The Winnow Wizard
Kit and Complete Assembly Instructions

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The Winnow Wizard Story

When I started working for Frank Morton at Wild Garden Seed in 2014, my only previous experience with winnowing had been with homegrown popcorn, shelled during the holidays in Minnesota and carried quickly out into a snow-crusted field for a quick, numb-fingered winnow in a frigid wind. Through my first summer at Wild Garden, as we brought in kale and lettuce, calendula and amaranth, we stored the chaffy seed in wrapped up tarps awaiting the right wind. When the sea breeze rolled through on August afternoons we would abandon our fieldwork in the hot sun and set up winnowing stations in the shade of great oaks, letting the wind carry away the dust, leaves, and seedpods, concentrating the seed for storage until final cleaning season in the fall and winter.

When fieldwork wrapped up in October, we moved into the greenhouse with our bins, screening and winnowing the seed multiple times to bring it from a wind-winnowed ~75% pure up to 99.9% for sale. Our screens were perfectly precise: if 7/64" let through too many weed seeds we could switch to 6.5/64" or 6/64". Flat seeds like lettuce fit through narrow slots that trapped anything larger, and tiny debris and pigweed fell through the 1/18" holes. But screening is only half of the equation. To get out the lighter seeds, and the chaff the same size and shape as the seed, we needed to winnow, and our winnowing had no such precision.

Many years prior Frank had the insight that the airflow is more uniform behind a fan than in front of one, so he built cardboard-box wind tunnels behind fans as winnowing stations. For anything lighter than beans, the smoother airflow behind the whirling blades proved a great improvement, but it was still a far cry from the accuracy of our screens. There we would stand, for hours on end, smoothly pouring a curtain of seed into a bin below, looking down at the divide and trying to keep our hand in place, plus or minus a half inch or so, shaking the container gently to keep the seed flowing. For the zen artists on our crew, this was a fun and meditative activity. For a perfectionist engineer like me, it was torture. My wrist hurt after a few hours, and my body felt tense from trying to maintain a precise position. It didn't take long for me to notice that even behind a fan the airflow isn't quite even. I came to dread the winnowing and prefer the screening. So, you see, I didn't build the first Winnow Wizard with any grand purpose in mind. I simply wished to be happier in my work, and I knew there had to be a better way.

Winnow Wizard #1 (at right), built over a weekend in December of 2014, was a double-stacked, two-fan monstrosity that bears little resemblance to the current design. An operator on a stool poured seed through a slot in the top, and it was supposed to catch the seed in the middle and then drop it past the second fan for a second winnow. The stacking didn't work at all - seed bounced everywhere - but it did have three major improvements over our manual winnowing: a slot to drop seed straight down, a sheet of perforated metal in front of the fan which served to even out the turbulence produced by the blades (inspired by the laminar flow hoods of my microbiology days), and a movable divider that rested on ruled rails, allowing a setting to be "dialed in" for each seed lot. I still had to stand there and pour, but the body tension was gone. The others weren't quite convinced that this contraption was a step forward, but for me it made all the difference.

For the next few months I poured seed through the Wizard while the others continued the old ways, and gradually folks started to come around. As others used it, they started making requests. "I feel like I'm just an arm," Hank Keogh told me one day. "It needs a hopper." So back to my workshop I went, devising an inverted-pyramid hopper made from four equilateral triangles, an oddly-attached sliding gate, a frame to hold it, and a feed tray that vibrated thanks to a deconstructed fan with the blades cut off and six screws added to one side to unbalance the shaft. It worked - mostly. The hopper opening was too small and the tray didn't tilt to feed the last seeds, but it meant that now we could pour in a bin and walk away, saving substantial time.

By the end of 2015 we had a Winnow Wizard wish list: stronger wind, adjustable wind speed, more even airflow, angled feed tray, multiple dividers, shorter stature. Frank was sufficiently smitten that he signed off on the expense, and I set to work designing it. For a stronger and more even airflow we would need a greater pressure difference across the screens, and a fan wouldn't cut it. I found a used 1/3 HP furnace blower on eBay and adapted it to the wind tunnel. For the feed tray to tilt and rest against the feed plate, it needed to be suspended from above. My first suspension used stainless steel bars that made an angry noise when the vibration was turned on. That was replaced by ropes, and eventually by the cable suspension used now. The hopper gate found its current form. The dividers changed from an A-frame design to 3"-4"-5" right triangles, which could be placed close together without interfering. One screen proved insufficient to stabilize the airflow, so I added a second.

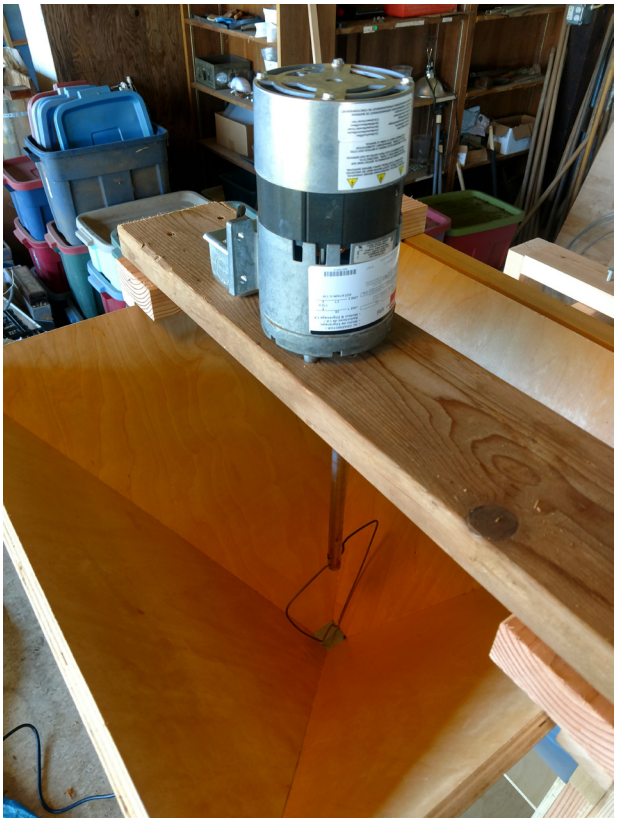
I finished Winnow Wizard #2 (below) just ahead of the Organic Seed Conference in Corvallis in 2016. I had no plans to put it on display, but Petra Page-Mann of Fruition Seeds, visiting Wild Garden ahead of the conference, insisted that it needed to be there. So into my trailer it went, and we found it a spot right outside the entrance where I winnowed, re-mixed, and re-winnowed a bin of quinoa seed many times.

I wasn't offering to build them at that point, but Nash Huber (of Nash's Organic Produce in Washington) wanted one. I made a few more changes, adding a screen and increasing the blower to 3/4 HP, and in June of 2016 constructed Winnow Wizard #3. Nash neglected to pick it up for some months, and so we had it through the fall seed cleaning season where it winnowed nearly full time alongside #2 in the Wild Garden Seed greenhouse. That year I created the first assembly plans and user manual over many days in the guest lounge of the RenVilla Nursing Home in Renville, Minnesota, accompanying my father through the last stages of a long illness.

When Nash's machine finally left in early 2017, Frank commissioned a replacement. That was Winnow Wizard #4, which as of this writing in early 2020 is still the main seed-cleaning workhorse at Wild Garden Seed. I launched Luterra Enterprises LLC around that time; Petra and Matthew at Fruition Seeds were my first official customers, and their Winnow Wizard #5 was the first to incorporate a permanent screen closer to the blower to further enhance airflow evenness.

The two accessories evolved in 2017. Hank Keogh needed to winnow a large amount of orach seed, which has paper husks that cause it to flow poorly along with extremely irritating dust. To get the seed to flow unattended, we rigged up a cordless drill with a giant auger bit turning in reverse in the hopper, and later an old gearmotor with a wire agitator. As I searched for standardized and reliable components to accomplish the same goal, I settled on a 60 RPM gearmotor with a choice of two agitating attachments.

Frank returned from a visit to a large quinoa processing facility and described their "stoner" - a machine that used powerful electromagnets to eject naturally-magnetic rocks and dirt from a stream of seed. That year, as often happens thanks to the species' ground-hugging habit, we had a large amount of unremovable dirt in our sacred basil seed. On a lark I ordered two rare-earth block magnets and put them together for an even stronger magnetic force. They did indeed attract dirt, but it took us awhile to figure out how to use them efficiently. At first we simply waved them about over shallow pans of seed, lifting the dirt particles off the top, but that took forever and missed a lot. Hank was the first to discover that - if placed near a stream of falling seed - the magnets would cause the dirt to deflect but leave the seed unaffected. That led to the magnetic hopper gate attachment, which nicely polished our basil in that year and all years since, and has also cleaned up quinoa, many flower seeds, and a thousand or so pounds of dry beans at a nearby farm. I think there is yet room for improvement in the magnet design; it tends to "clog up" with small dirt particles, necessitating occasional cleaning or multiple passes to remove 90+% of the dirt particles from a seed lot.



Above: Magnetic hopper gate in action; dirt particles are deflected toward the magnet and land behind the divider below.

Left: An early hopper agitator design; the current version has a shield to keep seed off of the motor and a sturdier spring-steel paddle.

By early 2018, I had received several testimonials describing the Winnow Wizard as a “game changer” for small-scale seed producers. As a density-based separator, it is much less expensive and simpler to operate than a gravity table. It works on all sizes of seed from yarrow and poppies up to beans with minimal adjustment, and it has almost no nooks and crannies to trap seeds and cause cross-contamination between lots. So I returned to the Organic Seed Alliance conference, this time with pamphlets and order forms, and began to build them for growers around the United States. I commissioned Victor Sauvie, Wild Garden’s seed cleaning maestro and resident artist, to create a custom line drawing on each machine, and I signed and dedicated each one upon completion.

Victor’s artworks

Four completed Winnow Wizards in 2019

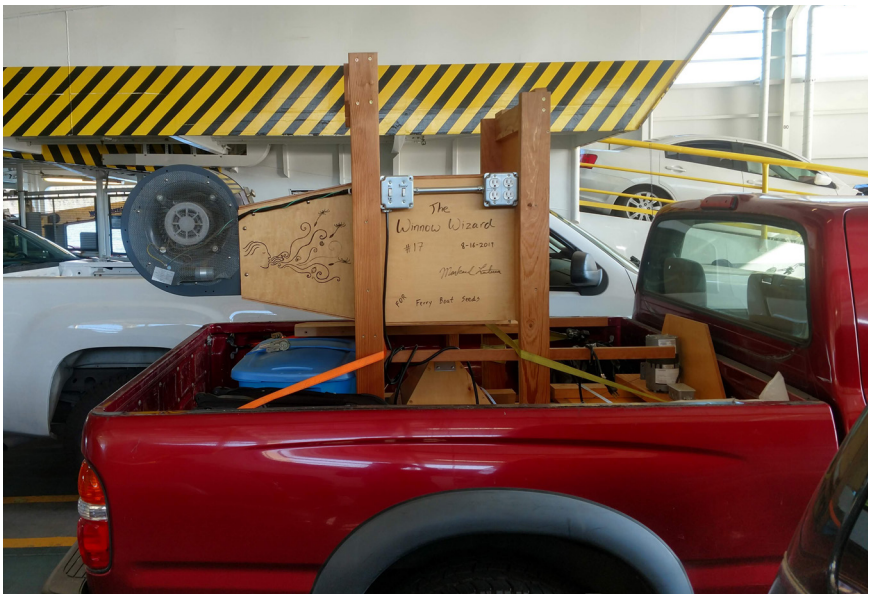
Over the last two years improvements to the design have become progressively smaller and less noticeable. A larger hopper opening, smaller tolerances, adjustments of a millimeter here or there, different aluminum alloys, improved epoxy adhesives. I have thus far procrastinated on requests for updated plans, knowing that they would soon be obsolete, but I feel that the design is now sufficiently settled that there will be few significant changes moving forward.

In fall of 2019 I constructed a machine with a 1 HP blower, along with a few changes to the wiring and wind tunnel to accommodate it. The goal was to achieve higher wind velocity and better separation of dry beans and grains, and at this it was successful. While the standard model can remove all chaff, the stronger version can also remove some lighter/smaller/rain-damaged beans as well as split seeds. I am sufficiently happy with it that I have added a 1 HP blower as an option, and changes for the 1 HP version are noted in these plans where appropriate. While it offers an improvement for the heaviest seeds, the 1 HP model requires a 20 amp circuit and is too strong, even at the lower settings, for most seeds lighter or smaller than amaranth.

Winnow Wizard #21 bound for Colorado

Shipping a machine of this size is a challenge, and I am most grateful to the team at Freight Pros for working with me to find reasonable quotes and options. At first I winched crates onto my trailer and hauled them to Eugene for loading onto trucks - a slow and tedious process. In 2019 I convinced Frank to purchase pallet forks for his tractor, and since then have been loading semis at the Mosaic Farms feed mill across the street. An assembled Winnow Wizard will fit in a standard 6' pickup bed, so a number of local and regional buyers have elected to pick theirs up from my Oregon workshop.

As of this writing, in early 2020, there are 30 Winnow Wizards cleaning seeds in Oregon, Washington, California, Montana, Colorado, New Mexico, Minnesota, Wisconsin, Maine, Massachusetts, New York, and Virginia. Satisfied Wizard operators include Wild Garden Seed, Fruition Seeds, Uprising Seeds, Adaptive Seeds, Floret Flower Farm, Siskiyou Seeds, Hudson Valley Seed Company, Southern Exposure Seed Exchange, High Desert Seed, and an assortment of community seed hubs, contract growers, seed banks, researchers, and hemp seed producers.



Riding the ferry to San Juan Island

A Note on Scale

I designed the Winnow Wizard for the scale of Wild Garden Seed. Our seed lots range from one pound up to a few hundred pounds, with most lots in the 10-60 pound range. The hopper holds about 50 pounds, and the receiving bins will also hold this amount. Depending on feed rate, throughput ranges from 50-400 pounds per hour. It may be possible to build a smaller Winnow Wizard – maybe even at the scale of a hair dryer for a blower – though it could be difficult to obtain sufficient drop for good separation. Scaling up would certainly be possible; I can imagine a three-phase, 5-hp blower feeding four side-by-side 40”-wide wind tunnels, integrated with other machines with a throughput of 2000 pounds per hour or more. It is not immediately clear whether an industrial-scale Winnow Wizard would offer a cost or quality advantage over the large gravity tables and other machines currently used for density separations, but if anyone wants to try it I would love to see the report.

A Research Request

I have heard from a number of growers who much prefer the Winnow Wizard to a gravity table for density separations, but I don’t yet have any hard data to compare the two machines. If you find yourself with access to both, I encourage you to run the same seed lot on each machine and compare the results in terms of germination, loss of good seed, throughput, cleanout time, ease of operation, etc. If you are in the United States and are interested in collaborating on a published report on such a comparison, please let me know.

Ownership and Intellectual Property

Developed by a proud supporter of the Open Source Seed Initiative, this is an open source design. Publication of these plans in the public domain legally precludes any entity from seeking a patent, and I have no intention of seeking a patent myself. That said, I do lay a moral claim to this design as an original invention, inspired by prior art and with creative input from a number of individuals, but ultimately unique and not derivative of any existing seed cleaning machine.

Individuals and companies are free to use these plans to construct Winnow Wizards for themselves, in exchange for voluntary compensation as described on the following page. The plans may be copied and redistributed free of charge, but this page must be included in any reproduction and the voluntary compensation applies to any constructed machines.

If you would like to produce Winnow Wizards or components thereof for sale to others, please contact me (mark@luterra.com, +1-541-714-0492). I ask that any effort to commercialize this design, in any country, include me as a partner with both opportunities for intellectual input and a financial compensation arrangement.

If you are aware of any small-scale manufacturers in the Pacific Northwest who might be interested in constructing these machines or components thereof, or if you manage such an operation yourself, please contact me as well. While I enjoy being a solitary craftsman for now, if demand for Winnow Wizards increases over time I would prefer to focus more on outreach, education, and operator training rather than manufacturing.

This is me, Markael Luterra.

I ask that you respect the Winnow Wizard as my contribution to the world of seed, and include me in any efforts to commercialize it.

Purchase/Build Options

If you would like to add a Winnow Wizard to your operation, you may purchase one fully assembled, purchase a partial kit and source the remaining components locally, or build one from scratch. Unless you really enjoy tinkering, I recommend going with the fully-assembled option for those within the continental United States.

Fully Assembled

Fully assembled Winnow Wizards may be picked up in Philomath, Oregon or shipped to any truck-accessible address in the continental US. Shipping to Canada should also be possible, as all wood is heat-treated, though I have yet to navigate the customs process. The dirt-removal magnet and hopper agitator are optional, though recommended, accessories. Please visit luterra.com/winnow-wizard for current pricing.

Partial Kit

The partial kit includes everything except the blower, dimensional frame lumber, narrow bin, and plywood base. It includes a dedication, serial #, and original artwork by Victor Sauvie. All wooden components are considered processed (plywood) and should be eligible for import worldwide except in countries subject to US trade restrictions. Shipping weight is approximately 50 kg (110 lbs) in three boxes. Estimated construction time is 6-12 hours. Please specify 115V or 230V based on the power supply in your country. See p. 13 for blower specifications and measurements. Please email mark@luterra.com for pricing information.

You Build

Please send a photo of your completed Winnow Wizard to mark@luterra.com

Contract Build On Site

Once you have received the kit and arranged to obtain the remaining components, contact me to arrange my visit. Cost is my travel and lodging plus US $500 per machine, and includes machine training time. I am open to rustic accommodations including couches, air mattresses, or tents.

Complete Build

Source all components as described here, or find locally available substitutes. Estimated construction time is 40-50 hours, based on experience and available tools. Please send photos of your completed Winnow Wizard to mark@luterra.com.

If you build from scratch using these plans and are happy with the result, please contribute the greater of:

- One day's earnings (i.e. your annual income divided by 365), or
- 10% of your estimated annual savings due to the Winnow Wizard (e.g. if you expect to save $5,000 per year in labor costs or by cleaning up unsaleable seed lots, then please send $500).

If seeds are a labor of love that earn you no cash reward, or if you struggle to make ends meet, or if you are ultimately unhappy with your Winnow Wizard, then no contribution is necessary. On the other hand, if the machine saves you tens of thousands of dollars over many years, additional donations in support of this work are greatly appreciated.

