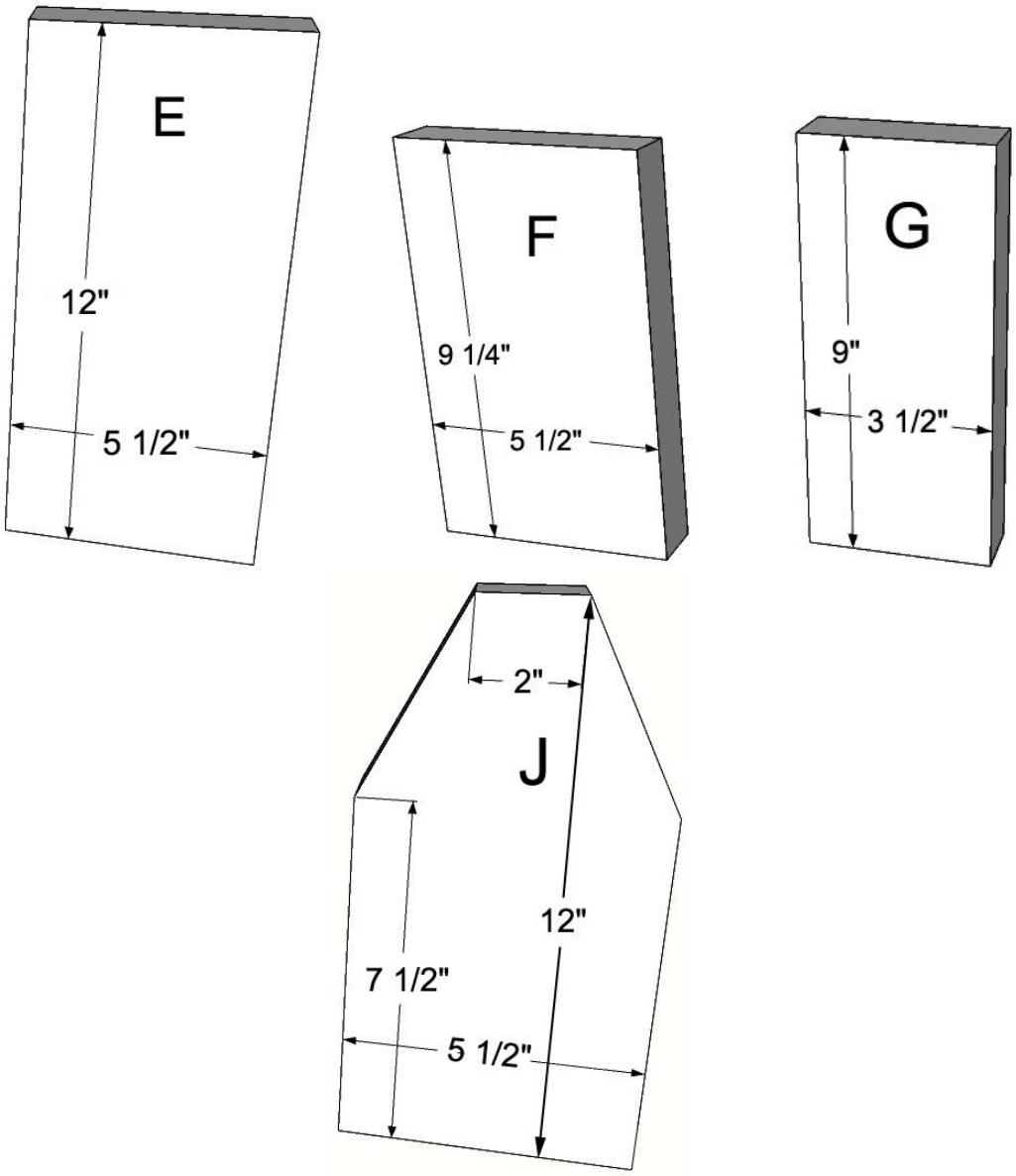


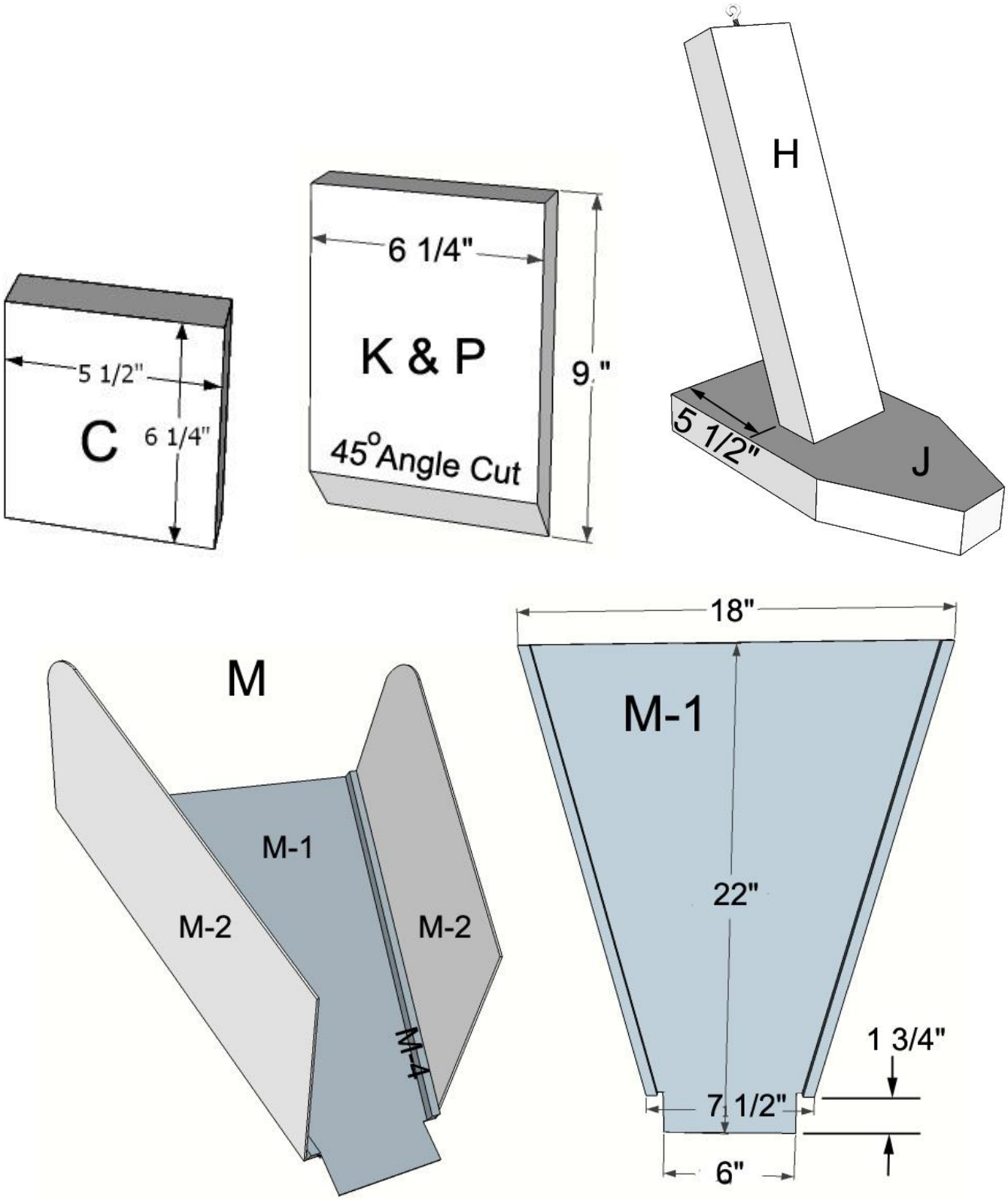


PART	PCS	DESCRIPTION
Wood	2	8’ X 3 ½” X 1 ½”
Wood	1	5’ X 5 ½” X 1 ½”
Wood	1	40” of ½” X ½” framing for the feed chute.
Wood	2	25”’ X 8” X 1/8” for M-2
Wood	1	18” X 22” X 1/8” for M-1
A	2	Feet - 1 ½” X 3 ½” X 18”
B	1	Base Plate - 1 ½” X 5 ½” X 24”
C	1	Rail Separator Lower - 1 ½” X 5 ½” X 6 ¼”
D	1	Rail Lower -1 ½” X 5 ½” X 12”, 5/8” slot, see drawing for location
E	1	Rail Upper - 1 ½” x 5 ½” x 12”
F	1	Rail Separator Upper - 1 ½” X 5 ½” X 9 ¼”
G	1	Grinding Cup Support - 1 ½” X 3 ½” X 8”
H	1	Grinding Cup Pressure Arm - 1 ½” X 3 ½” X 14”
J	1	Grinding Cup Pressure Foot - 1 ½” X 5 ½” X 12” See drawing for angle cut
K	1	Feed Stock Guide - 1 ½” X 6 ¼” X 9”
L	1	Grinding Cup, See drawing for construction details, Weight about 21 #
L-1	2	Grinding Cup Top/Bottom Support - 1 ½” X 5 ½” X 6 1/8”
L-2	2	Grinding Cup Side Support - 1 ½” X 5 ½” X 13”
M-1	1	Feed Chute Base - Cut from 1/8” X 18” X22” Stock, see drawing for cut details
M-2	2	Feed Chute Side - Cut from 1/8” X 8” X30” Stock, see drawing for cut details
M-3		Not present
M-4	2	Feed Chute Framing Corner - ½” X ½” X 20”
N-1	1	Handle arm, cut from 1 ½” X 3 ½” X 9 ½” stock, with 5/8” center hole. See the drawing for hole locations. ½” x 5 ½” bolt threaded into 7/16” hole.
N-2	1	Handle retaining plate, ½” x 3 ½” x 3 ½” with 5/8” center hole
