Farm-scale winnower

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Appropriate Technology for Small and Subsistence Farms
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[Other designs available at http://www.agronomy.ucdavis.edu/LTRAS/itech/]

This electric winnower removes chaffs from small grains (barley, clover, quinoa, wheat), large grains (vetch, pea, bean) and dried roots. It uses a blower with a 1/3 horsepower 1025 rpm, AC motor and a 10-inch diameter wheel (Figure 1). The winnower chute is 14 inches wide because 30-gauge galvanized sheet metal flashing (roofing material) comes in 14-inch wide rolls (Figures 2 and 3).

The winnower separates grains from chaff by density difference; the greater the differences in density, the more complete the separation. Materials to be winnowed are placed in the grain tray, and then pushed into the chute through the grain entrance near the top of the chute (Figure 1). The blower forces air upwards from the bottom of the chute. The airflow causes the lighter chaff to follow the air up and out the top of the chute, while allowing the heavier grain to drop down the chute. The winnower cannot separate materials with similar densities (beans from dirt clods; beans from fresh nightshade berries; or wheat from vetch).

Air velocity in the chute is determined by the blower size and rpm, the size of the blower opening, the throat depth of the chute (Figures 2, 3 and 4), and the amount of material in the chute being winnowed. Adjust the air velocity to lift the grain up but not high enough for the majority of the grain to exit through the top of the chute. This design has a 5-inch hurdle (Figures 3 and 4); chaff must rise more than 5 inches above the grain entrance to exit the top of the chute. For initial settings, adjust the air velocity to lift the grain 6 inches or adjust the air velocity to float 1 percent of the grain out the top of chute while allowing 99 percent of the grain to drop down the chute. Re-winnow the 1 percent of grain that exited the top of the chute.

Air velocity in the chute is not constant. When materials enter the chute, they obstruct the airflow and decrease the air velocity. Varying the rate in which materials are pushed into the chute will affect the degree of obstruction, the air velocity, the proportion of grain lifted out the top of the chute and the proportion of chaff remaining in the winnowed grain.