Please send a message to mark@luterra.com with the amount you wish to contribute and your preferred means of payment. I will respond with a mailing address for a check or a card-payable electronic invoice.

Tools Required (kit build)

Circular saw

Chopsaw or miter saw

Chisel, or router with wide, 3/4” deep bit

Drill

Drill bits up to 7/8” (22 mm)

Bit drivers for drill, or impact driver

Tape measure

Square

Hammer

Wire cutter

Wire stripper

Screwdrivers

Additional Tools Required (complete build)

Jigsaw

Angle grinder with metal cutting wheel

Metal bending brake, or 2 large C clamps

Small rod bender (if using music wire for agitator)

Cable ferrule crimper

Wood and metal files

Sheet metal shears

Drill bits up to 1-3/8” (35 mm)

Countersink bit

Materials Required (kit build)

Blower (see p. 13)

Lumber

(1) 4’x8’ (1220 x 2440 mm) sheet plywood, 1/2” or 12mm thick, sanded on at least one side

(5) 12’/4m “2x4”s, as straight as possible (actual dimensions 1.5” x 3.5” or 38mm x 89mm)

(1) 12’/4m “1x2”, as straight as possible, actual width 5/8” or 16mm

Electrical

Plug adapter from your country’s standard to NEMA 5-15 (115V) or NEMA 6-15 (230V)

Blower wiring, if necessary (see p. 13)

Adhesives

One-minute or five-minute epoxy

Materials Required (complete build, not including agitator and magnet)

Motors etc.

Blower (see p. 13)

C-frame motor for feed tray: Dayton 4M068 (115V), 4M069 (230V), or equivalent

Shaft collar (3/16”), Dayton 1L626

Lumber

(2) 4x8 (1220mm x 2440mm) sheet prefinished plywood, 1/2”/12mm thick

(5) 12’/4m “2x4”s, straight as possible (actual dimensions 1.5” x 3.5”/38mm x 89mm)

(5) 8’/2.5m “1x2”s, as straight as possible (actual dimensions 5/8” x 1-3/8”/16mm x 35 mm)

Scrap of 3/4” (18mm) plywood, min. 6”x24”

Metal (see pp. 30-31)

(1) Perforated steel sheet, 18” x 24”, 0.036” thick, 3/64” holes, 0.081” stagger, 28% open area, sourced from Consolidated Mill Supplies in Tennessee, available on eBay

(3) Perforated steel sheet, 18” x 24”, 0.036” thick, 1/16” holes, 1/8” stagger, 23% open area, Online Metals (OM) part #13526 *qty (2) for 1 HP model*

(1) Perforated steel sheet, 18” x 24”, 0.036” thick, 1/8” holes, 3/16” stagger, 40% open area, OM part #13529

(1) Perforated steel sheet, 18” x 21.25”, 0.06” thick, 1/8” holes, 3/16” stagger, 40% open area, OM part #13516

(1) Perforated steel sheet, 18” x 18”, 0.06” thick, 3/16” holes, 1/4” stagger, 51% open area, OM part #13518 *omit for 1 HP model*

(1) Stainless steel sheet, 6” x 21.5”, 0.024” thick, OM part #6824

(1) Stainless steel sheet, 12” x 12”, 0.060” thick, OM part #6828

(1) Aluminum sheet, alloy 5052-H32, 24” x 36”, 0.02” thick, OM part #17922

(1) Stainless steel rod, 1/4” diameter, 8” length

1/8” hardware cloth, 2’ x 3’

Magnets

(35) 1/4” x 1/16” cylindrical neodymium magnets, Applied Magnets part #ND011

(6) 1/2” x 1” x 1/8” rectangular neodymium magnets with countersunk holes, Applied Magnets #NB033-TH2

Fasteners etc.

5’ length, 1/16” stainless or galvanized cable

(8) 1/16” cable ferrules

4” length, 3/16” heat shrink tubing

(10) 1/8” “L” screw hooks

(4) 3/16” x 3” eye hooks

(12) 1” #12 sheet metal screws

(35) 1/2” #8 sheet metal screws

(4) #6-32 x 2” bolts with lock nuts

(1) #8-32 x 1” bolt

(2) #8-32 hex nuts

(3) small round metal door pull

(12) 5/8” #4 wood screws

(~50) 1” #6 wood screws

(~50) 1-1/4” #6 wood screws

(~200) 1-5/8” #6 wood screws

(~20) 3” #9 wood screws

(~30) 3-1/2” #10 wood screws

Adhesives

1 7/8” heavy duty duct tape

1/16” x 3/4” adhesive rubber strip, 12”

Cyanoacrylate (“super”) glue

High-grade epoxy such as 3M DP420NS

Misc chemicals and supplies

Thread lock liquid

Mineral spirits

Industrial degreaser/detergent

Sponges and chemical gloves

Electric motor oil

Metal drilling oil

Materials Required (complete build, continued)

Note: Available electrical components will vary by country; this list is based on North American components. See pp. 22-23 to choose appropriate components.

Electrical (all voltages)

(2) 2-gang metal exposed work boxes with grounding terminals

(1) 2-gang box cover, two switches

(1) 2-gang box cover, two duplex outlets

(1) 20A switch

(1) 20A three-way switch

1/2” conduit, short section 12”+

(2) 1/2” conduit-box clamps

(1) 3/8” cord-box clamp (NM-B clamp)

(1) 1/2” knockout bushing

(3) 1/2” cable clamps

14 gauge wire in green (~5’), white (~2’), black (~2’), and red (~2’)

Wire nuts

Grounding screws

Electrical tape

(1) 14-gauge ring terminal

(3) 16-gauge butt splices

(1) 16-gauge fuse holder

(1) slow-blow fuse, 1A

Electrical (115V only)

(1) 3’, 16-ga extension cord, ungrounded

(1) 9-20’, 14-ga grounded extension cord *3/4 HP or less*

(1) 20’, 12-ga grounded extension cord with 20A plug *1 HP model*

(2) 15A duplex outlet

Electrical (230V only)

(1) 6’, NEMA 6-15, 16-ga extension cord

(1) 20’, NEMA 6-15, 14- or 16-ga extension cord

(2) NEMA 6-15 duplex outlet

Additional Materials - Agitator

(1) 2x6 or equivalent, 26.5” long

3’ length of 1/8” diameter music wire (spring steel)

2’ length of 12-gauge high-tensile electric fence wire

(1) 1-gang metal exposed work box with grounding terminal

(1) 15A switch

(1) 1-gang box cover, one switch

(3) 1/4” cable holders

(2) 3/8” cord-box clamps (NM-B clamps)

(1) 14-gauge ring terminal

(1) 5/32” hex wrench

(3) 1/4” x 2” bolts

(3) 1/4” washers

(1) 5/8” shaft coupler

2’ length, 5/8” diameter aluminum rod

115V Only

(1) 60 RPM gearmotor (Dayton 1LPL6)

(1) 6’, 16-ga grounded extension cord

230V Only

(1) 60 RPM gearmotor (Dayton 4Z521)

(1) 6’, NEMA 6-15, 16-ga grounded extension cord

Additional Materials - Dirt Magnet

(2) 0.75” x 1” x 2” neodymium magnets, Applied Magnets #NB057-W2-N52

(1) galvanized steel sheet, 0.06” thick, 12” x 12”, Online Metals #13265

(1) small metal door pull

Blower Selection

The blowers in Winnow Wizards that I build are either Dayton 1XJY2 (3/4 HP) or Dayton 1XJY3 (1 HP). The specs of these motors are shown below.

Model	Elect. input	Full load amps	Full load watts	RPM (high)	Motor speeds	High spec. airflow	Low spec. airflow
Dayton 1XJY2	115V 60 Hz	9.0	1035	1100	4	2000 CFM @ 0.9” SP or 3425 m3/h @ 225 Pa	875 CFM @1.3” SP or 1500 m3/h @ 325 Pa
Dayton 1XJY3	115V 60 Hz	15.3	1760	1100	3	2700 CFM @ 1.2” SP or 4600 m3/h @ 300 Pa	1384 CFM @ 1.8” SP or 2350 m3/h @ 450 Pa

These types of blowers are ubiquitous in furnaces, ventilation systems, air filtration and exhaust systems, etc. In the US used ones are often available on eBay for reasonable prices; you may also have success asking a local heating/cooling/ventilation contractor if they have used blowers available or a source for new ones. Be sure that any blower you find matches your country’s electrical voltage and frequency.

If all of the specs are listed, try to match the above wattage and airflow specs within 20% or so. Multiple motor speeds are nice but not essential. Wattage alone is a good measure of comparability, provided that the blower is intended for use with ducted ventilation. Blowers designed to operate with no static pressure (e.g. fans) or to deliver a small amount of air at high pressure (e.g. leaf blowers) will not be suitable for use in a Winnow Wizard.

Blower Measurements

To work with these plans, the blower outlet must be rectangular and be able to insert at least 1” (25 mm) into the blower adapter. Remove or cut off any mounting brackets attached to the outside. If it is not possible to make your blower outlet look like the one shown here, then modifications to the blower adapter will be necessary.

Measure the outside width and height of the blower outlet exactly, to the nearest mm or 1/16”. If ordering a kit, send the dimensions to me. If building from scratch, use the dimensions on p. 28 to construct a blower adapter.

Blower Wiring

To reach the junction box/switches on the right side of the machine, the blower motor leads must be at least 24” (60 cm) long. Add 18” (45 cm) to this length if the motor is on the left-hand side of the blower. A ground wire should be included for safety, and both the motor and the metal casing should be connected to ground. Purchase 14-gauge wire/cable, terminals, and splices as necessary to connect the blower to the control switches. If the blower has wires for more than two speeds, only the highest- and lowest-speed wires need to be used. Cover any uninsulated connections (e.g. to the capacitor) with quality electrical tape or heat-shrink tubing.

Winnow Wizard Assembly

Measurements are presented in inches and fractional inches. I will include an imperial tape measure with the kits, and I encourage metric-system builders to purchase one for this project and make a foray into inches. See p. 25 for further discussion of units.

Kit purchase includes up to two hours of support time by email (mark@luterra.com) or phone (541-714-0492). I will also offer support to scratch-builders; please consider the amount of support time when deciding on a financial contribution amount (p. 9).

1. Cut lumber

Cut the following pieces. Quantities are shown in parentheses. Choose the straightest boards for the uprights and the hopper support.

2x4s

- 72” (2) base frame rails
- 54” (2) rear uprights
- 49” (2) front uprights
- 39” (2) hopper support rails
- 25 1/2” * (4) frame horizontals
- 19 1/8” (2) rear wind tunnel spacers
- 18 5/8” (2) front wind tunnel spacers
- 12” (2) hopper support crosspieces, one ripped to 2” width

* Frame horizontals are 22 1/2” plus two 2x4 thicknesses. Adjust this measurement accordingly if your boards are not exactly 1 1/2” thick

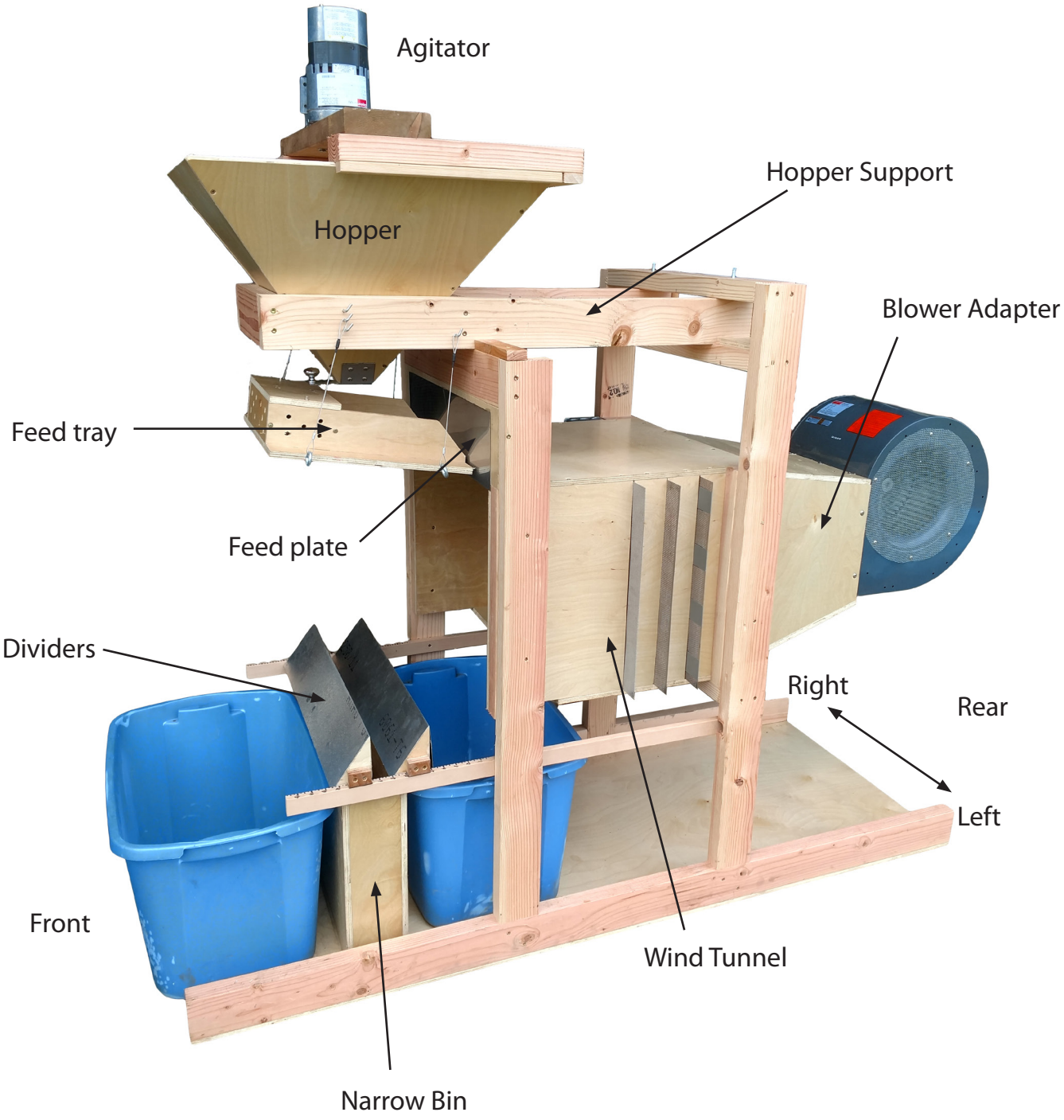
1x2s

- 40” (2) ruled divider support rails
- 6 1/2” (2) hopper support backstops
- 5 1/8” (4) hopper support guides

1/2” or 12 mm plywood

- 28 1/2” ** x 72” base
- Narrow bin pieces (optional): 24” x 15” (2), 24” x 5” (1), 15” x 4” (2)
- Save a remnant at least 6” x 27” for the feed plate. Actual dimensions will be measured later.

** Base width is 22 1/2” plus four 2x4 thicknesses. Adjust this measurement accordingly if your boards are not exactly 1 1/2” thick.


Agitator
Hopper
Hopper Support
Blower Adapter
Feed tray
Feed plate
Dividers
Right
Rear
Left
Front
Wind Tunnel
Narrow Bin

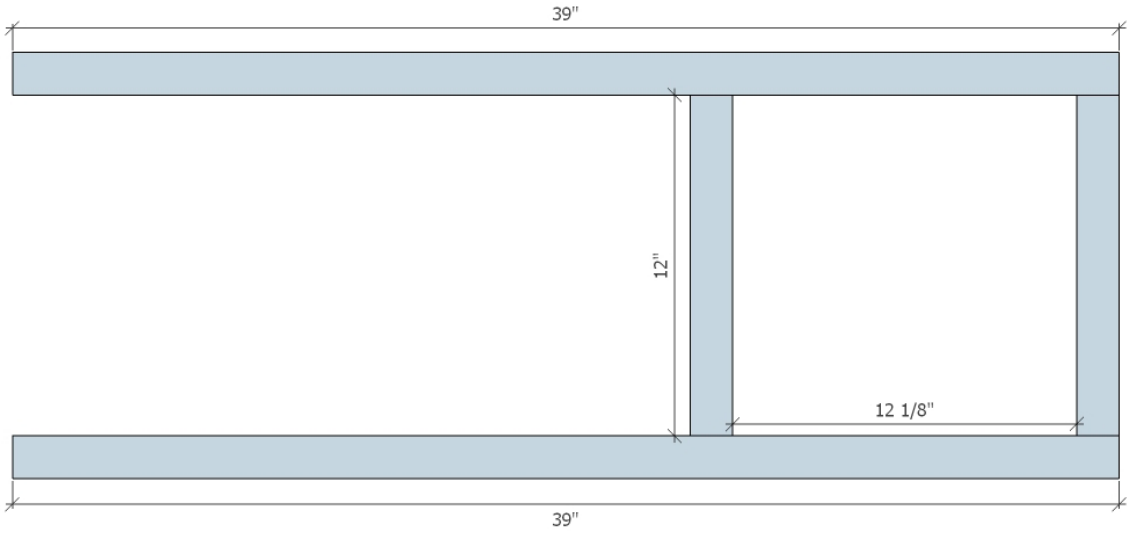
2. Prepare frame boards

Cut lap joints in the base rails and the bottom of the uprights. See diagram on p. 19. The outside edges of the lap joints should be at 24” and 48” along the base rails, with the width determined by the exact dimensions of your boards. Cut into the inside of the base rails and the outside of the uprights. If you don’t have a router or table saw dado blade, make multiple cuts to 1/2 of the board thickness with a circular saw, approximately 1/4”-1/2” apart, and use a chisel to remove the wood in betweeen.

Measuring from the bottom, mark the inside of the front uprights at 17 1/2” and 21”.

Measuring from the bottom, mark the inside of the rear uprights at 17 1/2”, 20 1/2”, and 49”.