N-A	1	Grinding Head, No Teeth, 6” diameter, 6” Long, Brushed Concrete, Weight about 17 #
N-B		Grinding head with Teeth, 6” diameter, 6” Long, Brushed Concrete, Weight about 17 #
P		Feed Stock Exit Base - 1 ½” X 6 ¼” X 9”
Q	1	Grinding Cup Force Control (Bucket of Rocks) about 4 to 12 pounds
R	2	6” Strap Hinge
S	2	Feed Chute Support 8” x 3 ½” x 1 ½”, Cut slot to fit location and size of support bolt
T-1	4	Pins for Drum & Handle Pin - 3/16” x 3”
T-2	2	Handle Bolt - ½” x 5 ½” threaded into an 7/16” hole
T-3	2	15” X 5/8” Steel Axel
T-4	3	Depth Post, 6” x ¼” wood, plastic or metal.

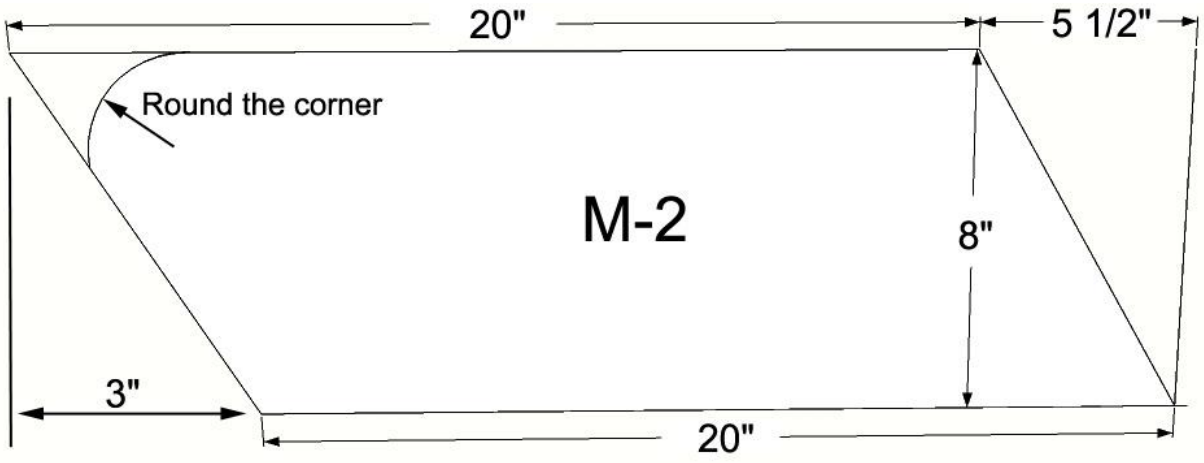
U	8	Teeth 6” X 1”,1”, 1” Triangle
V-1	1	Mold End Caps 6” x ½”
V-2	1	Mold End Caps 6” x ½”
W	2	Grinding head
W-1	1	No Teeth
W-2	1	With Teeth
W-3	1	Metal sheeting wrap for mold 7” X 24”
X	1	he feedstock plunger is curved to match the grinding head and assist with the initial grinding action by pushing the biomass against the grinding head.
X-1	1	Cut from a 24” x 3 ½” x 1 ½” stock
X-2	2	Cut from a 7” x 3 ½” x 1 ½” stock
Screw Eyes	4	3 inch long with wood screw base
Turnbuckle	1	4” Turnbuckle, Typical extension is about 6”
Bolts & Nuts	2	¼ X 2’ X20 TPI for feed chute support, plus Nuts & Washers
Washer	3	5/8” washers, one for each side of the grinding drum (if needed) and one for the inside of the handle, Part N
Fasteners	36	Wood screws, 3 ½” long
Fasteners	2	Wood screws, 4” long,