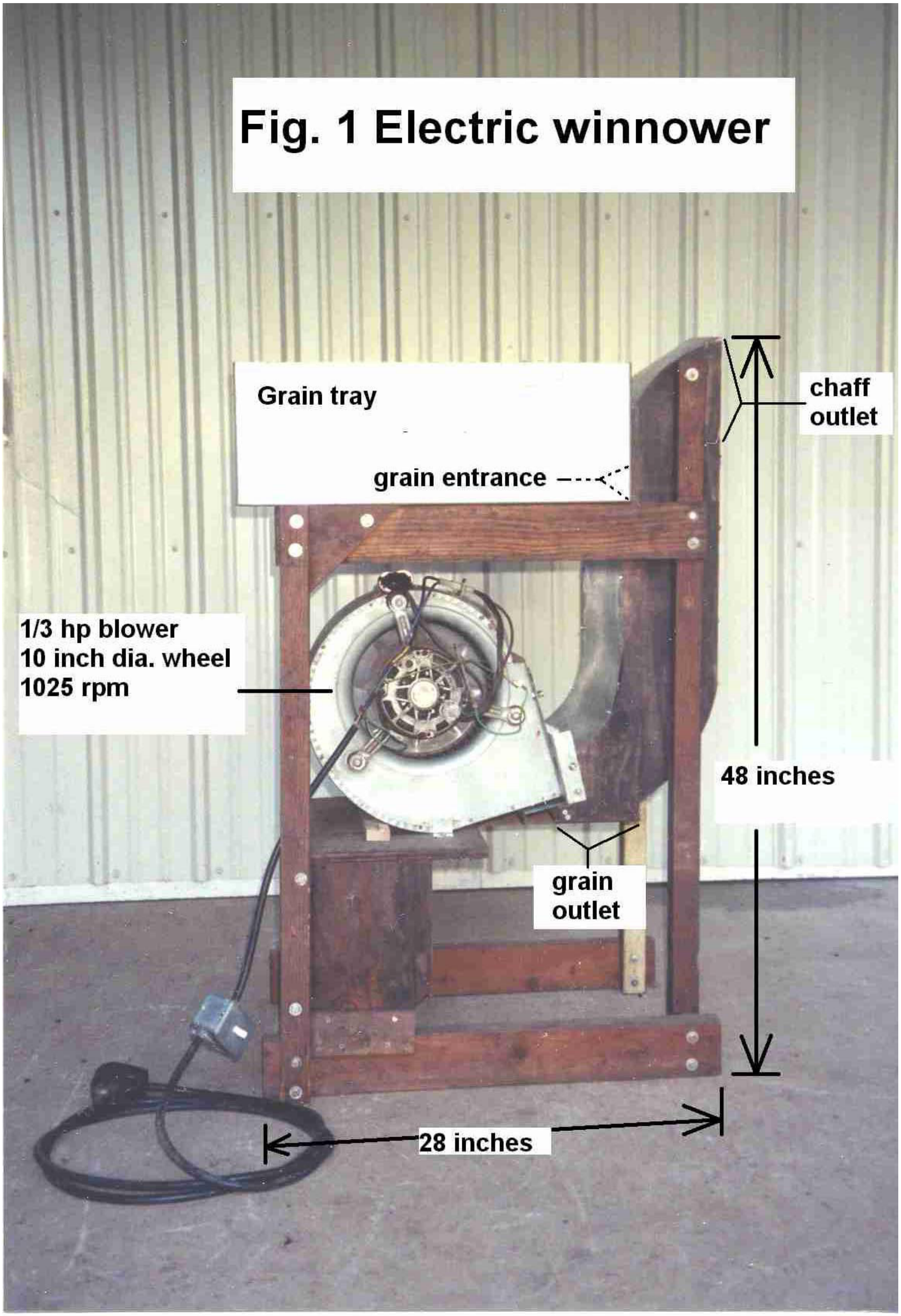


Fig. 1 Electric winnower
Grain tray
grain entrance
chaff outlet
1/3 hp blower
10 inch dia. wheel
1025 rpm
48 inches
grain outlet
28 inches

1. Design considerations: provide a uniform and well-regulated airflow across a large cross sectional area for winnowing.
    a. Using a blower with an AC motor complicates the design because it lacks continuously variable speed control. The reasons for using an AC motor are cost and availability. If cost were not a consideration then it would be simpler to regulate the airflow with a continuously variable speed DC blower.
    b. A typical 1/3 hp heating and ventilation blower with an AC motor provides excess airflow needed for winnowing, even at the lowest speed. The blower is baffled to reduce the airflow.
    c. The cross-sectional area for winnowing increases with increasing throat depth. However the uniformity of airflow begins to decrease significantly at a throat depth of 3 inches.
    d. Reducing the winnower throat depth with (removable) spacer boards may improve the uniformity of airflow across the cross-sectional area. The spacer board also causes the airflow in the chute to increase and requires corresponding baffle adjustment to reduce the airflow.
2. Airflow regulation is accomplished by blocking the blower opening with a baffle plate. Multiple boltholes are made to the baffle plate to allow adjusting the blower opening from ¼ inch to 3 inches. CAUTION, prolonged operation of an unloaded wide-open blower, without baffling, may cause the motor to 'over run' and burn the motor.
3. The throat depth of the winnower chute is 5 inches wide. Removable spacer boards are attached inside the chute using c-clamps to reduce the throat depth. A smaller throat depth (1 ¾ -2 ¼ inches) provides a more uniform airflow and more consistent winnowing of small grains. A larger throat depth (up to 3 inches) provides a larger cross-sectional area to winnow large grains. Larger materials such as dried roots may need a throat depth greater than 3 inches to pass through the chute efficiently. If the winnower will not to be used for large materials, then design the chute with a 3-inch throat depth and use spacer boards to decrease the throat depth as necessary.
4. The chute dimensions (height, radius of curvatures, angle for blower air inlet, grain entrance, chaff exit etc) are not critical as minor changes in dimensions are easily compensated using spacer boards and by varying the blower opening with a baffle.
5. Optional: to prevent grain and chaff from entering the blower, attach a screen with ¼ x ¼ inch wire spacing (wire cloth) in the blower opening or in the chute near the blower opening. The screen also helps diffuse the air inside the chute for a more uniform airflow.