3. Assemble hopper support



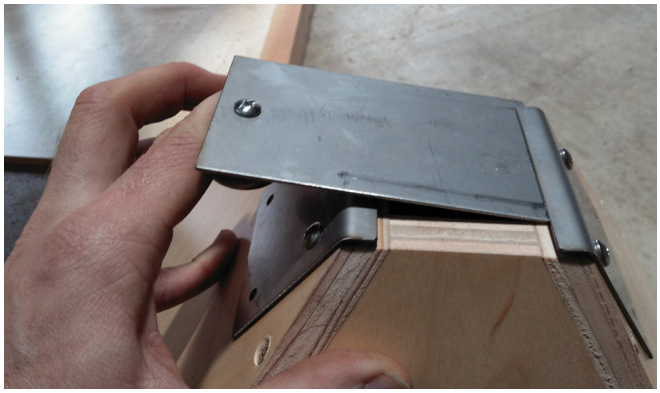
Use two 3 1/2” screws per connection, and pre-drill holes to avoid splitting. Ripping the front 12” crosspiece to 2” wide will improve access to the hopper opening. Ensure that the boards are flush on the top sides, and that the entire assembly is square and free of twist.

4. Assemble blower adapter, wind tunnel, and hopper.

Match reference numbers on the inside of each piece, and assemble using 1 5/8” screws. Avoid overdriving screws. Ensure that the screws hit the pre-drilled holes, particularly on the left side of the wind tunnel where slot width is critical. For the hopper, make minor adjustments as necessary when tightening the screws, so that the sides are even at the bottom opening. If building from scratch, assemble these components as shown on pp. 28-29, 35-38.

5. Add hopper gate and adjust movement

Place hopper upside down and slide gate into place. If fit is too tight, insert end of gate into slot and pry upward gently. If fit is too loose, tap on front corners of metal supports to bend downward slightly. Adjust until gate slides easily but does not fall out.



Pry edge up if too tight

Tap front corners if too loose

6. Attach blower adapter to wind tunnel

Mark top and bottom of wind tunnel on each side, 1” in from rear.

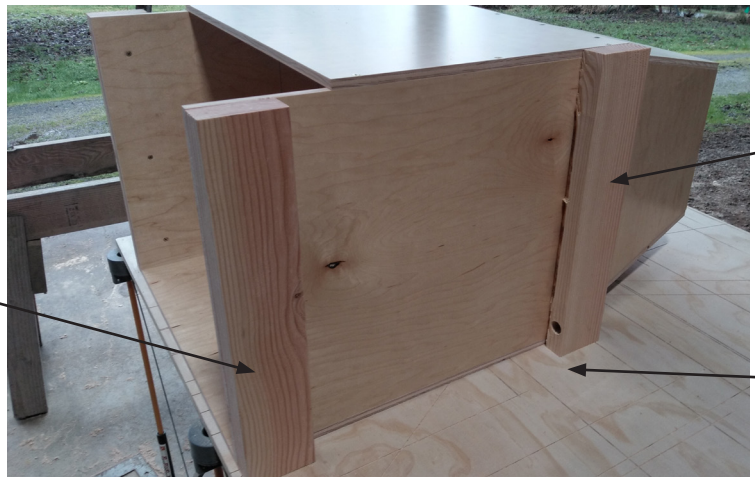
Insert blower adapter to align with marks. It is helpful to have an assistant for this step. Attach from the outside with five 1” screws on the top and bottom (seven for 1 HP version) and three 1 1/4” screws on the sides, 1/2” in from the edge. If using a kit, return screws to pre-drilled holes.

(Scratch-build) Install rearmost screen guide board, leaving a 1/8” gap from the edge of the blower adapter.

7. Attach wind tunnel spacers

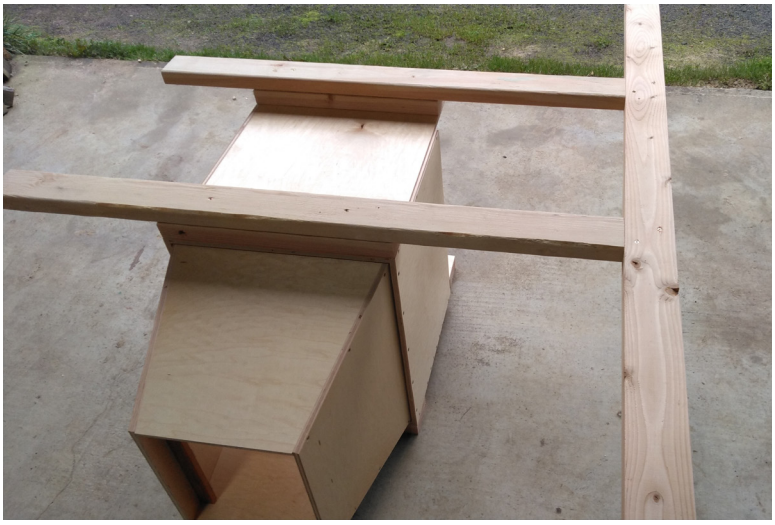
For the kit, drill a 7/8” hole through the right rear spacer to align with the electrical box bushing and accommodate the blower wiring. If building from scratch, you can decide later whether to route the wiring through this board or over the top.

With the wind tunnel sitting upside down on a level surface, attach the 2x4 wind tunnel spacer boards from the inside, using three 1 5/8” screws per board. Boards should be even with the top of the wind tunnel, and with the front and rear edges.



8. Attach right-side frame boards

Set the wind tunnel on its left side. Attach the front upright with two 3” screws, aligning the 21” mark with the bottom of the wind tunnel and with front edges even. Do the same for the rear upright, aligning the 20 1/2” mark with the bottom of the wind tunnel. Attach the bottom rail, securing the lap joints with two 1 1/4” screws from each side.



9. Attach the left-side frame boards

Tip the assembly onto its right side. If working with a kit, the switches will now be sufficiently recessed to be protected. Repeat the previous step with the left-hand uprights and base rail.

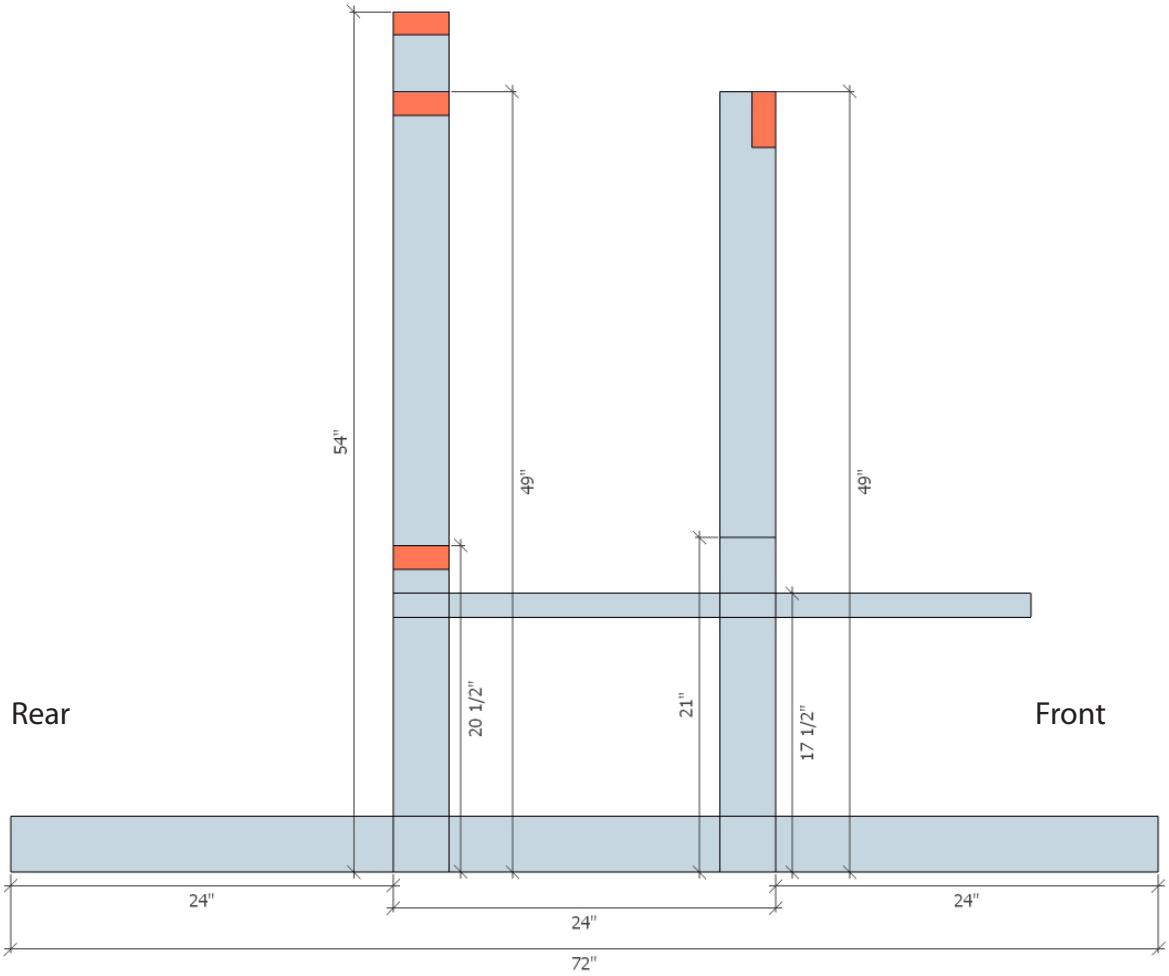
10. Attach the plywood base

Align the base with the edge and ends of the left base rail, and attach with six 1 5/8” screws along its length. Tip the assembly onto its left side and attach the base to the right base rail. Then tip the assembly upright for the last time.

11. Attach the frame horizontals

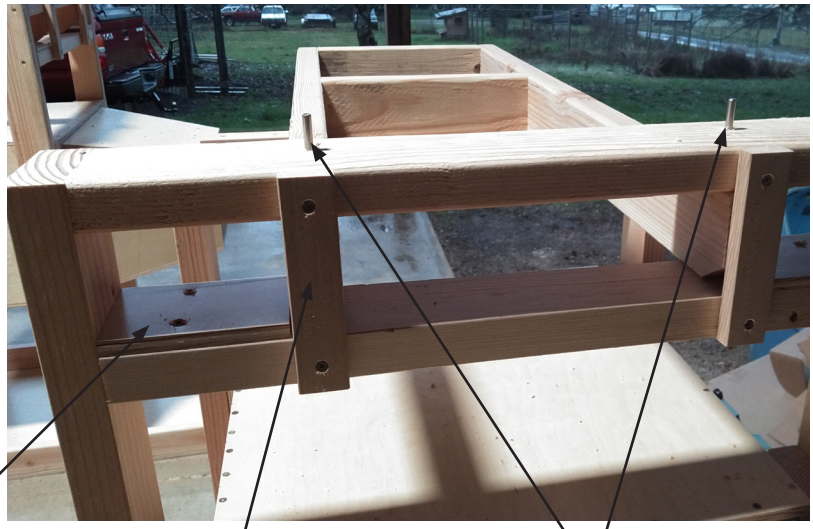
Using two 3 1/2” screws per connection and pre-drilling holes, attach the four frame horizontals as shown on the next page with red rectangles. When attaching the front horizontal, ensure that the frame is square. Attach the lower rear horizontal in contact with the underside of the wind tunnel for support.

Leave the top rear horizontal for last. With the rest of the frame complete, place the hopper support approximately in position, place the still-unattached stainless steel feed plate on top as a spacer, and then place the remaining horizontal brace on top and secure in place. Pull the spacer out, leaving a small gap for easy removal of the hopper support.



12. Add the hopper support guides and backstops

Center the hopper support and attach the guides and backstops to the frame horizontals as shown, using 1 5/8” screws and pre-drilling to avoid splitting.



Front guide

Rear guide

Backstop

4” pins to lock hopper support in place

13. Secure the hopper support in place

With the hopper support centered and against its backstops, drill 17/64” (7mm) diameter, 3” deep holes through the top horizontal and into each rail of the hopper support. Insert the supplied steel pegs (kit), or cut two 4” long pegs from the 1/4” diameter stainless steel rod (scratch build).

14. Install the feed tray suspension hooks

With the hopper support in its final position, measure forward 1 1/2” and 9 1/2” from the front horizontal on both sides. At the 1 1/2” mark, measure up 1” from the bottom. At the 9 1/2” mark, measure up 1 3/8”, 2”, and 2 5/8”. Pre-drill at these eight marks and install the square-bend hooks as shown.

15. Measure and cut the feed plate

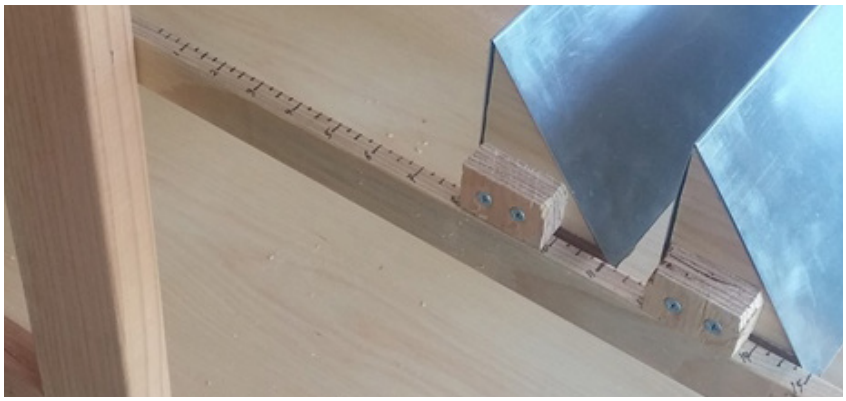
Measure the dimensions of the rectangular opening at the front, above the wind tunnel and below the top frame horizontal. Measure to the nearest mm or 1/16”. Cut a piece of 1/2” plywood to these dimensions and secure it in place with five 1 5/8” screws at the bottom and one 3” screw through the frame upright on each side. To avoid splitting the plywood, pre-drill all holes to their full depth using a bit just slightly smaller than the screw diameter.

16. Attach stainless steel to the feed plate

Glue the 0.024” thick stainless steel plate in place as shown, covering the top edge of the wind tunnel. Use a generous application of a high-quality two-part epoxy and hold in place until glue sets. If you have cyanoacrylate (“super glue”) handy, apply small spots to the corners to hold it in place until the epoxy sets.

17. Mark a ruler on the divider rails

Measure and mark 16” in from the end of each 40” rail. Using a fine-tipped paint pen or permanent marker and a ruled square or yard/meter stick, draw a ruler onto each rail from the 16” mark to the end. Mark every 1/4” or 1/2 cm. Mark the rails on opposite sides so that the ruler marks face inward.

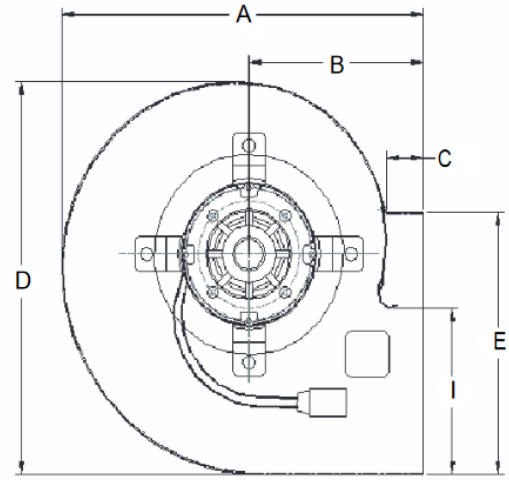


18. Attach the divider rails

Align the the top of the rails with the 17 1/2” mark on the inside of the uprights, and align the start of the ruler with the front edge of the front uprights. Attach with 1 5/8” screws, pre-drilling holes to avoid splitting the divider rails. See diagram on p. 19.

19. Attach the blower

Ensure that the blower fits snugly into the adapter and that it can insert at least 1”. Measure the distance “C” in the diagram, and make a mark the same distance in from the front at the bottom of each side.



If necessary, loosen the bottom rear screws attaching the bottom of the blower adapter to the sides, to allow the blower to fit.

Insert the blower until the curved top contacts the top edge of the adapter, and anchor in place at the top with a centered #12 x 1” screw, 5/8” in from the edge. Pre-drill with a 5/32” bit. Hold the blower level and re-tighten the bottom screws on the blower adapter.

Align your marks on the sides of the blower with the rear edge of the blower adapter on each side, and anchor with a #12 x 1” screw on each side.

Ensure that the blower is level and square. Pre-drill and drive the remaining screws, three on each side for a total of 12.

20. Wire the blower motor

Some blower motors have a terminal block to which wires attach; others have hard-wired leads. There will be a diagram on the blower or in the manual with instructions and color codes.

Extend the common (neutral), high-speed, and low-speed wires sufficiently that they can reach the switch box on the side of the machine. Locate the ground screw on the blower frame, or install one if none exists. Run a ground wire from the motor to this screw, and run a second ground wire from this screw to the switch box on the side of the machine. Use 14-gauge or equivalent wire. Use electrical tape or heat-shrink tubing to insulate any exposed connections/terminals that may contact the blower housing or (once installed) the protective intake screen.

Wrap wires with electrical tape or a protective jacket, route them into the switch box through the hole in the upper right spacer board, and secure them to side of the blower adapter.

21. Complete the electrical wiring

Remove the cover from the witch box and remove the swiches from the cover. Unscrew the wire nut connecting the ground wires and add the ground from the blower to the bundle. Attach the common wire to the other white (neutral) wires with the provided wire nut (115V), or to the upper left terminal of the double-pole power switch (230V). Attach the high-speed wire to the upper right terminal of the three-way blower speed switch,

and attach the low-speed wire to the upper left terminal. Ensure all connections are secure and reassemble the box.

If building from scratch, the wiring and switch design is entirely up to you. The electrical layout of US model (120V) Winnow Wizards is shown below.

20A heavy duty power switch

20A Three-way switch (single-pole single-throw) for blower speed control

1/2" EMT conduit containing switched hot wire (black), unswitched hot wire (red), neutral (white), ground (green)

Unswitched outlets for lights etc., or to run agitator without airflow for magnetic separations.