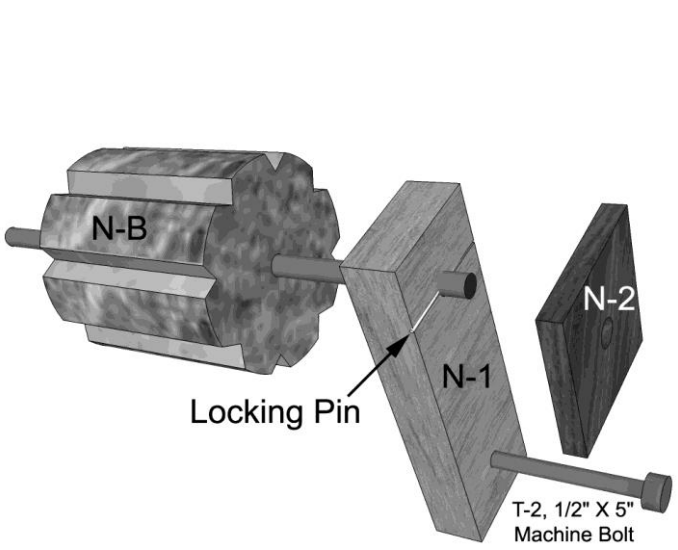


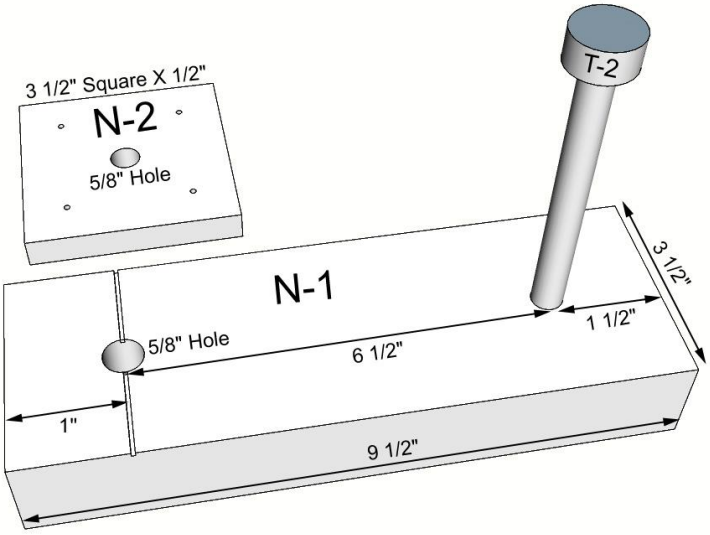

E
12"
5 1/2"
F
9 1/4"
5 1/2"
G
9"
3 1/2"
J
2"
12"
7 1/2"
5 1/2"

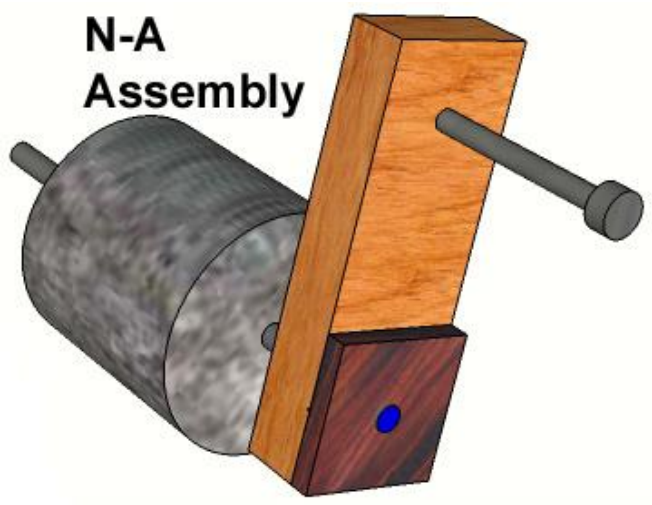


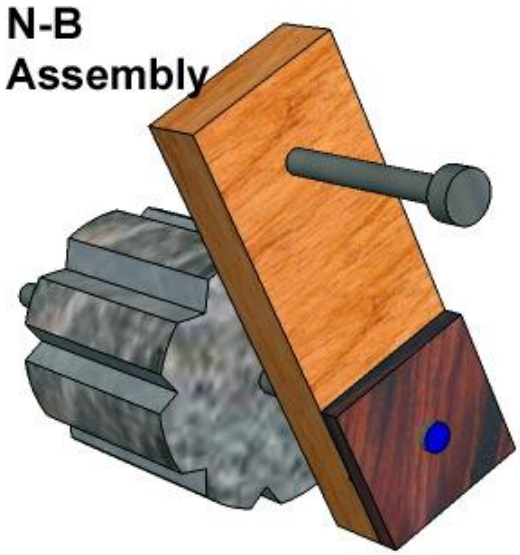
M-4 wood frame is from ½" X ½" stock

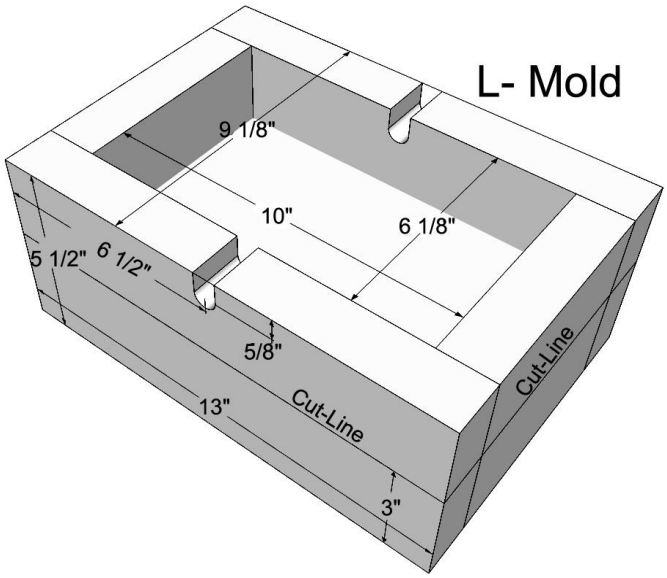

20"
5 1/2"
Round the corner
M-2
8"
3"
20"

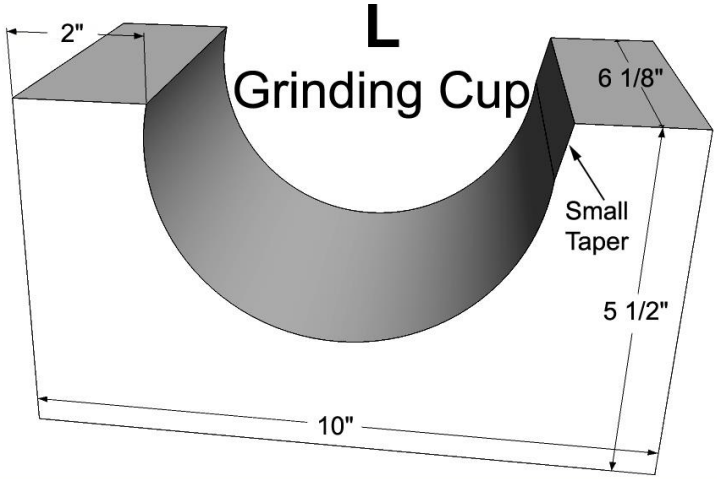

N-B
N-2
N-1
Locking Pin
T-2, 1/2" X 5"
Machine Bolt

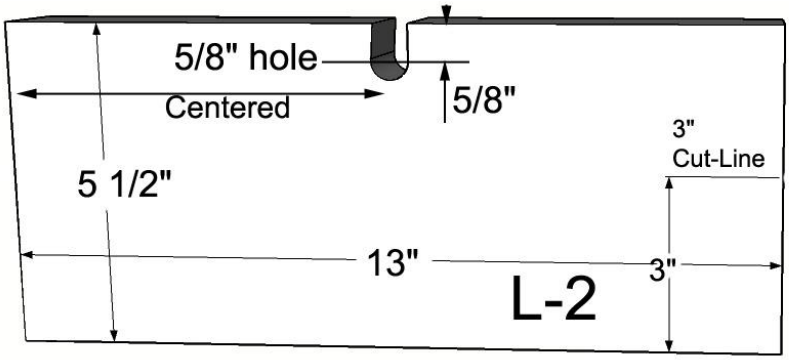

3 1/2" Square X 1/2"
N-2
5/8" Hole
T-2
N-1
3 1/2"
5/8" Hole
6 1/2"
1 1/2"
1"
9 1/2"