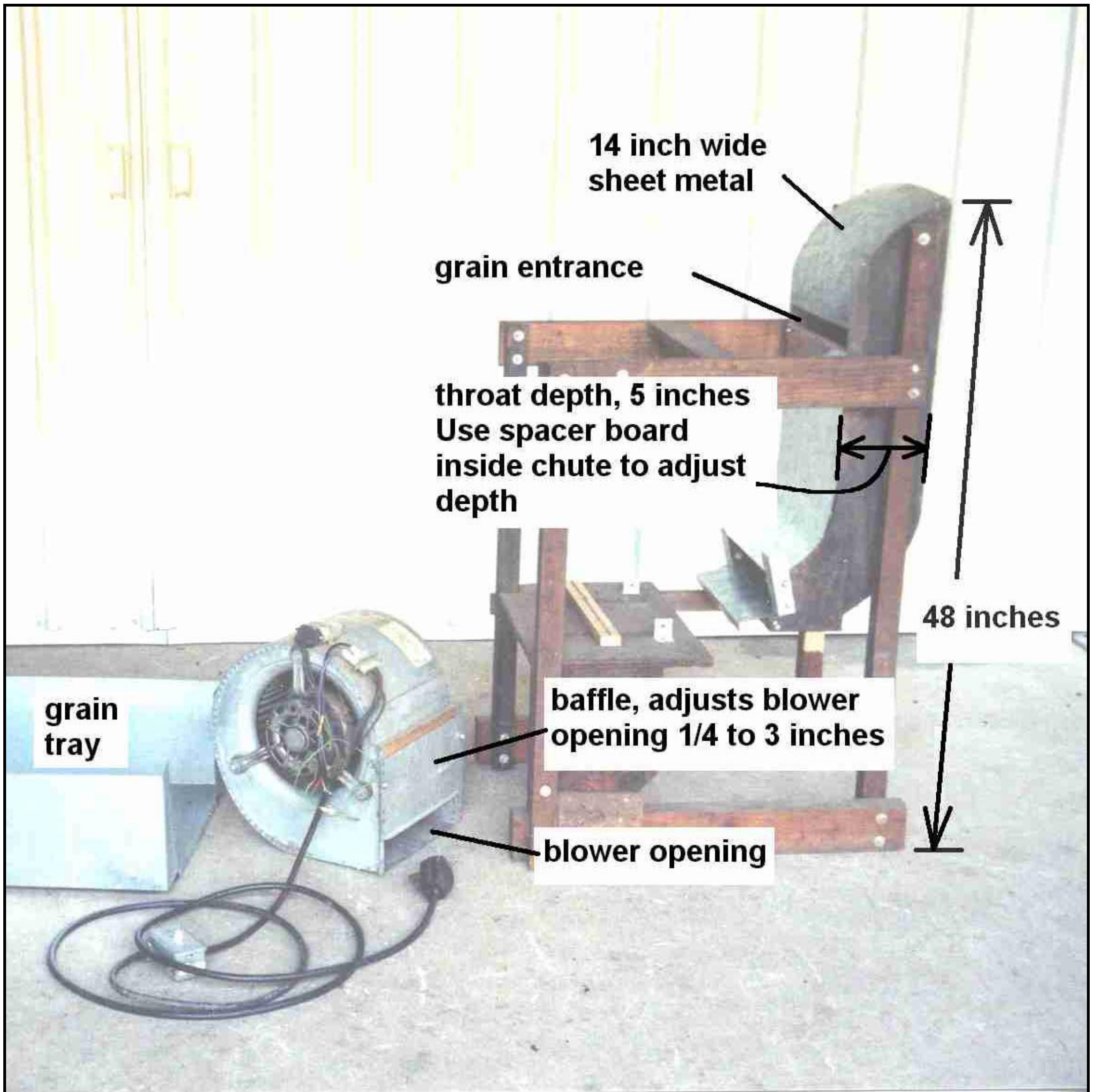


Fig. 2 