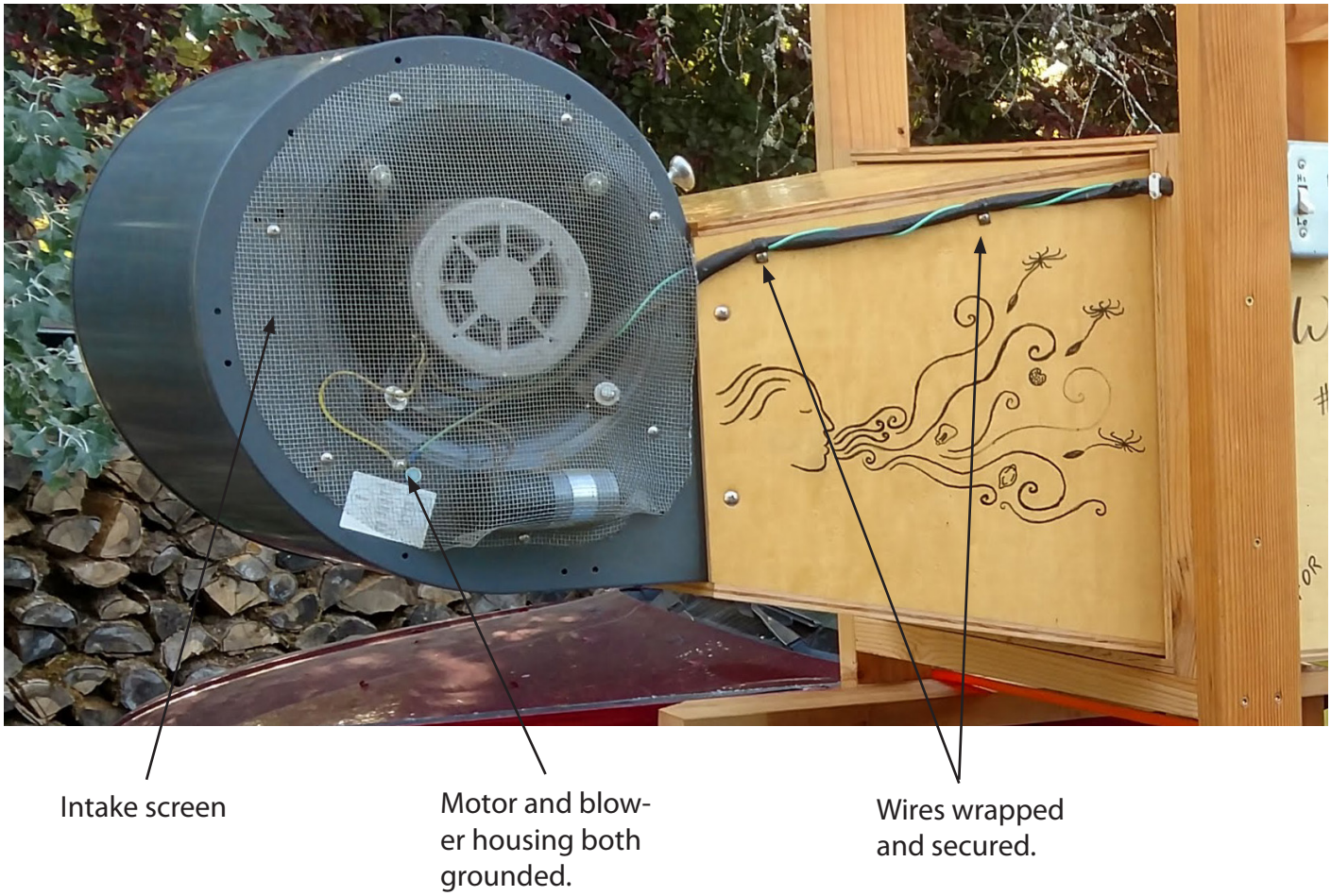
Switched outlets for feed tray and agitator.

22. Test the wiring

Plug the cord into a grounded, preferably GFCI-protected outlet. Test the blower on both speeds, the switched outlets, and the unswitched outlets (if present).

23. Cover the blower intakes

Cut 1/8" hardware cloth covers for both sides of the blower intake. On the motor side, cover the capacitor as well, and ensure that all electrical connections are insulated if there is a risk they could contact the intake screen. Attach the screens with pan-head #8 x 1/2" sheet metal screws, pre-drilling with a 1/8" bit.



24. Assemble the modules

Suspend the feed tray from the hopper support using the middle angle setting. Rotate the eye screws as necessary to level the tray and equalize cable tension. Place the hopper in the support with the gate facing forward. Place the agitator on top of the hopper with the seed shield facing forward. Plug the agitator into the upper switched outlet and the feed tray into the lower switched outlet. Place a divider on the ruled rails.

Insert the screens with the smooth side facing the blower.

25. You're good to go!

If you will be building accessories, proceed to p. 46.

Refer to the operating manual and "Seed Cleaning Strategies" documents for operating instructions, techniques, and troubleshooting.

For scratch-builds, if airflow is uneven left to right, especially on higher airflow settings, first try the other three possible orientations of the "S" screen. Minor imperfections in screen perforations or hole diameters can cause surprisingly noticeable effects. If using different screen specs than the US version, you may need to experiment with different configurations to optimize evenness.

Building from Scratch

If you're sourcing everything yourself the parts list gets quite a bit longer (pp. 11-12). Start here to build the components, then return to p. 14 and proceed from there with frame construction and assembly. Pre-drill all screw holes into edge grain with a 1/8" bit to avoid splitting, and it can be helpful to pre-countersink for the screw heads as well.

A word of warning...

These instructions are excessively prescriptive for an international audience given that plywood thicknesses and sheet dimensions, available fasteners, available perforated metal, and more vary from country to country. Aside from helping others to build Winnow Wizards this document serves a second purpose: it is my own manufacturing manual, collecting all of the minor adjustments and improvements I have made over the years.

In many cases, a lower degree of precision is perfectly acceptable and will produce a functional product. You may find it easier to follow the general design principles and adapt the particular dimensions to match the materials available to you.

About all those inches...

I realize that we Americans are in the minority in our use of inches, quarters, eighths, sixteenths, 32nds, and even 64ths. I have elected not to offer metric conversions here both because there would be so very many and also because most of the "nice" even numbers would become arbitrary decimals. I encourage any engineers/builders in metric countries to create a set of metric plans, changing dimensions slightly so that they are "nice" metric numbers and also easily cut from metric-sized plywood sheets. I would gladly post a metric version of the plans alongside my own on my website, or versions of the plans translated into different languages. In the meantime, if you are willing to take a foray into inches, imperial rulers and tape measures are widely available on the internet.

Plywood cut sheets

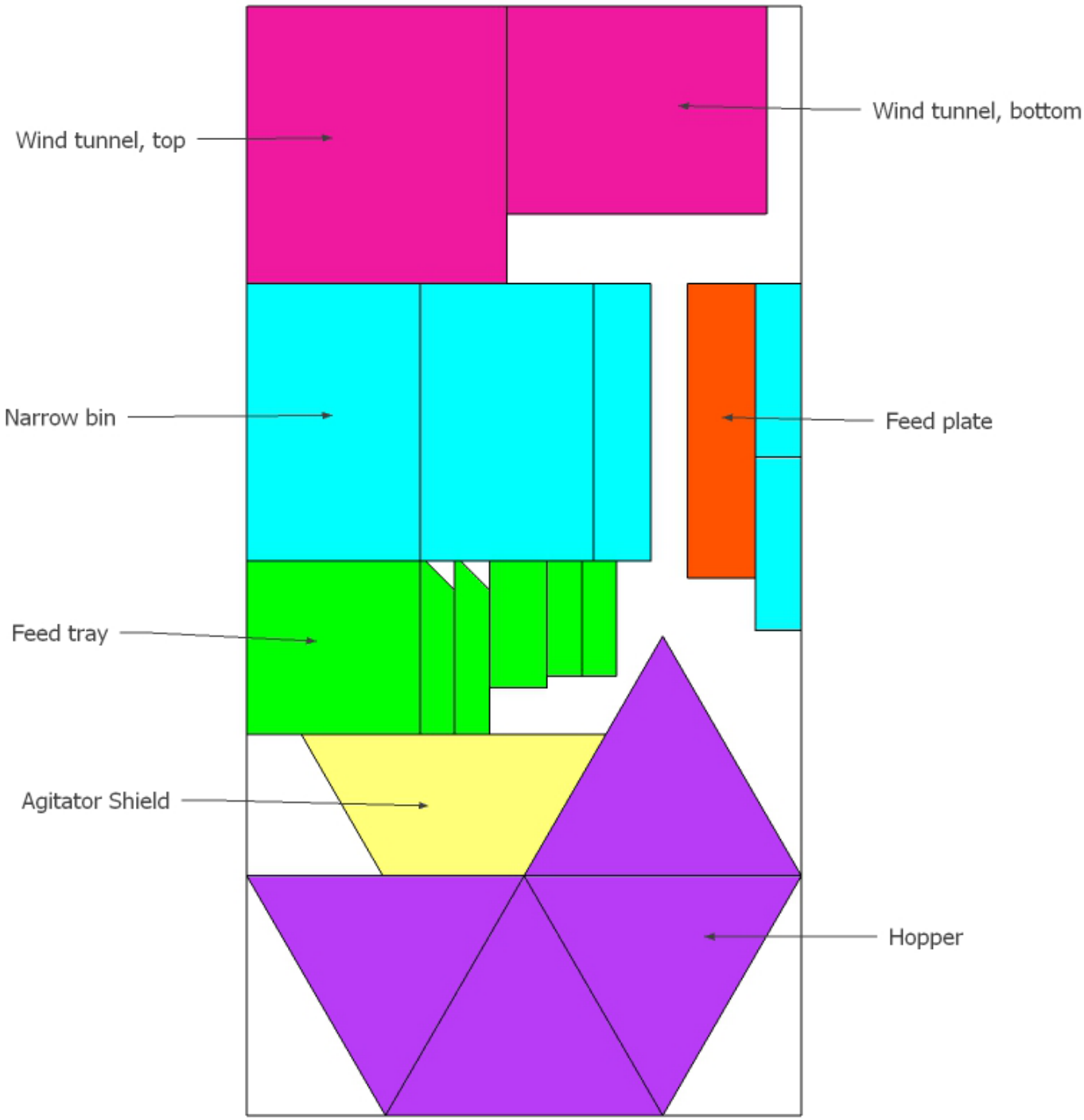
A Winnow Wizard can be constructed from two 4' by 8' sheets of 1/2"/12mm plywood. It is essential that some surfaces - like the hopper walls - be highly polished. I recommend purchasing prefinished plywood - or if you have the tools you can purchase sanded sheets and finish them yourself.

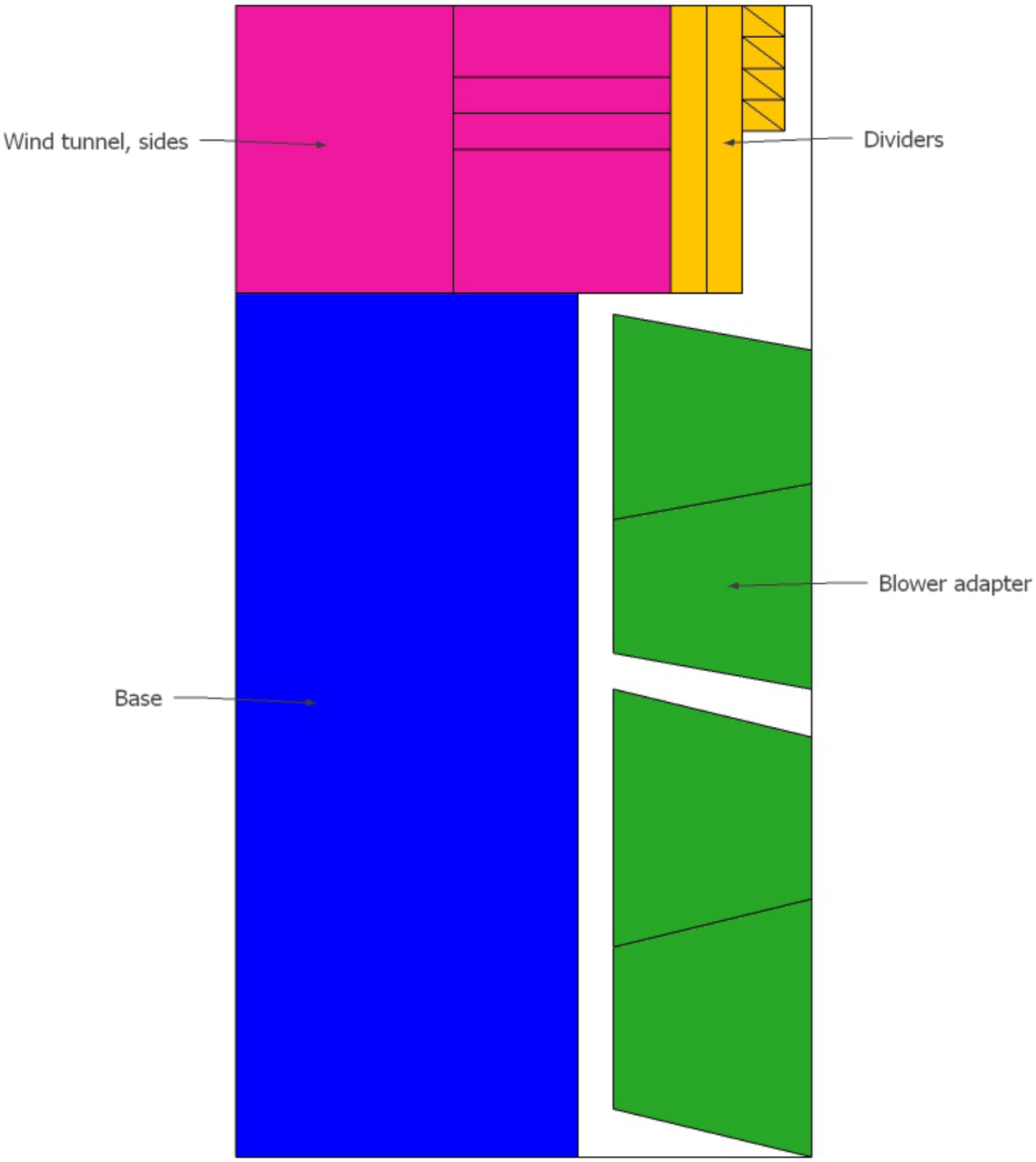
To avoid errors due to the width of the saw kerf, mark the cuts one at a time rather than marking a whole sheet. A track saw is a very helpful tool for this process, but a circular saw along a clamped straightedge will do. If you are building multiple machines, up to 3-4 sheets can be clamped and cut together, with the exception of the hopper edges and other angled cuts.

Start by cutting 24" off of one end of both sheets, then go from there. The hopper and feed tray should be located in an area free of defects. The exact dimensions of each component are shown on the component pages. I recommend cutting all of the plywood before starting on assembly.

Leave the extra material around the feed plate until you have a final measurement of the feed plate size - once the frame is assembled around the wind tunnel.

Save the scraps until you are finished. There are a few small pieces that are not shown on the cut sheets that can be cut from the scraps.


Wind tunnel, top
Wind tunnel, bottom
Narrow bin
Feed plate
Feed tray
Agitator Shield
Hopper


Wind tunnel, sides
Dividers
Blower adapter
Base

Blower Adapter

The adapter is customized to each blower. The wide end of the adapter fits cleanly into the wind tunnel, while the narrow end is sized to fit precisely over the blower outlet. Depending on your blower design, you may need to bend or remove metal to create a rectangle that will fit inside the blower adapter. Note that the dimensions at the wide end will change if the inside dimensions of the wind tunnel change, which will occur if your plywood thickness is different than 12 mm or 1/2”.

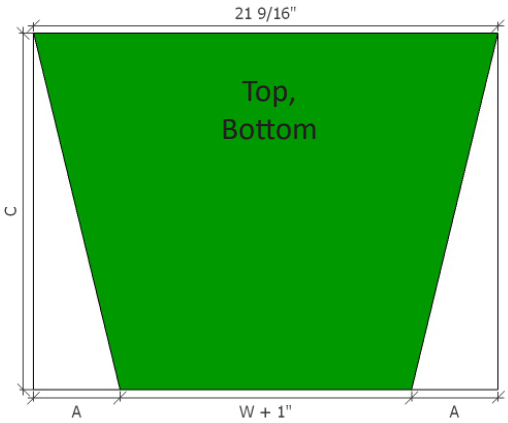
1. Measure the outside width (W) and height (H) of your blower outlet.

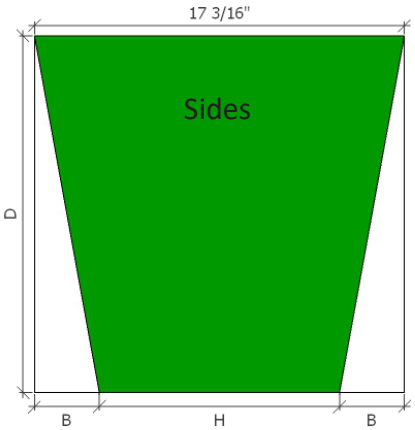
2. Calculate the following dimensions to the nearest 1/16” or degree:

A = (20-1/2” - W)/2
B = (17-1/8” - H)/2
C = SQRT(256 + B^2)
D = SQRT(256 + A^2)
θ = arctan(B/16”)

For the standard 3/4 HP blower (Dayton 1XJY2):
A: 3 3/4”
B: 2 15/16”
C: 16 1/4”
D: 16 7/16”
H: 11 5/16”
W+1: 14 1/16”
θ: 10º

For the standard 1 HP blower (Dayton 1XJY3):
A: 4 3/16”
B: 1 15/16”
C: 16 1/8”
D: 16 9/16”
H: 13 5/16”
W+1: 13 3/16”
θ: 7º





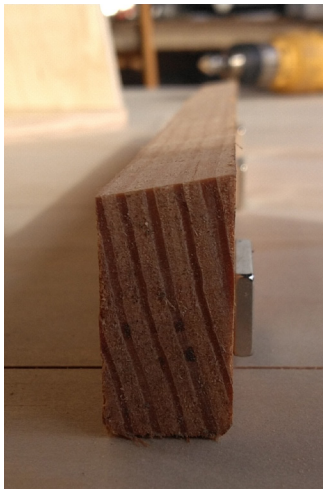
3. Measure and cut the four pieces as shown at right.

4. Without removing any length, cut the front and back edges of the top piece at angle θ, such that the edges are vertical once assembled. Turn the piece over between cuts so the side view is a parallelogram.

5. Assemble with three #6 x 1-1/2” screws per edge, screwing through the top/bottom into the sides. Skip steps 6-10 if you are building a 1 HP machine.

6. Measure and record the inside width and height of the wind tunnel 3” forward from the the rear end. Cut a 1x2 to this length and another 1/2” shorter. Trim one edge of the shorter piece at angle θ. In the standard model, these lengths are 14 1/2” and 14”.