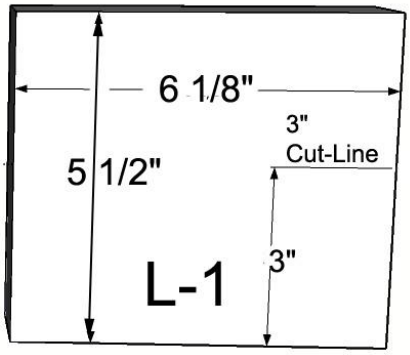

N-A
Assembly

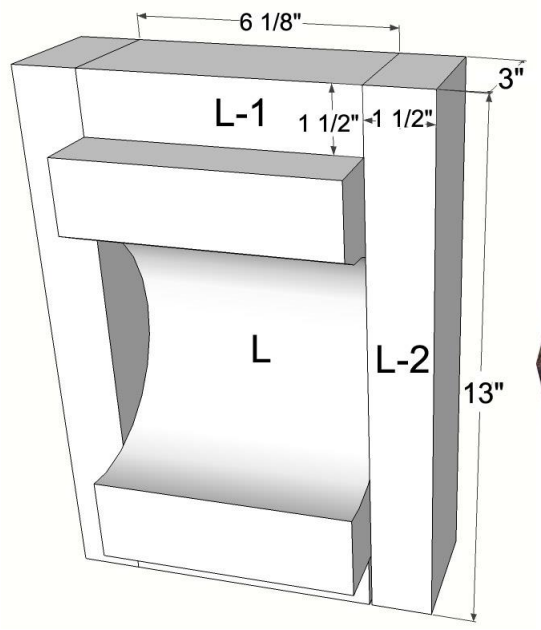

N-B
Assembly

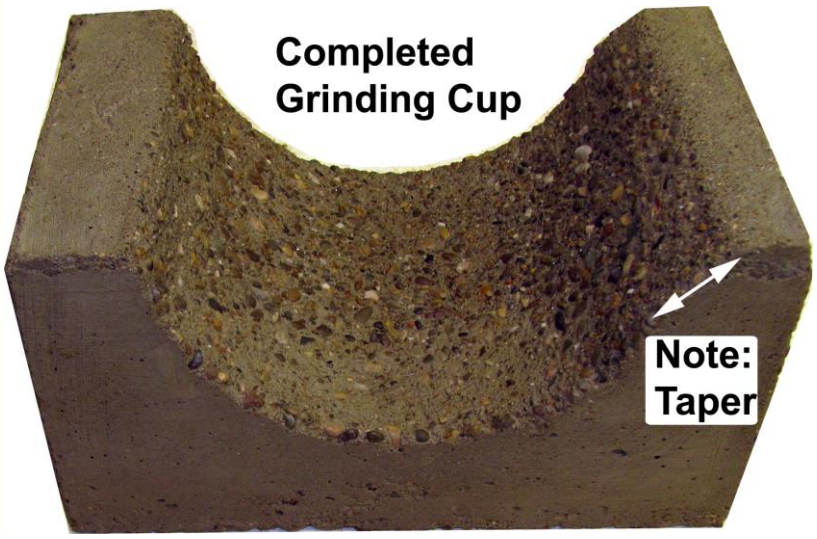

L- Mold
9 1/8"
10"
6 1/8"
5 1/2"
6 1/2"
5/8"
13"
Cut-Line
Cut-Line
3"

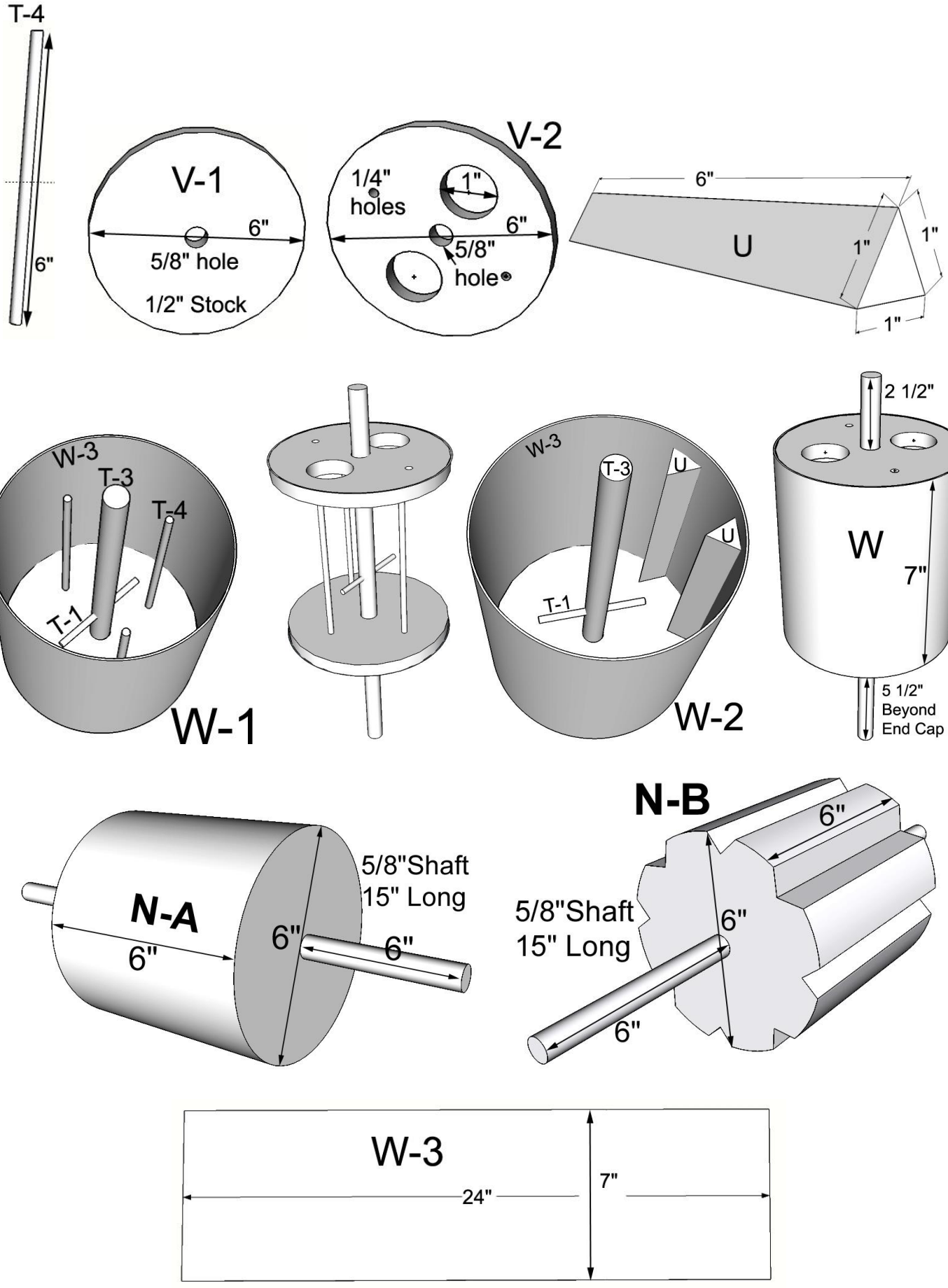

L
Grinding Cup
2"
6 1/8"
Small
Taper
5 1/2"
10"