Winnower, disassembled

Winnower chute

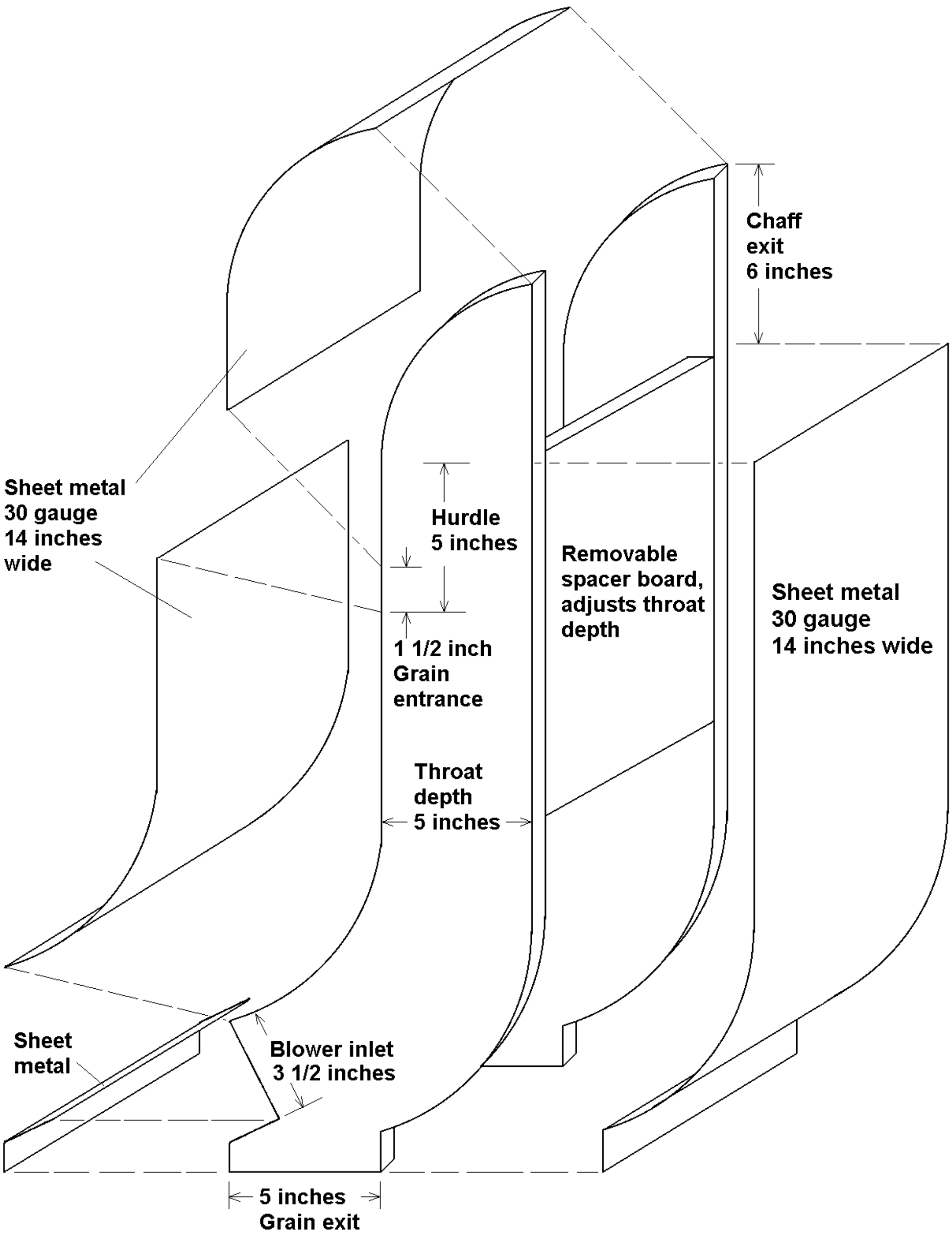