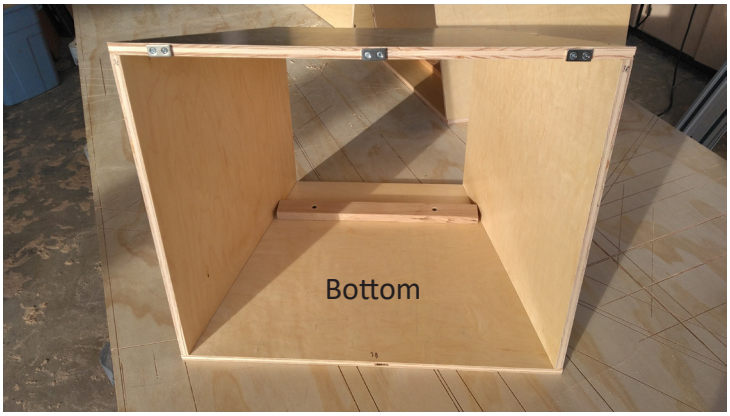
7. Using #4 x 5/8” screws, attach three countersunk magnets to what will be the front of the shorter 1x2, as shown.



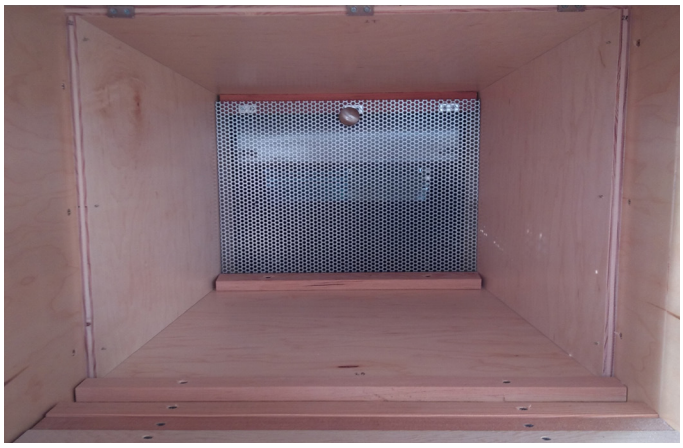
8. Inside the wind tunnel, mark 3 1/8” in from the rear on the bottom and 2 1/4” in from the rear on the top.

9. Using 1” screws from the inside, attach the longer 1x2 to the bottom with the rear edge on the 3 1/8” mark.

10. Using 1 1/4” screws from the outside, attach the shorter 1x2 vertically with the rear edge on the 2 1/4” mark, with the angled edge against the top such that it will be vertical in its final orientation.



11. Using #4 x 5/8” screws, attach three magnets along the front, angle-cut edge of the top. If building a 1 HP machine, attach five magnets equally spaced along this edge.



These magnets will hold the permanent screens. If you have the rearmost screen cut you can test its fit at this point, but leave it out until the machine is finished.

Perforated Metal

The perforated metal screens are the heart and magic of the Winnow Wizard: they transform a wild, turbulent blast from the blower wheel into a uniform laminar airflow capable of performing precise density separations.

It is highly unlikely that the exact specifications of perforated metal described here will be available in different countries, and the material is rather expensive to ship so regional sourcing is best. In searching for substitutions, I caution that the selection and spacing of screens in the Winnow Wizard has been empirically determined, and that some combinations that seemingly ought to work well result in unexpectedly turbulent or uneven (left-to-right, or top-to-bottom) airflow patterns.

In terms of overall design principles, for optimum uniformity:

- There should be at least three screens in the airflow.
- The screen with the smallest hole size should be closest to the front - both for improved airflow uniformity and because this screen will require frequent removal for cleaning.
- More restrictive screens (lower % open area) should be placed closer to the front, as airflow uniformity is correlated to the pressure difference across a screen.
- If using partially obstructed screens, they should be placed in the rearmost slot with two screens downwind to smooth out the airflow.

To test for uniformity upon completion, pour a small, uniform, cleaned grain (e.g. amaranth, teff) through on high speed - it should deflect at least 6-7” - and set the divider so that it just shaves the *back edge* of the curtain of seed. Place your hand behind the divider and feel whether more seeds are falling behind the divider on one side or the other, in the middle, or on both edges. If it is nonuniform, experiment with changing screen orientation (this can have surprising effects due to minor imperfections in manufacturing), or changing the order of screens in the slots. In general, if airflow is uniform at the highest speed configuration it will be fine at lower speeds.

Sliding screens must be square; I have occasionally run into issues with this when purchasing metal pre-cut. The 24” dimension can be shortened by up to 1/2” without consequence, so trim an edge square if necessary.

Screens typically arrive coated in a cutting oil. While this helps to prevent corrosion, it is tacky and results in rapid dust accumulation and hole clogging during operation. I remove this factory oil coating using mineral spirits followed by an industrial degreaser and water rinse.

I have been unable to source screens with 13% and 6% open area, so I create these by partially obstructing screens with duct tape which requires replacement every five years or so. If you can source screens with these specs directly in your area that would be preferable.

See p. 7 of the user manual for recommended screen placement and wind speed settings. Face the smoother side of the screens (the side it was perforated from) toward the blower to minimize dust and debris buildup during operation.

Screen specifications (original and recommended range)

Rear permanent screen (in blower adapter, 3/4 HP models only)
Thickness: 0.06” (~1.5 mm)
Hole size: 3/16” (5 +/- 1 mm)
Open area: 51% (+/- 3%)
Dimensions: Blower-dependent, from p. 28, step 6. Subtract 1/8” from width and 1/2” from height.

Forward permanent screen
Thickness: 0.06” (~1.5 mm)
Hole size: 1/8” (3 +/- 0.5 mm)
Open area: 40% (+/- 3%)
Dimensions: 21 1/4” W x 18” H

All sliding screens:
Thickness: 0.036” (~1 mm)
Dimensions: 24” W x 18” H

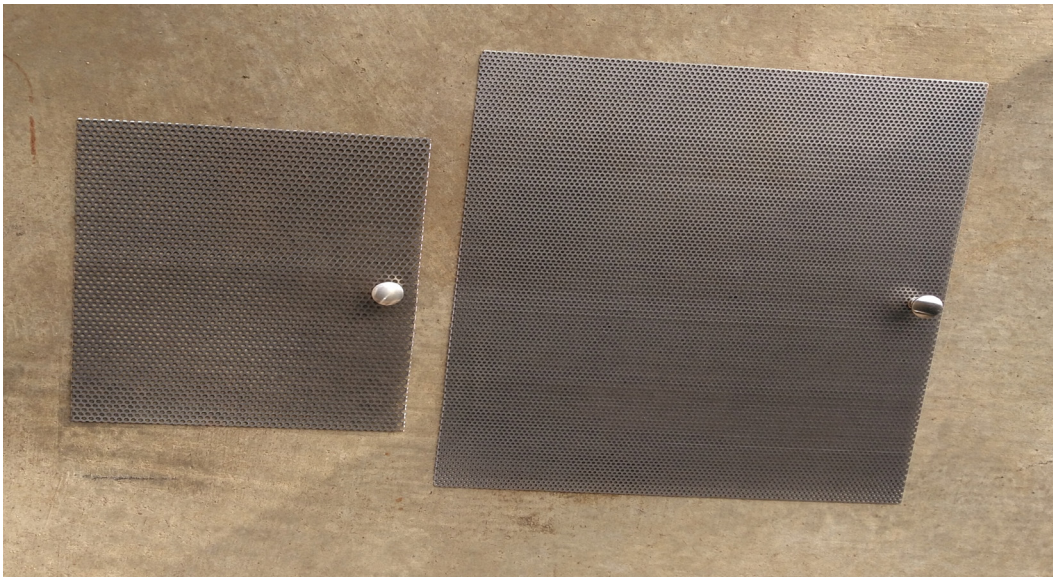
Screen “L” (optional to improve uniformity for 3/4 HP, required for 1 HP)
Hole size: 1/8” (3 +/- 0.5 mm)
Open area: 40% (+/- 3%)

Screen “M”
Hole size: 1/16” (1.6 mm +/- 0.2 mm)
Open area: 23% (+/- 2%)

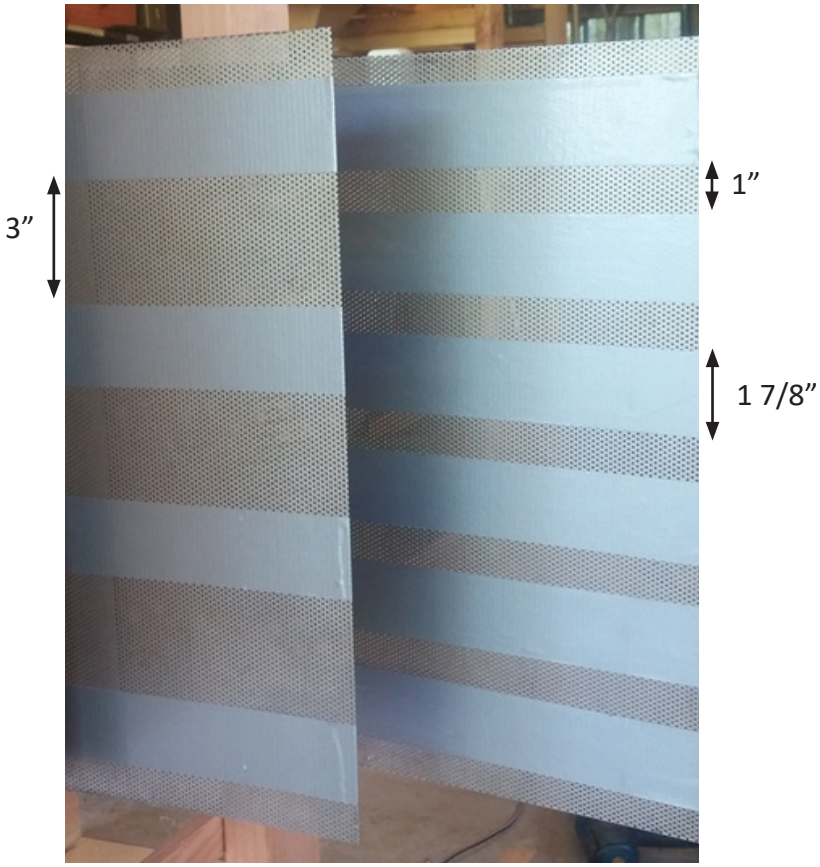
Screen “R1”
Hole size: 1/16” (1.6 mm +/- 0.2 mm)
Open area: 13% (+/- 2%)
Or construct from screen “M” by partial obstruction

Screen “R2” (3/4 HP model only)
Hole size: 1/16” (1.6 mm +/- 0.2 mm)
Open area: 6% (+/- 1%)
Or construct from screen “M” by partial obstruction

Screen “S”
Hole size: 3/64” (1.2 mm +/- 0.2 mm)
Open area: 28% (+/- 2%)



Add door pulls to the magnetically-attached permanent screens to facilitate removal for cleaning. Either shorten the bolts supplied with the pulls or purchase #8 x 1/2” bolts.



If screens with ~13% and ~6% open area are not available, partially obstruct a ~23% open area screen with tape as shown here to create the “R1” (45% obstructed) and “R2” (70% obstructed) screens.

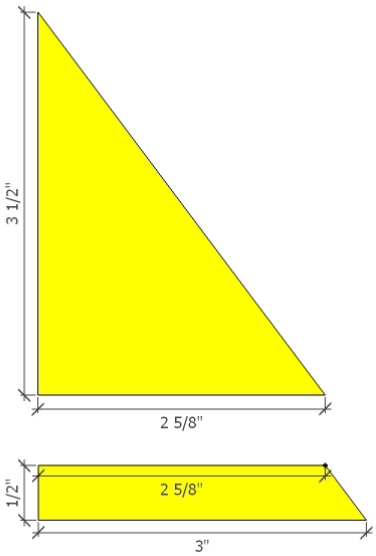
Dividers

The dividers are constructed as 3-4-5 triangles, a “Pythagorean triple” that harkens back to high school geometry. The main challenge in constructing them is making a sharp, straight fold in the aluminum covering.

1. From 1/2” plywood, cut two base boards, 24” long x 3” wide on the bottom, with one edge cut at a 37º inward angle (shown as end view). Cut eight right triangles, 3 1/2” x 2 5/8” (shown as side view). This is easiest accomplished by cutting a 3 1/2” x 24” piece from alongside the wind tunnel sides (see p. 27) and then using a miter saw for the crosscuts. The remaining scrap can be cut into two 3 1/2” x 5 1/8” pieces to serve as rear hopper support guides.

2. Assemble plywood into two splitter frames (see photo) with two 1 1/4” screws per connection. Pre-drill and countersink screw heads to avoid splitting.

3. Using 3/4” plywood or 1-by lumber scrap, cut four blocks measuring 3/4” x 1” x 1 3/4”. Attach to ends 1/2” up from the bottom (even with the top of the base board) with 1 1/4” screws. Attach 3/4” wide adhesive rubber strips to the bottom to hold them in place on the ruled rails.



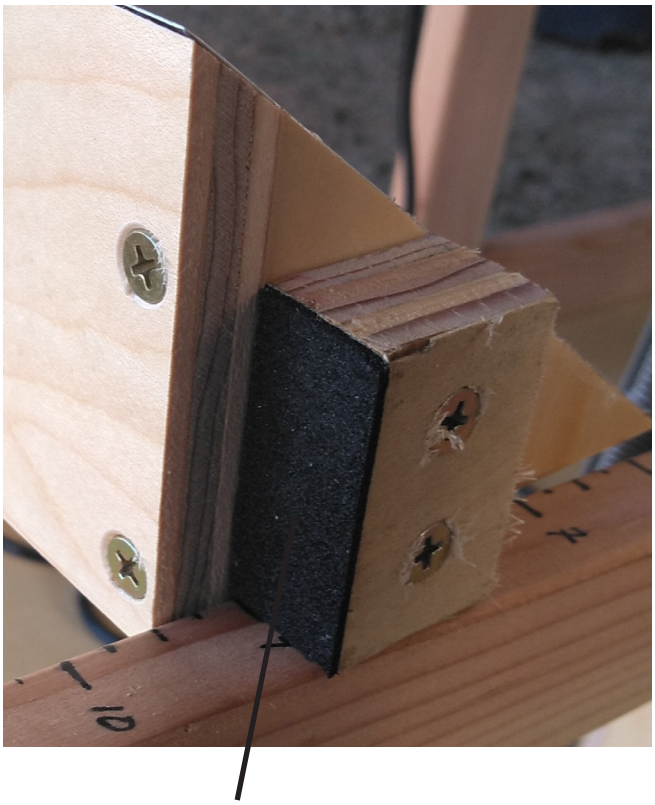
4. Cut two rectangles of 0.016” or 0.02” thick aluminum, 9” x 24”. Draw a line at 4”. Note that highly tempered alloys (including the common 6060-T6) will crack if folded sharply; 5032-H32 or 3003-H14 are good options. From the remainder, cut a piece measuring 10 1/2” x 11” for the feed tray.

5. Fold the metal on this line. If you have access to a shop with a bending brake, this is easy. If not, you can use available materials. Cut a warp-free piece of plywood scrap at least 24” long at a 45º blade angle. Clamp together a sandwich of a 2x4 on the bottom, metal, plywood scrap with the angled edge aligned with the bending line, and another 2x4 on top. Using a third piece of 2x4 scrap, fold the metal over as sharply as possible.

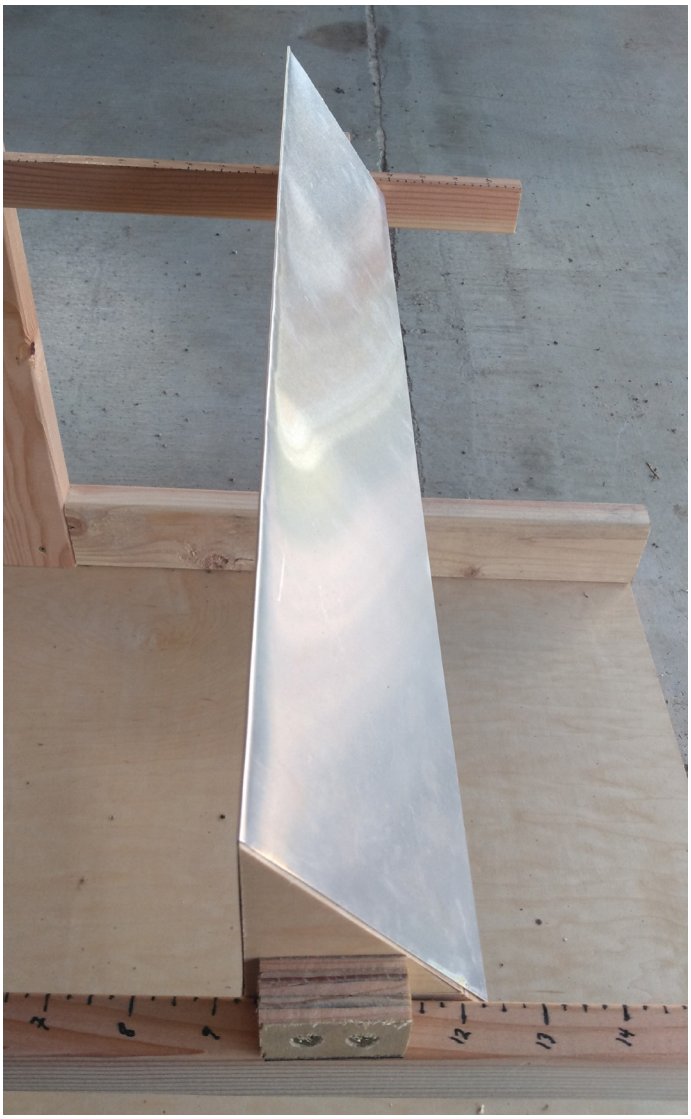
6. Fold the metal over completely and, with a 2x4 scrap protecting the fold, hammer the fold as flat as possible.