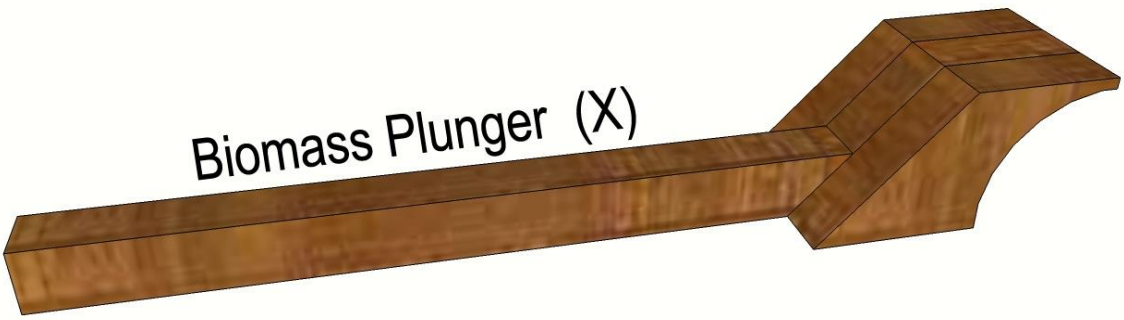

5/8" hole
Centered
5/8"
5 1/2"
3"
Cut-Line
13"
3"
L-2

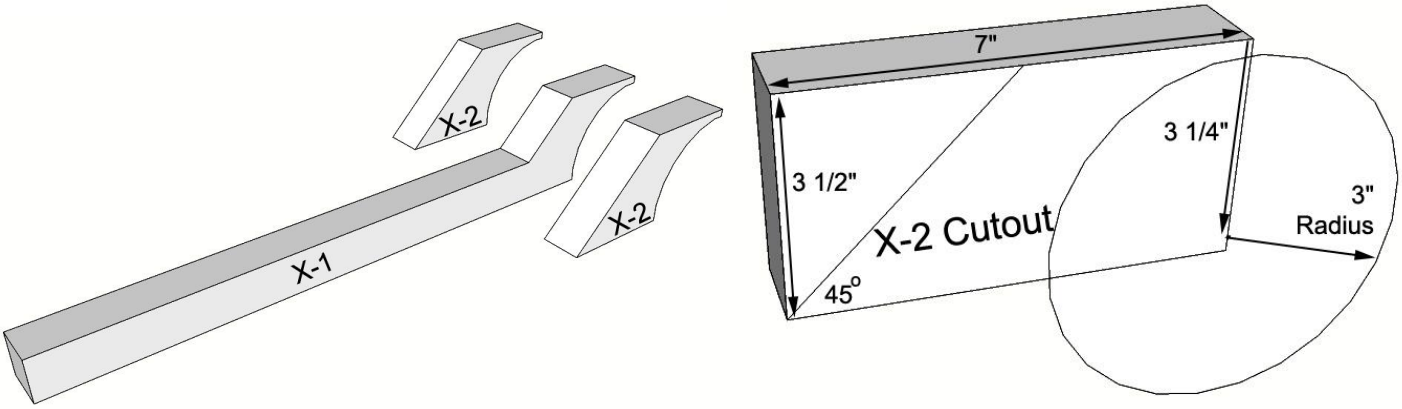

6 1/8"
5 1/2"
3"
Cut-Line
3"
L-1

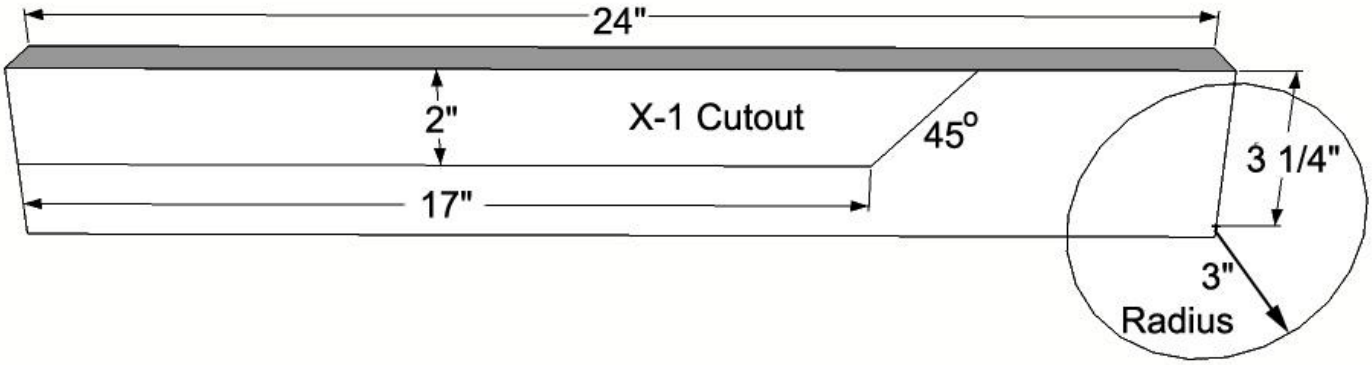

6 1/8"
3"
L-1
1 1/2"
1 1/2"
L
L-2
13"

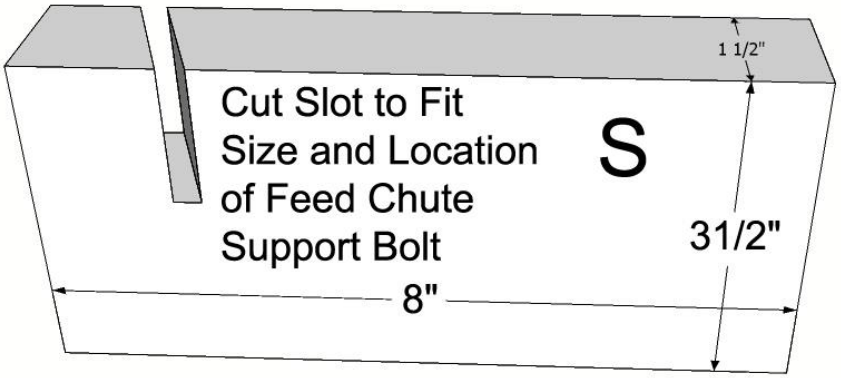

Completed
Grinding Cup
Note:
Taper


T-4
6"
V-1
6"
5/8" hole
1/2" Stock
V-2
1/4" holes
1"
6"
5/8" hole
6"
U
1"
1"
1"
W-3
T-3
T-4
T-1
W-1
W-3
T-3
U
U
T-1
W-2
2 1/2"
W
7"
5 1/2" Beyond End Cap
N-A
6"
6"
5/8"Shaft
15" Long
6"
N-B
6"
5/8"Shaft
15" Long
6"
6"
W-3
24"
7"


Biomass Plunger (X)


X-2
X-2
X-1
7"
3 1/2"
X-2 Cutout
45°
3 1/4"
3"
Radius


24"
2"
X-1 Cutout
45°
17"
3 1/4"
3"
Radius


1 1/2"
Cut Slot to Fit
Size and Location
of Feed Chute
Support Bolt
S
31/2"
8"

The dimensions are based on a standard lumber size of 3 ½" wide X 1 ½" thick material, and 5 ½" wide X 1 ½" thick material. The grinder can be constructed using softwood.