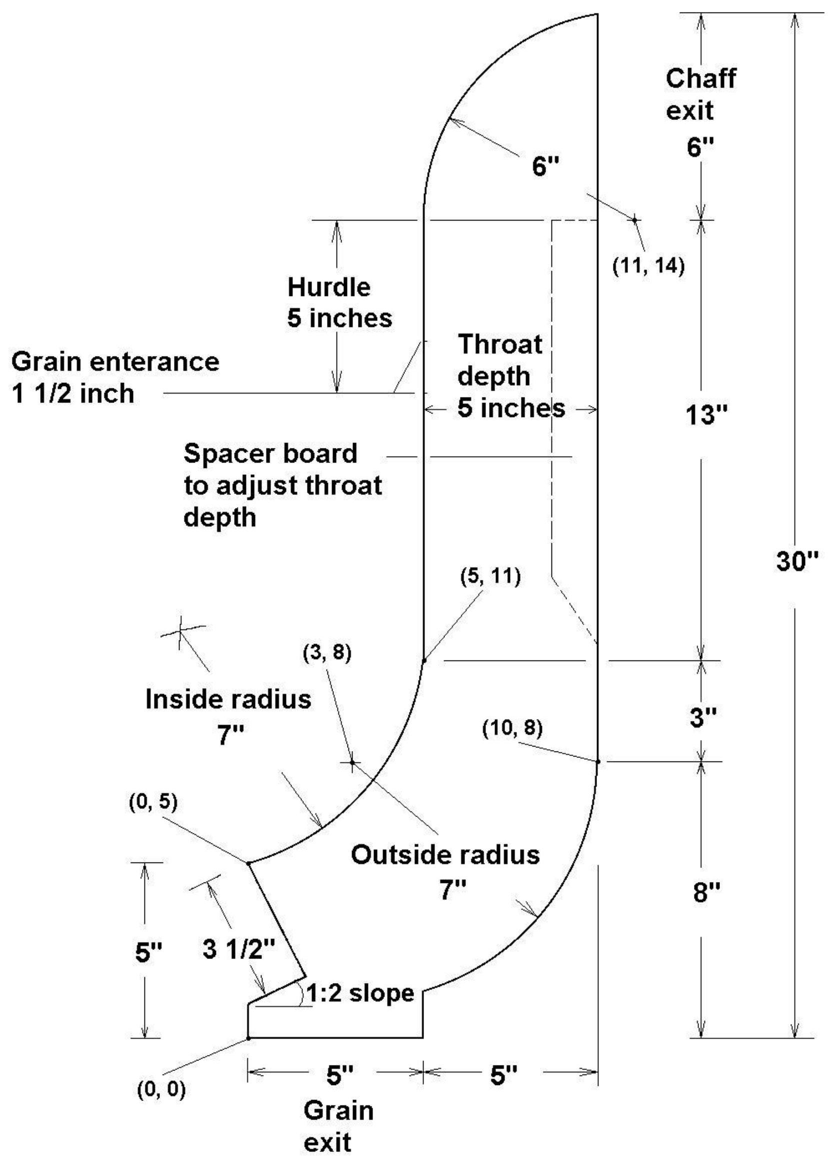