7. Using the 45º plywood scrap, hammer the fold back open to an angle of ~30-35º.

8. Place the folded aluminum over the splitter frame and glue in place with a high-quality epoxy.

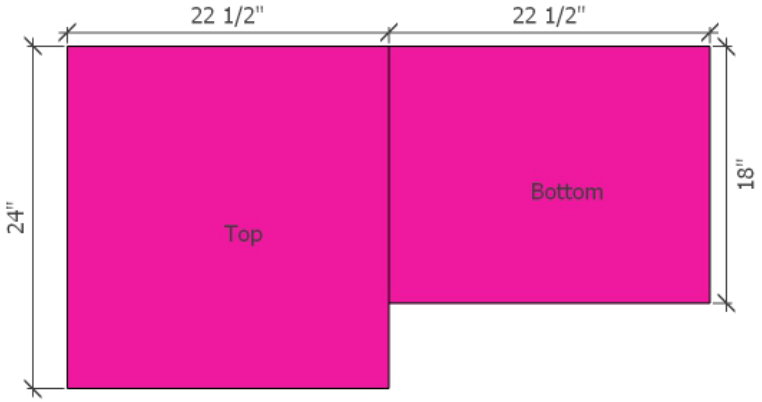


Rubber strip on bottom

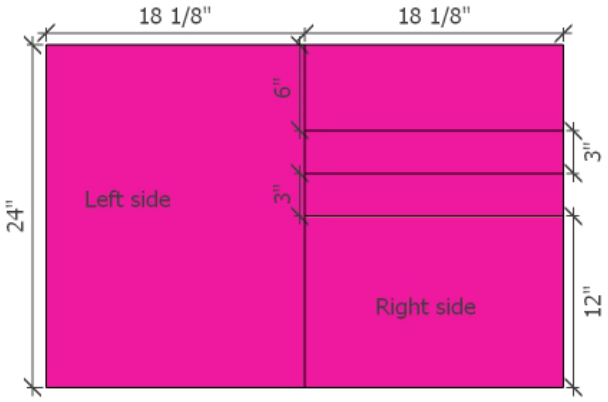


Wind Tunnel

1. Cut plywood pieces. For the left side, start with a piece 18 1/8” x 24”, then make the three dividing cuts. The saw kerf width will be left open as slots for the perforated screens.



2. Assemble plywood box using #6 x 1 5/8” screws, screwing through top and bottom into the edges of the sides. Align the bottom flush with the sides and top at the back, leaving a 6” gap at the front. This prevents seeds from landing inside the wind tunnel when bouncing off of the dividers. For the left side, start with the 6” piece in back and keep the pieces in their original orientation. Use a sliding screen plus the 0.02” thick aluminum (from p. 33, step 4) to set the slot width. If you have tape covered R1/R2 screens, use these along with the aluminum spacer to set the rear slot width slightly wider. It is important that the slots are not too wide, as escaping air can affect left-to-right airflow evenness.



3. Cut twelve 21 3/8” lengths of 1x2, leaving the straightest, most knot-free lengths for the frame rails. Cut one piece 1” x 21 3/8” from 1/2” plywood scrap.

4. Using 1” screws, attach eleven 1x2s to the top and bottom inside of the box as screen guides, leaving 1/16”-1/8” wide slots aligned with the screen slots on the right side. For the rearmost top guide use the plywood strip instead to allow clearance for inserting/removing the permanent screen behind. Save the remaining 1x2; it will be added as a permanent screen guide after the blower adapter is attached (p. 17, step 6, shown in photo below).

View into wind tunnel from front, after blower adapter attached and front permanent screen inserted.

Mark forward from rear edge for screen guide boards, and mark at 1” for later blower adapter insertion.

Bottom screen guides installed, aligned with slots on left side. If your 1x2s are wider than 1 7/16” you will need to rip four of them narrower to fit between the screen slots.

Hopper

The hopper is built from equilateral triangles and is half of an octahedron. There are a lot of angled cuts - the angles don't need to be perfect but should be within one degree or so for a good fit.

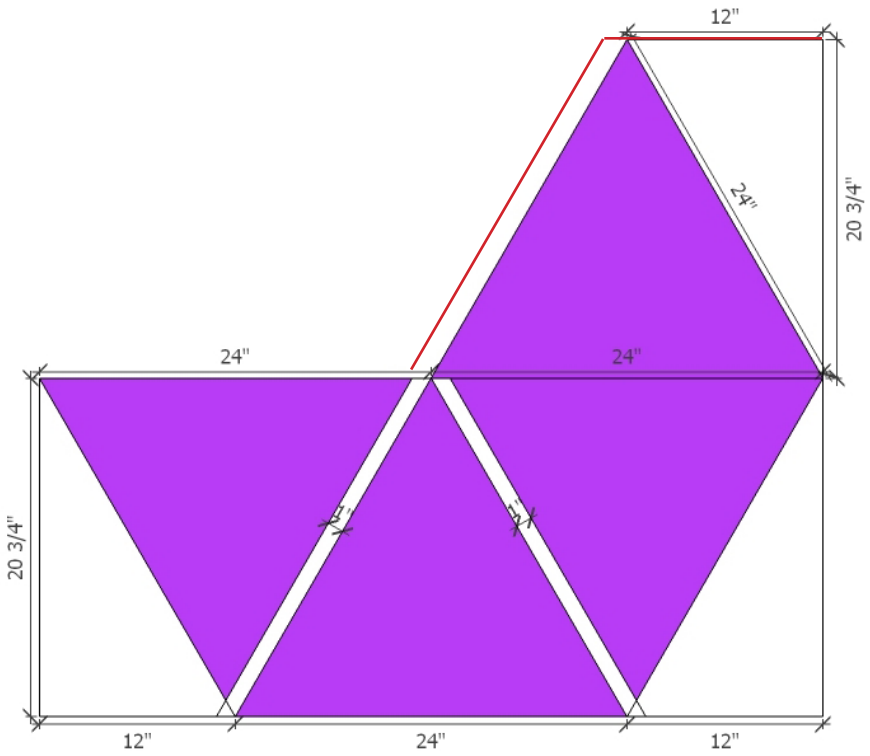
1. Select the better side of the pre-finished plywood for the inside of the hopper, and draw your lines on this side.

2. Mark at 12" and 36" along the 4' edge of plywood.

3. Draw a line 20-3/4" from the edge and mark at 24" and 48" along this line.

4. Connect the marks to form three equilateral triangles.

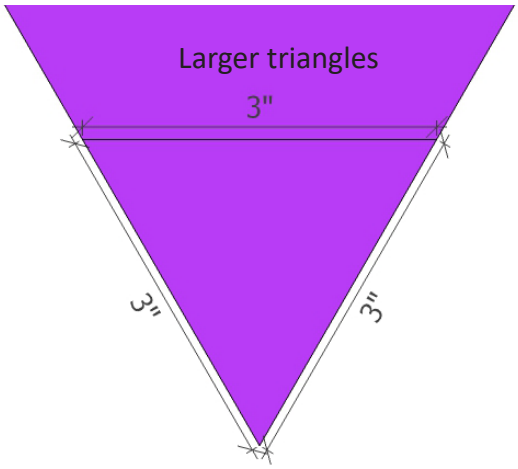
5. Starting with the edges of the center triangle, draw parallel lines 1" away, as shown in the diagram. This makes the right and left triangles smaller; they will go inside when assembled while the larger triangles will go outside.

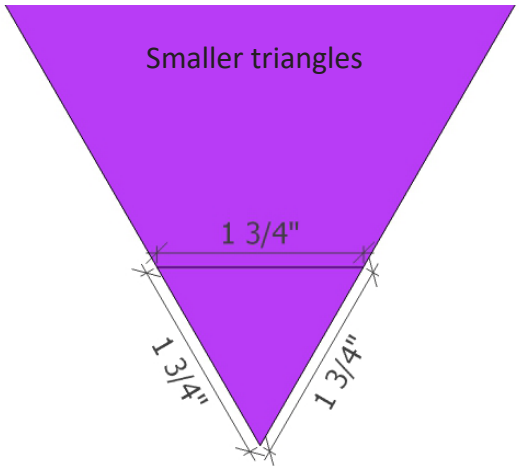


6. Make the straight cut at 20-3/4".
Draw the fourth triangle and cut along the red lines to remove it from the plywood sheet. Cut the diagonal ~1" away from the edge of the triangle.

7. Set the blade angle to 19.5º (that's the mathematical angle, but half-degree accuracy is not essential). Cut all of the diagonals, with the blade angled inward so that the bottom surface of the triangles is narrower than the top. Cut as straight as possible, especially on the smaller triangles where the edges will form seams. Keep the smaller and larger triangles separate.

8. The triangles now have two angled edges. The corner where the two angled edges converge is the bottom corner. Working on the same side of the plywood as before, draw lines in the bottom corners as shown below.





9. Set the blade angle to 35º. Carefully cut along the lines to truncate the bottom corners, again angling the blade inward.

10. Deburr the acute angle edges with a file, then assemble the four triangles with four #6 x 1 5/8” screws per side, predrilling, countersinking the heads, and screwing through the larger triangles into the edges of the smaller triangles. Align the bottom corners exactly. The bottom will form a square opening 1 3/4” on a side. Round the top outside corners with a file, and if you will be building an agitator file back the side top corners so they do not project beyond the rear top edge.

Adding the sliding gate

11. From 0.06” thick stainless steel, cut two squares measuring 3” on a side (the gate supports) and one rectangle measuring 2 5/8” x 4” (the sliding gate). Deburr the edges with a file.

12. Draw a line on the squares 3/8” in from an edge. Clamp along this line between two pieces of 2x4 scrap, with 3/8” protruding. Using a hammer and another small 2x4 scrap, bend the protruding edge through an angle of approximately 56º. A bending brake makes this task much easier. Test the angle on the bottom of the hopper; it will likely take some further adjustments to get the angle correct. It is much better to have the angle slightly too steep than too shallow; only the outside edge of the support should contact the sliding gate.

13. Drill four holes in the larger portion of each of the bent squares, using a bit large enough to clear your 1/2” sheet metal screws with some room for adjustment.

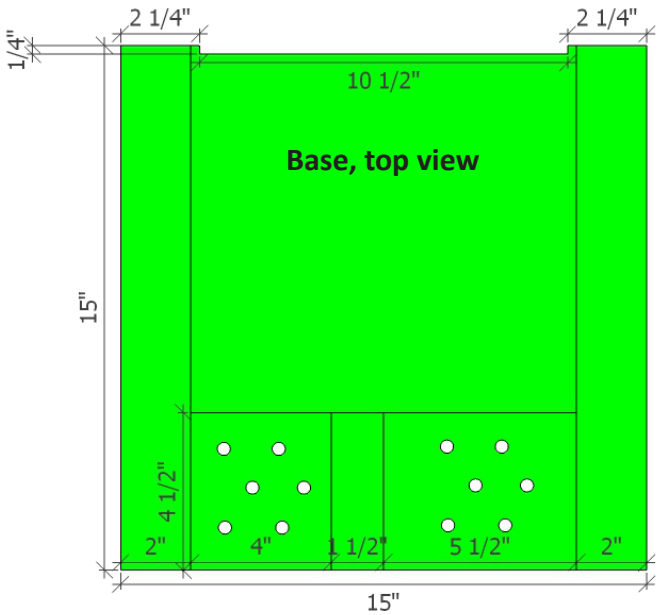
14. Attach the door pull 3/8” from a narrow edge of the 2 5/8” x 4” rectangle. Trim the bolt that came with it, or substitute a 1/2” bolt.

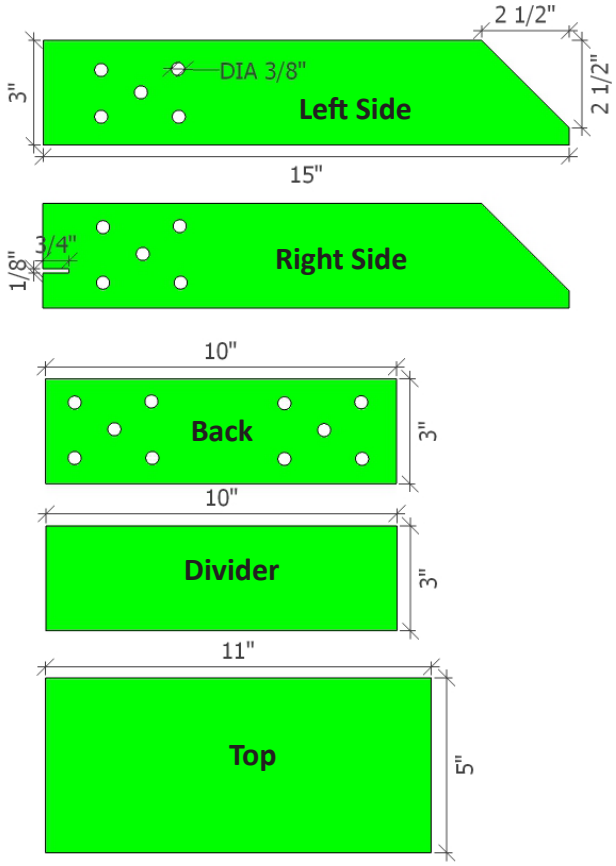
15. While holding the sliding gate in place, attach the gate supports to the non-seam sides of the hopper with 1/2” sheet metal screws. When tightening the screws, adjust the tension so that the gate slides with reasonable ease but is held firmly at any position from closed to fully open. Perform fine tension adjustments as shown on pp. 16-17.

Feed Tray

The feed tray needs to accommodate the shaker motor. If you find a different motor you may need to adjust the dimensions accordingly. If desired, locking slide-bolts or other methods may be used in place of stacking magnets to adjust feed slot width.

1. Cut the following plywood pieces. Use a jigsaw to make the front notch in the base and the cord notch in the right side.



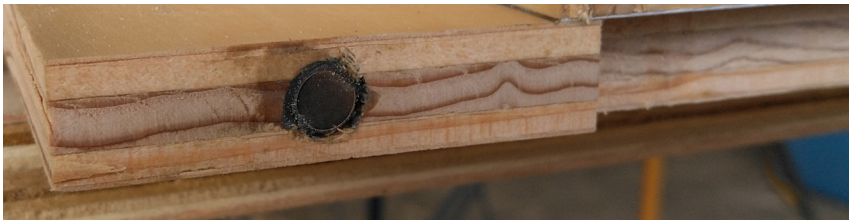


2. Mark lines on the top of the base, as shown.

3. Drill 3/8” holes for motor ventilation, as shown. Do not drill holes in the top, or in the forward divider. Depending on where you will be using/storing the machine you may wish to cover these holes with fiberglass window screen to deter wasps and spiders from moving in.

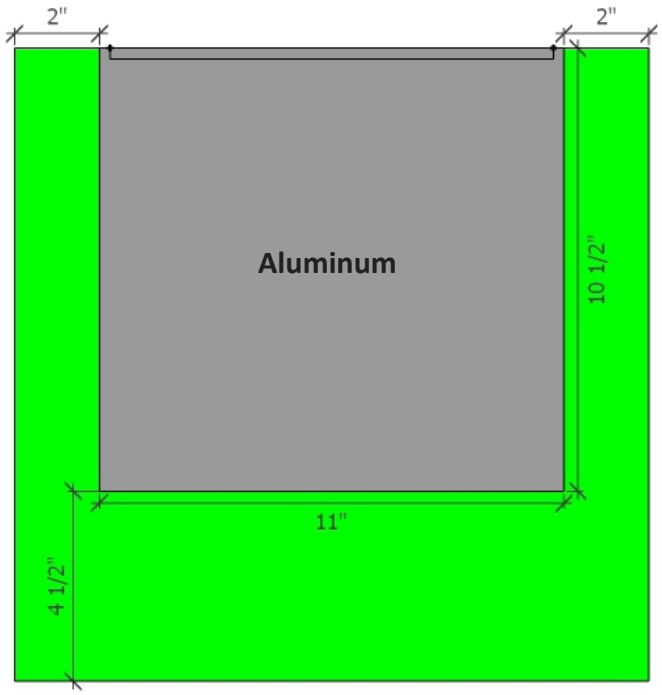
4. Mark the side edges of the base, 2 1/2” in from the ends. Drill four centered holes at these marks, of sufficient diameter and depth to accommodate your eye screws without splitting. For me these are 3/16” x 3” deep holes. Align the drill carefully such that the holes remain centered in the wood through their length.

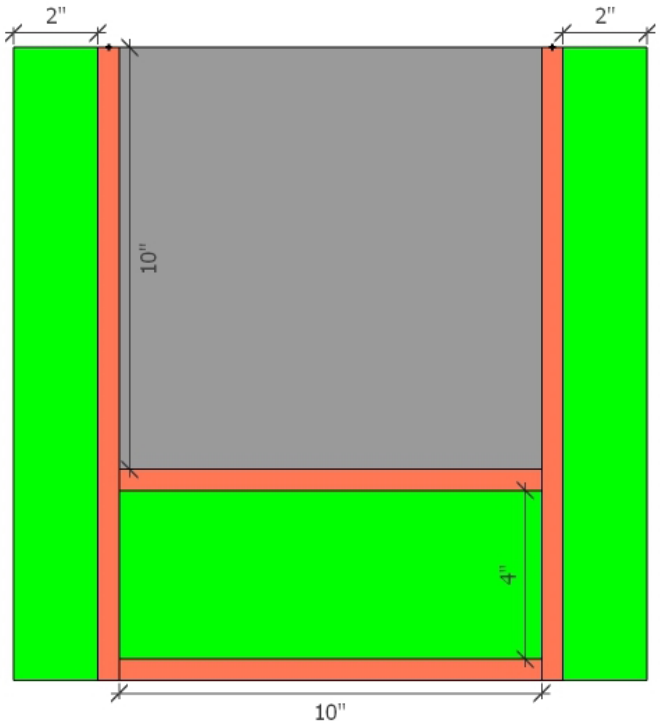
5. Mark the front edges of the base, 1” in from the ends. Countersink with a 5/16” bit to 1/8” deep, then pre drill a centered hole with a 1/8” bit. Drive in a #6 x 1 1/4” screw, setting the head 1/16” below the surface. Then add a drop of epoxy and a 1/4” x 1/16” cylindrical magnet, such that the front surface of the magnet is flush with the front edge.



6. Glue your 10 1/2” x 11” aluminum rectangle (from p. 33, step 4) to the top of the base as shown, using a high-quality epoxy. (Ventilation holes and marker lines not shown on this diagram.)