We suggest first building the mold for the grinding heads and the mold for the grinding cup. Then make both grinding heads, one after the other, and then the grinding cup. Set them aside to remain wet and cure for 4 to 5 days while you make the remainder of the grinder. Use the grinding head N-A as part of the L-Mold.

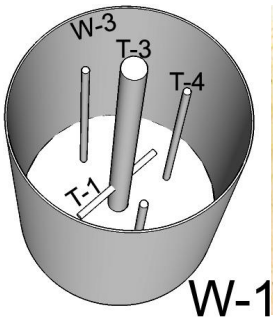
Make T3 complete with holes for the 3, T-1 pins. Construct the L-Mold, and make V-1, V-2, the eight teeth (U), the three spacer pins T-4, and the three shaft pins T-1. Accurately drill a 5/8 inch hole in the center of V-1 and V-2, and pay careful attention to make the end caps perfectly round. Mark the bottom disk V-1 with 8 equally spaced radial lines.

Soak the teeth (U), the end caps (V-1 & V-2) and the spacer pins (T-4) in hot oil or melted grease for a few hours. **It is very important that wood does not absorb moisture and swell up when in concrete.** If that occurs it can crack and break the concrete as the wood is swelling and the concrete is curing.

Assemble the mold parts, shaft, pins, end caps, teeth, flexible cylinder, flexible strap clamps or circle clamps, and concrete mix with aggregate.

Insert T-1 pin in the center of shaft T-3, and push T-3 through the end cap V-1 so the radial lines are visible from the inside of the mold.

Push the shaft 5 1/2 inches beyond the outside surface of the end cap. Wrap the metal sheeting cylinder (W-3) around the bottom end cap and secure with a flexible strap clamp.



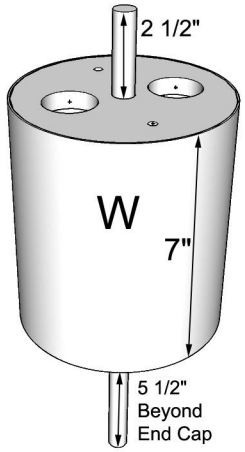
W-1

Loosely fit the second strap clamp to the top of the cylinder. Tighten the lower clamp so the sheeting is pulled tight around the bottom end cap. Lightly coat the inside surface of the cylinder with oil or light grease.

Fill the mold with concrete containing aggregate to about 1 inch from the top.

Position the three spacer pins (T-4) evenly and make certain they completely touch the bottom end cap. These spacer pins assure that the grinding head is exactly 6 inches wide. Using a long screwdriver or rod, jiggle and vibrate the concrete to release air bubbles.

Place the top end cap over the shaft and down into the cylinder until it is flush with the end of the cylinder.



Snug up the metal cylinder by tightening the top strap clamp until it is firmly touching the circumference of the end cap.

Finish filling the mold through the two fill holes in V-2. Vibrate the concrete often to distribute the concrete evenly below the end cap. Expect to see air bubbles from the two vent holes.

After the mold is completely full and free from air bubbles, remove any excess concrete in the fill hole.

Double check to make certain that the end caps are perpendicular to the shaft and that the end caps are evenly inserted into the very ends of the cylinder. They should not be pushed beyond the end of the cylinder. The objective is to have the ends parallel to each other and perpendicular to the shaft.

Allow the concrete to cure just enough to be firm but soft enough that you can use a wire brush to expose the aggregate. There is no accurate way to predict exactly how long this will take. With quick setting concrete the outer cylinder is ready to be removed in 70 to 90 minutes. However, with slow setting concrete you will need to keep testing the firmness by lightly scratching the concrete through the fill hole until you are confident that the cylinder can be removed. Make certain that the concrete is in the shade and away from heat or the sun.

After you have carefully removed the cylinder, keep the end caps attached to the shaft and in their location. This will prevent the edges of the grinding head from being damaged while the concrete is still fresh, and you wire brush the concrete.

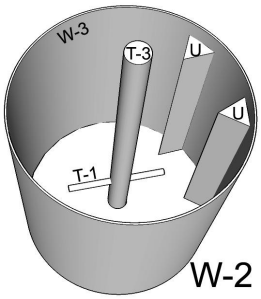
Carefully place the concrete drum into a shallow pan of water and using a wire brush lightly scrub the surface from both ends moving toward the center to remove concrete and expose the aggregate.

When you are comfortable that enough aggregate has been exposed, lightly rinse the outside of the drum, cover with a wet cloth, and leave it the pan to cure.

Cover the entire pan with a plastic bag and let cure for approximately 4 days. Open the bag occasionally to check on the progress and to make sure the cloth is wet. After 24 hours you can remove the end caps.

At the end of four days remove the bag, rinse the grinding head and allow to air dry.

Next, repeat this procedure to make the grinding head with teeth (NB). There is no need to use the spacer pins (T-4) since the wood teeth will accurately determine the correct cylinder width.



Use a small dab of grease to temporarily hold and position the teeth around the inside circumference. After the cylinder contains some concrete you can re-adjust the teeth for their final position. Make certain they are parallel to the shaft and evenly spaced.

Remove the cylinder when you are comfortable that the concrete has cured sufficiently to be able to wire brush the teeth to expose the aggregate. Do not wire brush the V section of the teeth. Again, keep the end caps in place for about 24 hours until the concrete has cured enough to safely remove them without damaging the edges. Again, cover with a wet cloth and plastic and keep wet for curing.

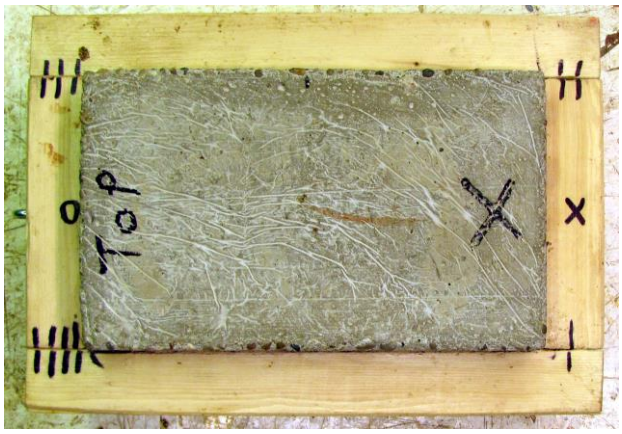
Completed Grinding Head Assemblies

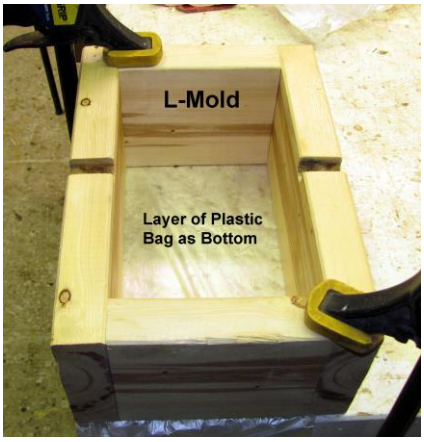
When the grinding heads have cured, assemble the handles onto the long end of the shaft (the 6” end).