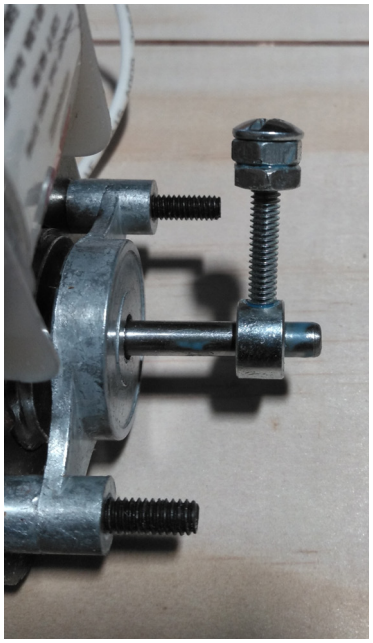
7. Assemble the sides and dividers as shown (top view, sides and dividers in red, 45º cutout at front of sides). Predrill holes from beneath and in from the sides, and use #6 x 1 5/8” screws. Do not add the rear divider yet.



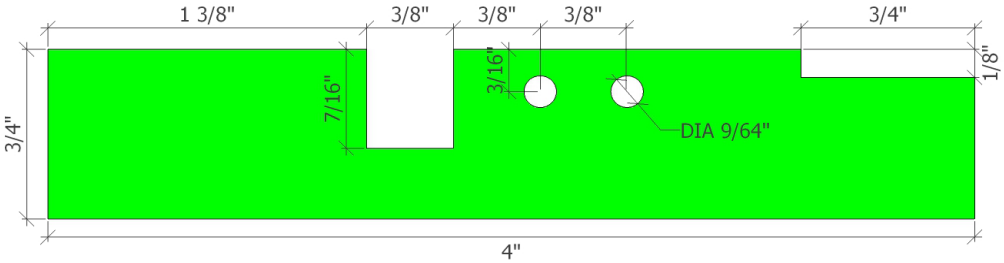


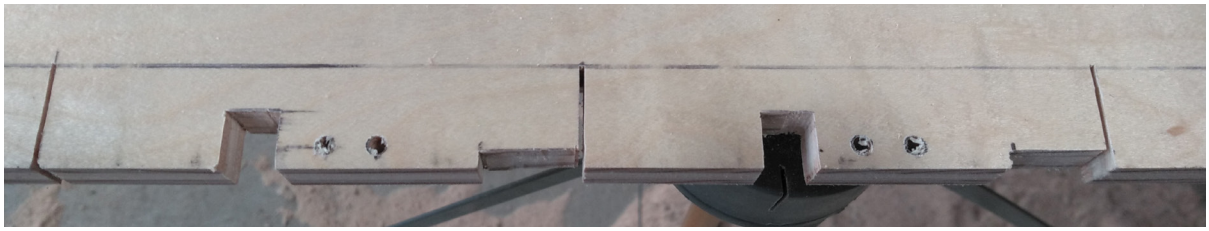
8A. Prepare the vibration motor (Dayton 4M068 [120V] or 4M069 [240V]) - or skip to 8B

a. Thread two nuts all the way onto the #8 x 1” bolt, tightening and securing with threadlocker. Remove the set screw from the 3/16” shaft collar and replace with the bolt, adding threadlocker to the bolt threads. Tighten onto the shaft as close to the motor body as possible while allowing at least 2 mm clearance between the rotating bolt head and the motor bolts.



b. Cut four motor mounts from 1/2” plywood scrap as shown below. Use a scroll blade on a jigsaw for the small notches, then cut them free with a circular saw.





c. Using four #6 x 2” bolts and nylon lock nuts, assemble the motor to its mounts. Feed the bolts through from the shaft side so the protruding ends don’t interfere with the vibration bolt. Tighten securely.

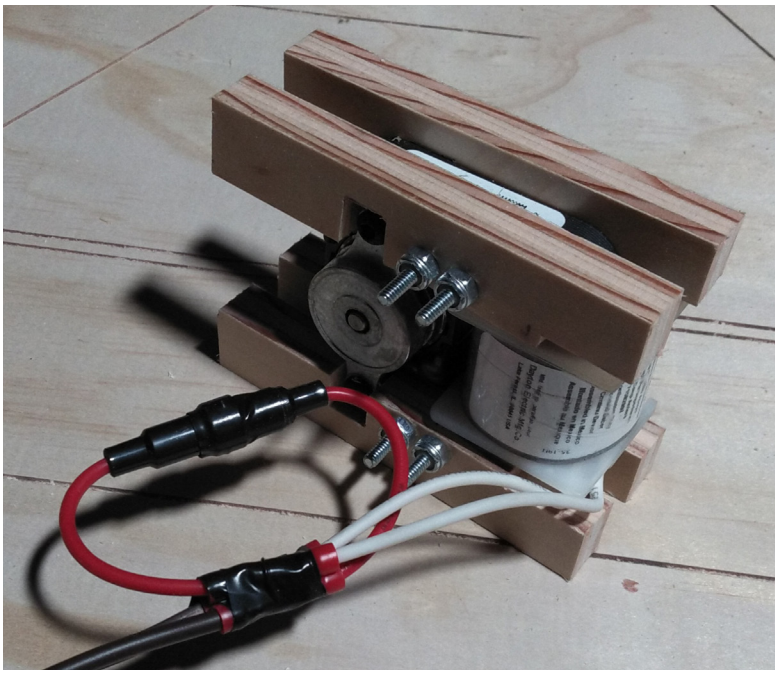
d. Trim the 16/2 extension cord to 31” (this length will change if your electrical layout differs from p. 23).

e. (optional) Insert a 1-amp slow-blow fuse into the fuse holder and connect the fuse holder to the hot wire of the extension cord with a crimp splice. (This is an added protection against overheating and fire in the event of electrical overload/motor stalling.)

f. Trim the motor leads. Connect the extension cord (and fuse holder, if present) to the motor leads with crimp connectors.

g. Apply a drop of 3-in-1 or small motor oil to both shaft bushings.

h. Plug the motor into an outlet to test, using care not to touch any live parts.



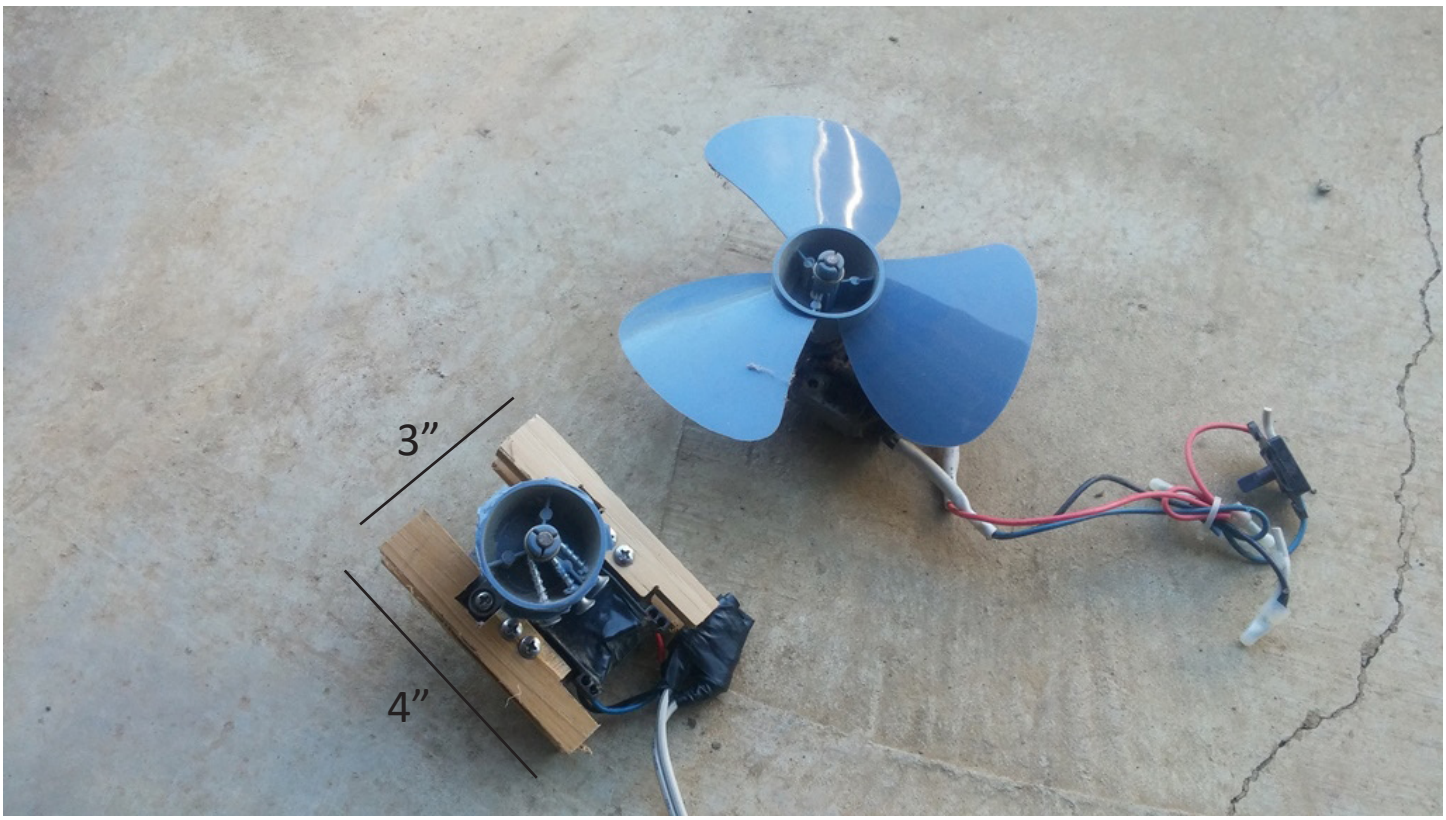
8B. Prepare the vibration motor, starting with a small fan (skip if you did step 8A)

a. Find a small desk fan or window fan that uses 30 watts or less and that has a C-frame motor less than 3” wide.

b. Cut off fan blades, and drive six 1” screws into one side of the shaft. This off-balances the shaft to create vibration.

c. Craft the motor mount using 4” lengths of 1/2” plywood, with notches and mounting holes as necessary to fit your motor. The direction of rotation should be clockwise viewed from the left (see diagram). Most fan motors have four mounting holes; use all of them if possible, and use lock nuts.

d. Proceed through steps d-h under 8A above.



Vibration motor next to unmodified fan motor. Note direct wiring to motor, blades removed, screws added to off-balance shaft, custom mounts attached with four bolts and lock nuts, dimensions 3” x 4” to fit into feed tray.

9. Mount the motor in the feed tray between the marked lines from step 2. The shaft-side edge of the motor mount should be on the centerline of the feed tray. Attach the motor mount with four 1” screws from below, using care to drill only 1” deep and to drill into the center of each rail ~1” from each end. For electrical safety the mounting screws should not contact the motor or the mounting bolts. Slip the cord into the notch, then clamp it in place by adding the rear divider with screws in from the sides and up from the bottom. If the cord is not held tightly enough to prevent movement, add glue where it passes through the notch.

10. Attach the top cover with four 1 5/8” screws into the sides, divider, and back, and four 1” screws into the motor mounts using the same precautions as in step 9.

11. Construct the suspension cables

Note that if you do not have access to small-diameter steel cable, ferrules, and a crimper, the feed tray can also be suspended by loops of rope 9 1/2” long.

a. Drive two square-bend hooks into a piece of 2x4, 9 1/2” apart.

b. Cut four 13 1/2” lengths of 1/16” diameter steel cable.

c. Form a ~1” loop in one end, enclosing an eye screw in the loop. Secure the loop with a cable ferrule.

d. (optional) Thread a 1” section of 3/16” heat shrink tubing over the free end. This will simply cover the sharp edges of the upper ferrule for more comfortable handling when adding/removing the feed tray and changing the angle.

e. Form a loop in the other end of the cable. Pull the cable snugly around the two hooks on the jig and secure the loop with another cable ferrule. Try to make all four of the cables the same length within 1/8” or so.

f. (optional) Slide the heat shrink tubing over the upper ferrule and use a lighter to shrink it into place.

12. Attach the suspension cables by screwing the eye screws into your predrilled holes along the edges of the feed tray.

13. Count out 32 cylinder magnets (1/4” x 1/16”) from the stack. Attach stacks of four to the front edge as an initial slot width setting, and store the remaining magnets in stacks attached to the screw heads on the sides.

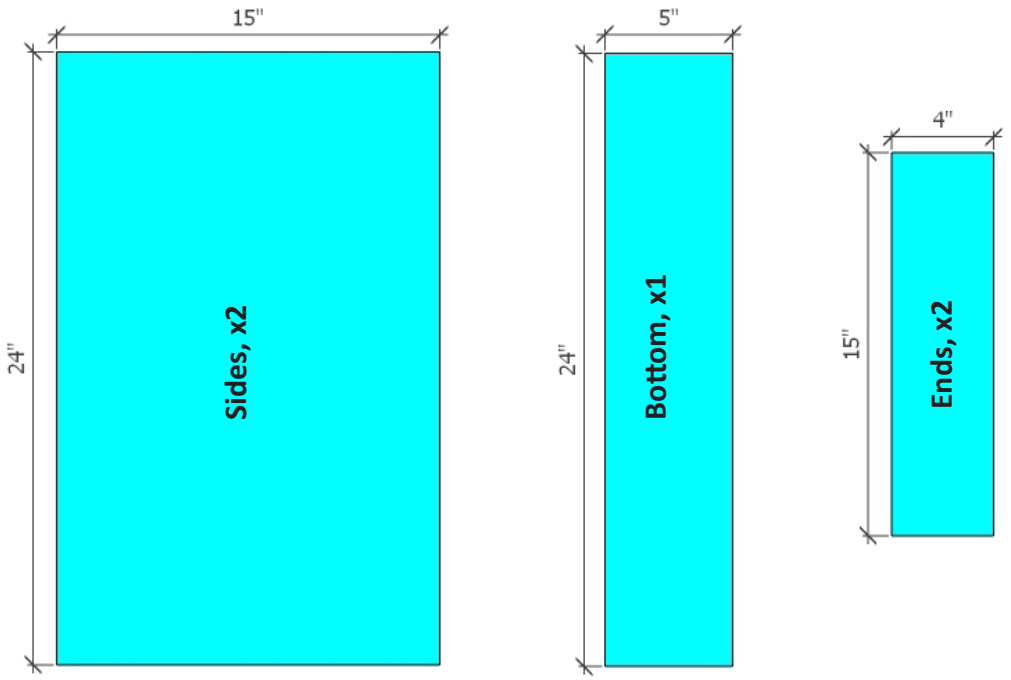
14. Once the remaining components and frame are complete, adjust level and equalize cable tension as described on p. 24, step 24.

Feed tray in place; note stacks of extra magnets on sides.

Narrow Bin (optional)

You can change the dimensions of the narrow bin if desired. A 4” width is enough to hold a decent quantity of seed and to get hands inside for cleaning. By changing the orientation of the dividers, the narrow bin can accommodate a divider gap of 1/2” up to 6” or so.

1. Cut prefinished or sanded 1/2” plywood pieces as shown.



2. Assemble with #6 x 1 5/8” screws, attaching ends between the sides (while ensuring bottom corners are perfectly even), then attaching the bottom. Final outside dimensions will be 24” L x 5” W x 15 1/2” H.

3. If desired, seal inside seams with caulk or tape to prevent small seeds from getting caught.

Return to p. 14 and proceed through p. 24 to construct the frame and complete assembly.

Magnetic Dirt Removal Hopper Gate (optional)

1. Cut three rectangular pieces of 0.06” thick galvanized steel. It is essential that this steel be magnetic (i.e. not stainless) and that it is exactly the same thickness as the stainless steel used for the hopper gate. Dimensions: one piece 4” x 2 5/8”, two pieces 4” x 1 5/8”

2. Glue the pieces together (with the same epoxy as used elsewhere) as shown below, with a 1/2” gap on each side of the narrow pieces. The wider piece forms the top (sliding hopper gate) and the stacked narrow pieces form a spacer that allows the magnet to ride below the gate supports. Choose the straightest edge for the magnet end, and set back the edges of the narrow pieces by ~1 mm so that they do not interfere with falling seed.

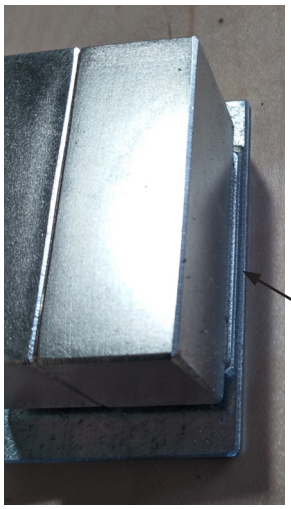
3. Drill a 3/16” hole through all three pieces at the non-magnet end, 3/8” in from the edge and centered across the width. Attach a door pull (of the same type used for the hopper gate) to the top side.

4. Assemble the two 3/4” x 1” x 2” rare earth magnets into one stronger magnet. **This is a potentially hazardous step; do not allow the two magnets to freely snap together as they may shatter in a cloud of sparks and release high-velocity shrapnel! This happened to me once.**

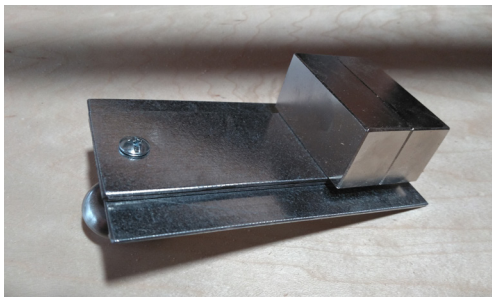
The magnets are shipped with a plastic spacer in between. Wearing eye protection and sturdy gloves, twist and pull one magnet off and set it on a nonmagnetic surface. Place a wooden clipboard or piece of 5 mm plywood on top of it. Grasp the second magnet by the sides (preserving the original orientation so that opposite poles are facing each other) and lower it toward the other with the wood spacer in between. They will snap together with surprising force, so ensure no fingers are pinched. Once attached with the spacer between, grasp both magnets and slide them off of the edge of the spacer material. They will snap together first at one end then the other as the spacer is removed.

5. Attach the paired magnets to the prepared gate as shown below, again wearing eye protection and being cautious of pinched fingers. Set the magnet edge ~1/8” back from the edge of the gate. This distance can be adjusted for optimum performance during operation.

See operating manual p. 15 for use instructions and precautions.