If the length of the grinding head turns out to be a little short, place a 6” disk of thin material on one end to prevent biomass from creeping into the open void when inserted into the grinder.

L-Mold

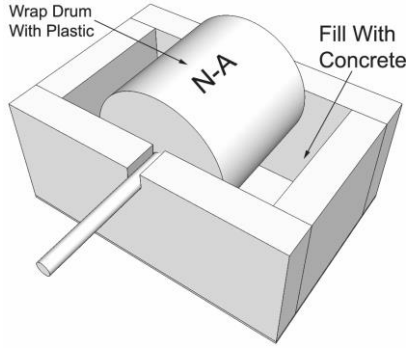
Place registration marks on the bottom corners of the L-Mold to ensure an accurate reassembly after the mold has been separated. Coat the inside of the L-Mold with oil or grease.

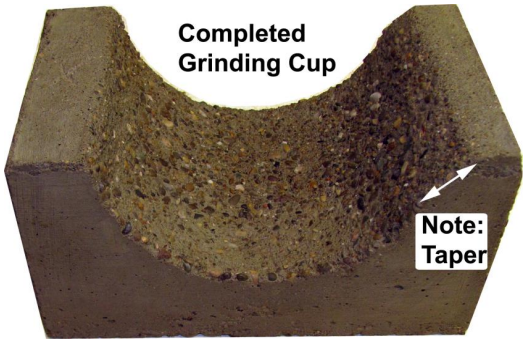




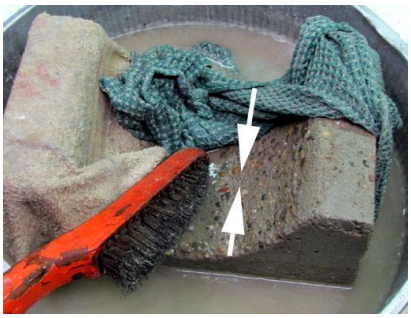
After the no teeth grinding head (NA) has cured for a few days, wrap it tightly in plastic and insert it into the two slots in the L-Mold. Fill the mold with concrete and jiggle to remove air bubbles.

After the concrete has a slight amount of firmness, use a trowel or putty knife, and create a slight taper in the diameter of the cup at the edge of the grinding head. See note below. Pull the concrete back about ½” wide and 1” deep. This is the entrance for the biomass in between the grinding surfaces.



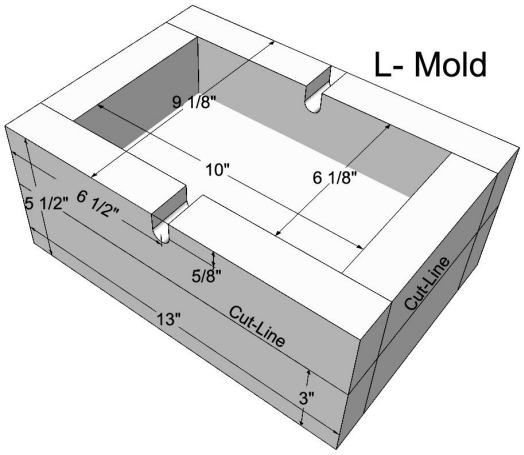


Remove the four sides of the mold when you are comfortable that the concrete is firm but soft enough to scrub to expose the aggregate. Make certain that you scrub from both sides toward the center so as not to damage the edges.

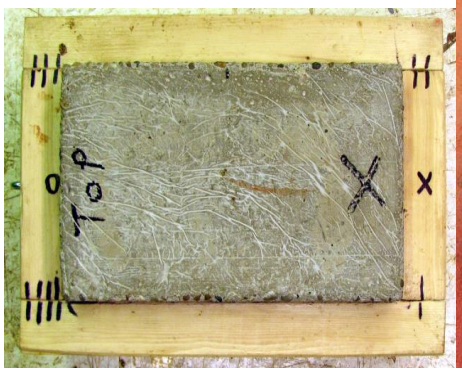


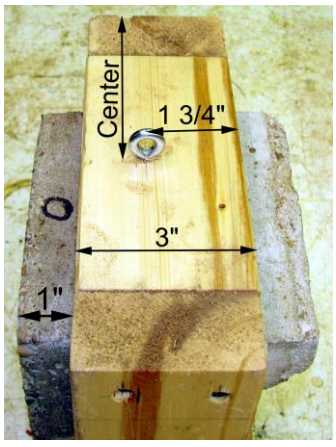
When you have exposed an adequate amount of aggregate, rinse lightly, cover with a wet cloth and enclose in a plastic bag to cure for about four days.

Reassemble the L-Mold and cut the mold into two sections at the cut line. Keep the bottom section of the mold as the holder for the grinding cup.



After the grinding cup has cured and following the registration marks, reassemble the bottom section of the mold around the grinding cup and leave 1 inch of the grinding cup extending beyond the back of wood frame. Place a screw eye on the top edge, i.e. the end with the taper.

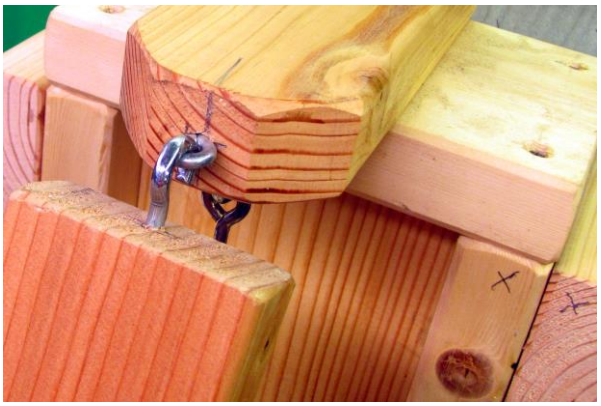


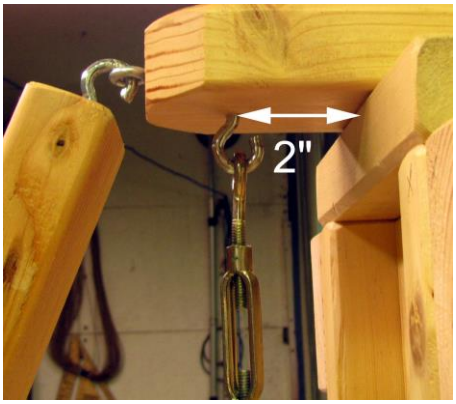


Make the remaining components for the grinder and assemble using your individual style of construction. There are no critical steps for the order of construction.

Centering: part B is centered on A, parts C, D,E & F are centered on B, part G is centered on F

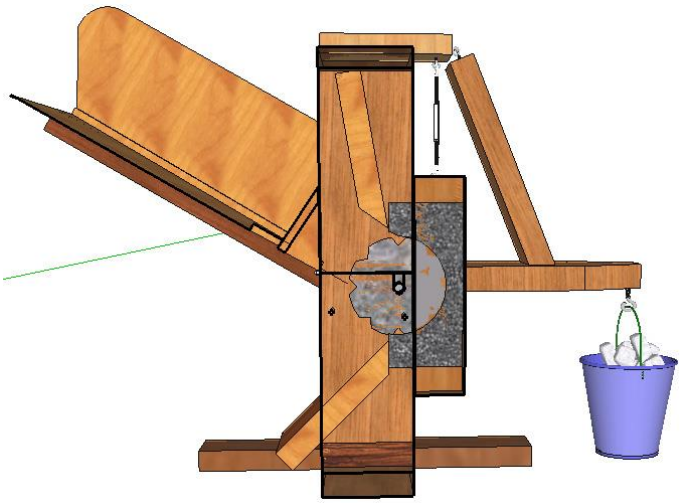
Hardware Connections





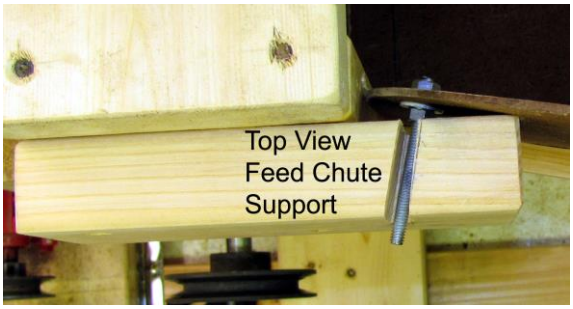
Clearance: Part K is adjusted for a close clearance but not touching either the grinding head or the front side of the grinding cup. The same clearance is required for the exit chute (P).

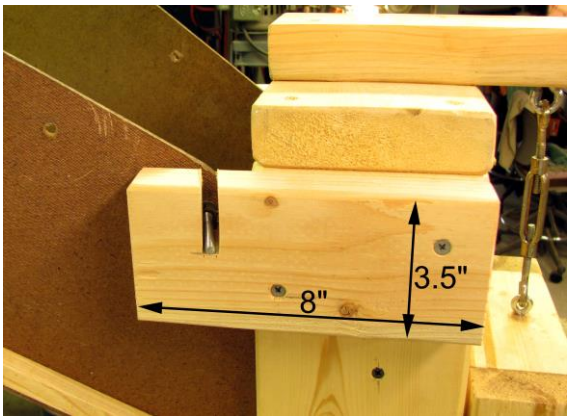
Place a screw eye centered on the end of (G) and a hook centered on the end of (H) for a quick connect/disconnect of the pressure arm.

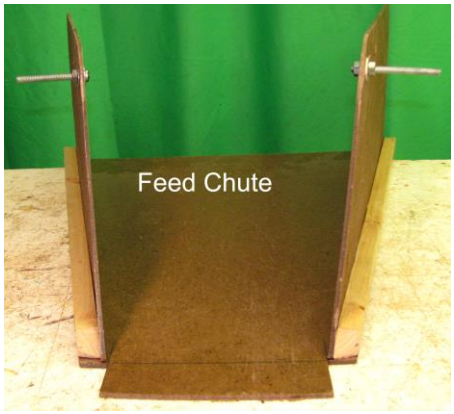


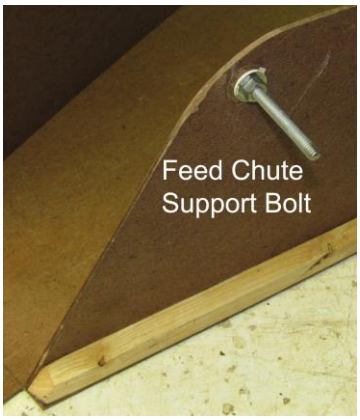
Temporarily attach the feed chute support brackets (S) to the top of part (E).

Temporarily hold the feed chute in position to determine exactly the correct height adjustment and the correct support bolt location, and mark accordingly. The correct location is when there is a very small gap between the grinding head and the bottom edge of the feed chute.

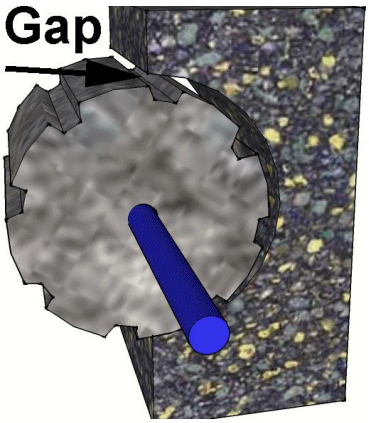




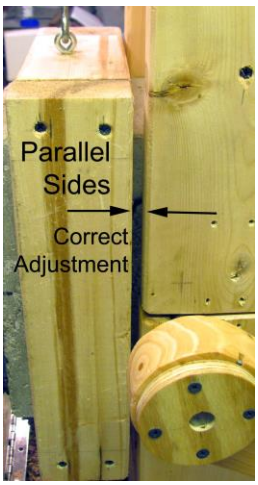


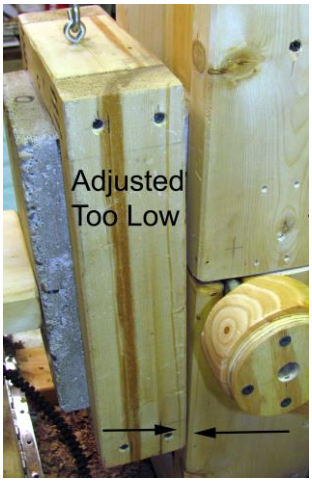


Proper Adjustment of the grinding cup against the grinding head is very important for good grinding. There are two necessary adjustments.



The first is the vertical adjustment of the grinding cup using the turnbuckle. After some wet concrete was removed to expose the aggregate for both the grinding head and the grinding cup, there is clearance between the two when placed together. Adjust the vertical position of the grinding cup so the bottom of the cup just contacts the bottom of the grinding head. This will allow for ample space at the top between the grinding head and the grind cup for biomass to enter into the grinding space. This adjustment may vary a little depending of the type of biomass. Adjust until you are happy with the grinding output.





Secondly, adjust the pressure of the grinding cup against the grinding head by selecting the weight of the rocks in the pail. This adjustment will vary depending of the type of biomass and the desired particle size. Typically around 8 pounds works well but will vary considerably for various biomasses.

Operation:

Expect to see the grinding cup move around a bit as the grinding head is rotated. The grinder was specifically designed to absorb movements from an out-of-round grinding head or from a small stone, or stick getting into the grinding space.

Use the plunger to push biomass up against the grinding head.

Reprocess the material until you have achieved the desired particle size.

The grinder only works on dry biomass.

Adjust both the height of the grinding cup and the inward force (pail of rocks) on the grinding cup to achieve the results you desire. While the grinder works well for a wide variety of material, it works best when the particle size is short, say under three inches. Long strands of biomass will not grind properly. Consider cutting or chopping into short sections if the material is long like some grasses or vines.

Experiment using both grinding heads to determine what works best for your specific biomass.

Occasionally lubricate the grinding head bearing supports with oil or grease.

The shaft on the opposite end from the handle is for a pulley or chain sprocket when powered from a motive source. We recommend not exceeding 90 RPM for the best grinding.