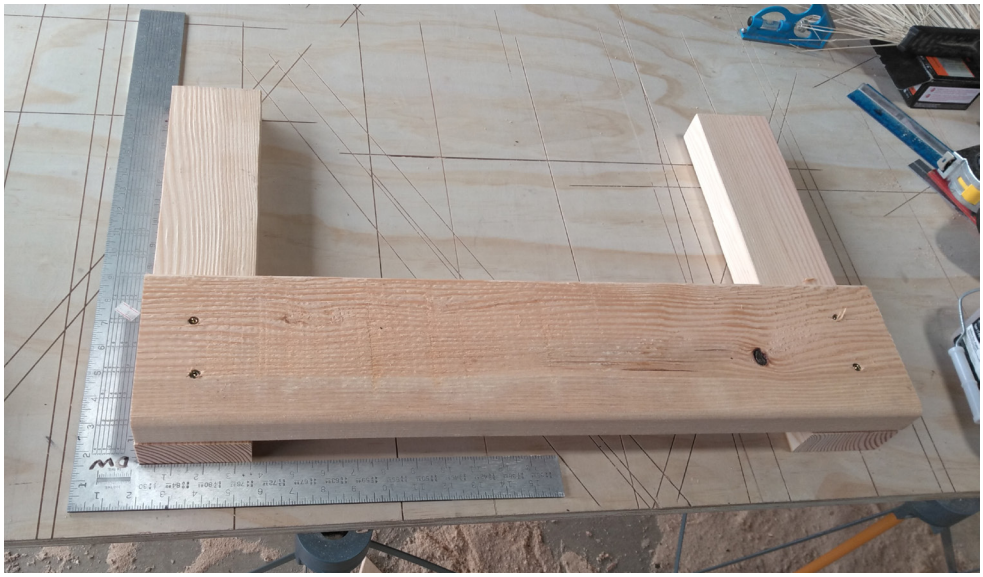
Note spacer metal set back ~1 mm from gate edge.



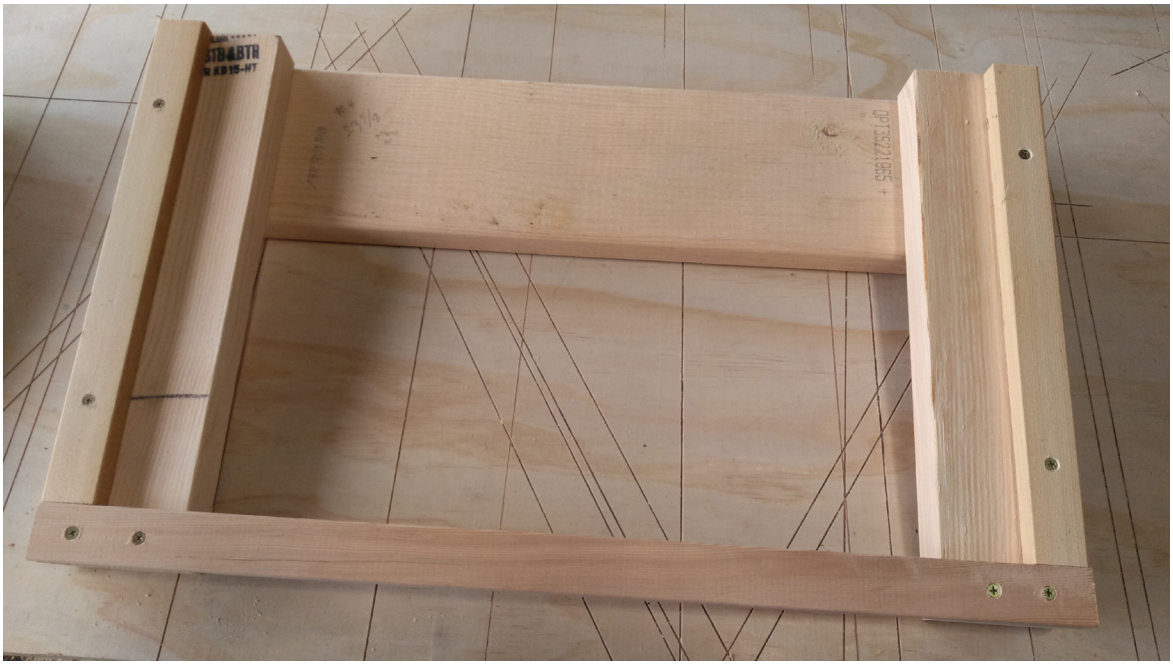
Hopper Agitator (optional but highly recommended, build after machine is complete and assembled)

1. Cut the following lumber:
   2x6: 26 1/2” (1)
   2x4: 16” (2)
   1x2: 26 1/2” (1), 14 1/2” (2)
   1/2” plywood: trapezoidal seed shield, 26 1/4” wide at the base, ~12” tall, 60º base angle (see p. 26)

2. Attach the 2x6 to the 2x4s as shown with 3” screws, ensuring that the corners are square.



3. Turn the assembly upside down and attach the long 1x2 to the rear edge with 1 5/8” screws, pre-drilling and countersinking to avoid splitting. Measure the width of your hopper at the top - typically it is around 23 1/2”. Add 1/8” to this measurement and attach the shorter 1x2s to the sides with exactly this distance in between. This ensures a good fit on top of the hopper.



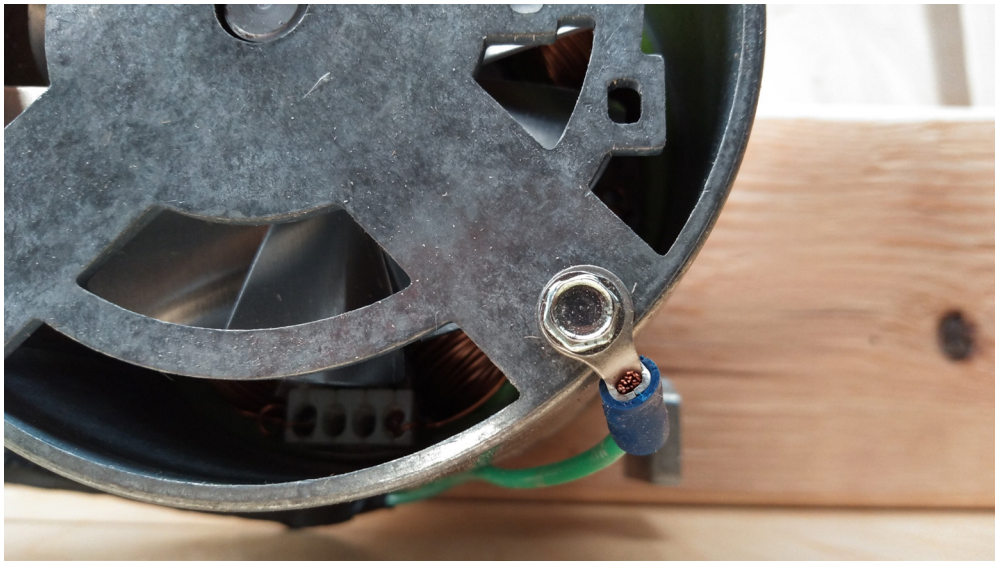
4. Turn the assembly right side up. Make a mark in the center of the 2x6, 2 3/4” in from the front edge. Drill a 1 3/8” or 1 1/2” diameter hole through the wood, centered on this mark.

5. Unpack the gearmotor and remove the shaft key - you won’t use it. Secure the shaft coupling to the shaft using the set screw (5/32” hex wrench). Slide the coupling only on far enough to obtain a solid connection, leaving as much room as possible beneath for the agitator shaft to adjust up and down.

6. Place the motor on the wood assembly with the shaft centered in the hole and the wire leads facing forward. Mark the mounting holes from above - outline with a fine-tip marker or use a sheet of carbon paper. For either of the Dayton motors (1LPL6 - 115V or 4Z521 - 230V), drill 1/4” holes at each mounting location.

7. Feed 1/4” x 2” bolts with washers through from below and tighten into the motor mounting holes.

8. Attach a ground wire to the motor frame using a ring terminal on one of the existing assembly bolts. Use electrical tape to wrap this ground wire together with the motor leads for a distance of 4-6”.

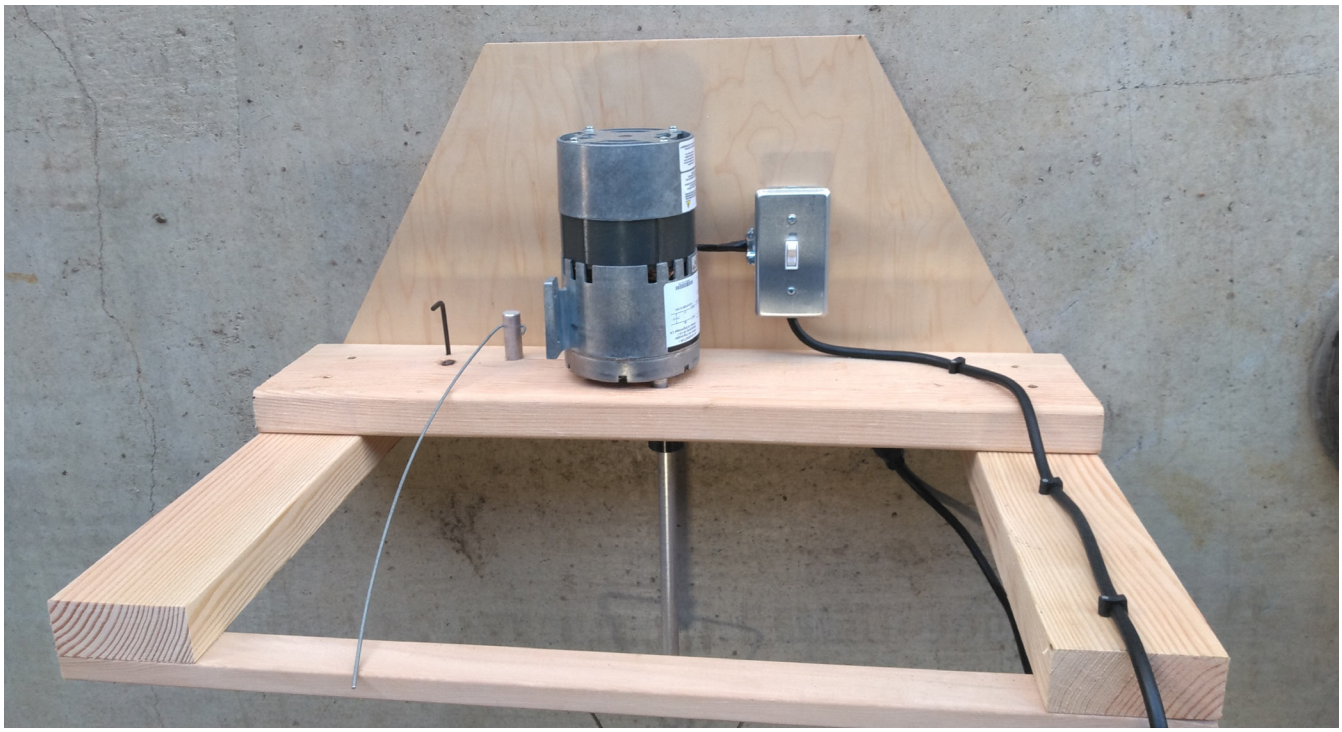


9. Attach the seed shield to the front with five 1 5/8” screws, with the bottom aligned with the edge of the 2x6.

10. Insert cord clamps into switch box knockouts. Mount box just to the right of the motor such that the motor leads easily reach the box with wire to spare. Use 1/2” sheet metal screws. Add a grounding screw and “pigtail” wire to ground the box itself. Insert motor leads and ground into side knockout.

11. Place agitator on hopper and measure the length of cord required to reach the upper switched outlet on the right side of the machine. If your dimensions and switch box placement are the same as mine, that length will be ~56”. Cut the 16/3 cord to this length, strip the cut end, and insert into bottom knockout. Secure the cord to the agitator frame in 2-3 places (see photo below).

12. Wire the 15A single-pole switch to the hot wires, connect neutral wires, connect ground wires, and close up the switch box. Plug in the motor to test.

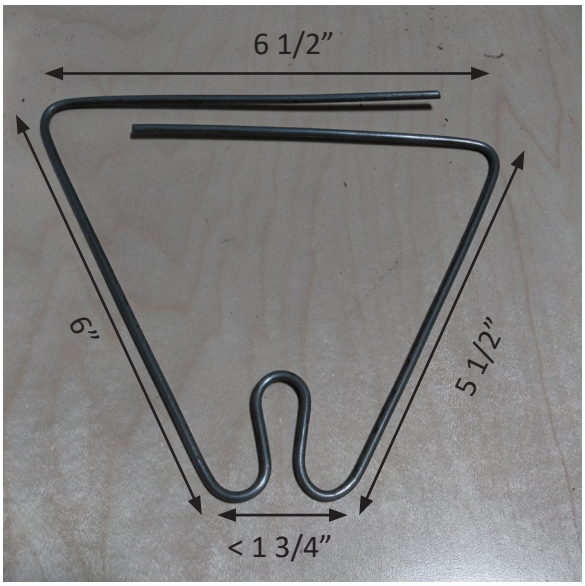


13. Ensure that your 5/8” diameter aluminum rod fits into the shaft coupling. If not (extruded rod tends to be slightly large), file down the first 5” slightly until it fits. Cut a 2 1/2” long piece from that end, then cut the remaining length to 11 3/8”

14. For the “wiggle wire” (at right), drill a hole just larger than the wire (7/64” for 12-gauge high-tensile), 1/2” from an end of the 2 1/2” aluminum rod. Insert the wire through ~1/2” and bend 90º, then bend the other side nearly 90º in the same direction. Flex the wire into a slight arc - so it will sweep out a circle inside the hopper - then cut it long enough that it sticks through the hopper gate ~1” when attached to the motor. This can be trimmed later - if using the wiggle wire with the magnet (see manual p. 15) the wire should be trimmed to stick through the gate only ~1/4” so as to avoid contacting the magnet surface.

15. For the “triangle twist” - which you will use far more often - I originally used 12-gauge high-tensile wire but found that it bent at the shaft eventually or when confronted with high resistance from large bean chaff, errant sticks, etc. So I have shifted to 1/8” spring-steel “music wire” which is very sturdy but also very difficult to form without special tools. So...if you don’t have a rod bender (shown at bottom right), choose the sturdiest wire/rod that you are able to form into shape. There is nothing especially magical about this shape, but it does work well with most seeds. The dual tips help, so that the wire doesn’t block as much of the gate opening.

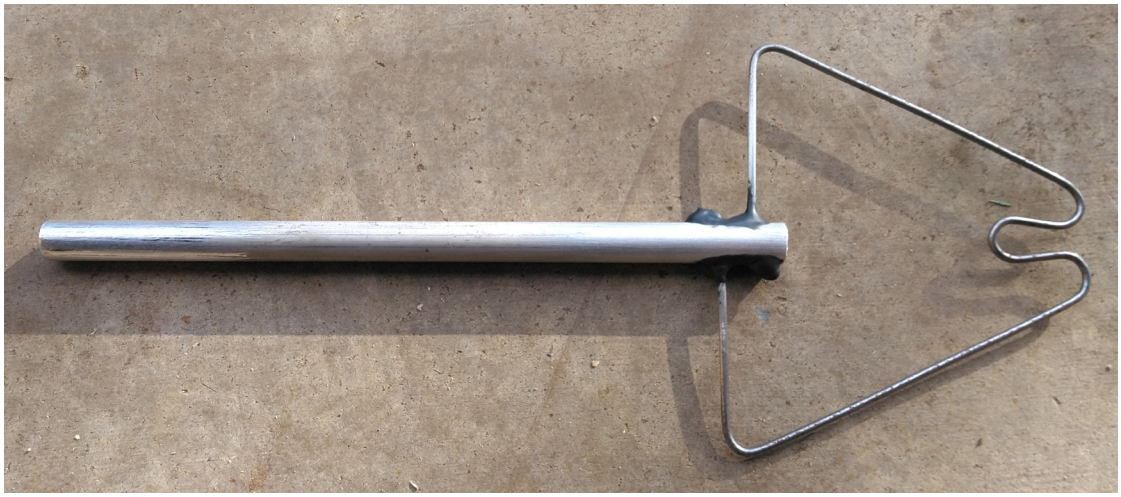
Cut a straight piece of rod/wire 26” long, and form it into the shape shown at right. Use coarse sandpaper to roughen the top pieces which will insert through the shaft, to improve epoxy adhesion.



16. Drill two parallel 1/8” (or as required) holes through the end of the 11 3/8” aluminum rod, 1/2” and 1” in from the end. Use coarse sandpaper to roughen the rod surrounding these holes to improve epoxy adhesion.

17. Insert the wire through the shaft; shape to the proper width, center the bottom on the shaft, and bend the ends over with pliers to hold it in place.

18. Trim the wire ends to ~1/4” beyond the bend, but leave the bend in place to anchor in the glue. Adjust the bottom of the triangle to be centered on the shaft and if necessary lock it in place with a drop of superglue. Using a very strong, non-flowing epoxy - I now use 3M DP420NS - completely cover both sides of the connection, encapsulating both bends. Allow it to cure for two days before using. This joint is subject to extreme stresses when encountering large debris, and even the best glues can fail. If it comes unglued it will still work; the triangle will just rub against the hopper sides at times.



Completed “triangle twist” attachment. Note generous epoxy and top section filed to fit into coupling.

19. Place the agitator on the hopper, with the rear guide firmly against the rear edge of the hopper, and insert the triangle twist. Adjust so it is sitting just above the hopper gate and tighten the set screw. Tighten the motor mount bolts to center the agitator in the hopper. You will see how it moves as you tighten the bolts; tightening the rear bolt moves it forward, tightening the front bolt moves it rearward, and tightening the side bolt moves it to the opposite side. Once it is centered (and all bolts are reasonably tight), lift it to ride ~1/2” above the gate. If it can’t be lifted this far, trim the coupler end of the shaft as necessary.

20. Drill a 5/8” hole partway through the 2x6 to the left of the motor to hold the attachment not currently in use. Drill an 11/64” hole to hold the 5/32” hex wrench. See photo on p. 49.

Additional attachments may be useful. In particular, some papery seeds, or grasses with awns, would benefit from an auger-shaped attachment actively moving material toward the hopper opening. If you develop additional or improved attachments please let me know.

Congratulations! Your Winnow Wizard is complete. Happy Winnowing!

~Markael Luterra, February 6, 2020

Please send a photo of your finished machine - and any comments or corrections for these plans - to mark@luterra.com.