Figure 3. Exploded view of winnower chute



Winnower chute, 5/8 inch plywood (X,Y) coordinates in inches

Figure 4. Winnower chute dimensions.

Technical assistance from Robert Rousseau and Larry Fisher, Davis, CA

Grain Huller for Rice, Spelt Wheat, Quinoa and Millet

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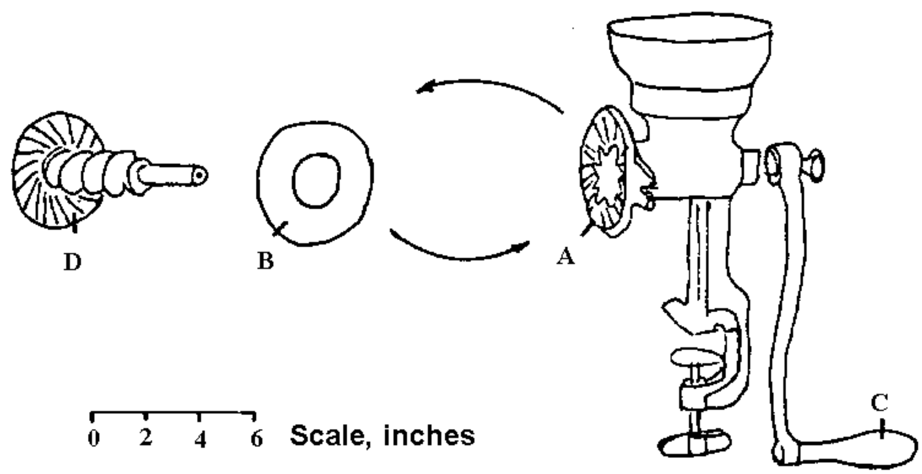
The two main components of the I-Tech rice huller are a hand mill/ flour mill or grain grinder and a rubber-faced disk made from:
A rubber disk,

- A steel washer for mounting the rubber disk on the hand mill,
- Cyanoacrylate glue ("super glue" or krazy glue") to attach the rubber disk onto the steel washer.

The stationary disk (A) is removed and replaced by a rubber-faced disk (B). By turning the auger handle (C), rice grains are pressed between the rubber-faced disk (B) and rotating disk (D) and then rolled out. The soft rubber disk allows the hulls to be removed with minimal damage to the rice kernels. Natural (gum) rubber is used for the rubber disk because it has better abrasion resistance than synthetic rubber. The "Corona" hand mill is available from R&R Mill Co., 45 West First North Street, Smithfield, UT 84335, USA.

Short grain rice can be hulled at a rate of 200 g/min. The percentage of rice hulled varies from 75 to 99% depending on the rice cultivars, the spacing between the stationary rubber disk and the rotating abrasive disk, and uniformity of spacing between the disks. A tin plated steel burr disk may produce a black gum residue when hulling rice, until the tin is worn off. No black residue was found when using a cast iron disk or stone disk.

The grain huller also hulls millet (*Panicum miliaceum*), sesame (*Sesamum indicum*), and spelt wheat (*Triticum spelta*) as well as remove saponins from quinoa (*Chenopodium quinoa*). To "wet" hull sesame, soak the seeds in 1% (w: v) lye (sodium hydroxide) solution for 10 seconds to 5 minutes, then rinse with water and 1% solution of acetic acid (Shamanthaka Sastry et al, J. Am. Oil Chem. Soc. 46:592A, 1969; Moharram et al, Lebensmit. Wissen. Tech. 14:137, 1981). A steel burr disk is preferred for wet hulling sesame, while a stone disk is preferred for hulling spelt wheat.



Hand operated rice huller: A) stationary disk, B) rubber disk, C) handle and D) rotating disk with auger. Remove stationary disk and replace with rubber-faced disk.

In the US, the C.S. Bell model 60 (cost ~$325) and the Corona hand mill (cost ~$40) represent two ends of the spectrum of hand mill quality. For serious hulling, the C.S. Bell is the better choice. This mill weighs 54 pounds; its auger shaft is supported by 2 bronze bearings with oilers; the grinding disks self aligns; and the mill can be motorized. The bronze bearing with oilers allow the shaft to rotate at 300 rpm without heating up. (CS Bell, PO Box 291 Tiffin, OH 44883, phone 419-448-0791).

The Corona hand mill weighs 14 pounds; it has no bearings; the grinding disks do not self-align; and the mill cannot be motorized. (R&R Mill Co., 45 West First North, Smithfield, UT 84335, phone 801-563-3333).

Conversion of a Leaf Shredder/Wood Chipper into a Grain Thresher

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A portable, engine driven thresher can be made by modifying a leaf shredder/wood chipper or a hammer mill. Small shredders/chippers use 5 to 8 horsepower gas engines that rotate at 2800 or 3600 revolutions per minute (rpm). The modification requires:

- Converting the free swinging hammers into rasp bars,
- Reducing the rotational speed of the hammers (250 to 1000 rpm on a 12 inch diameter hammer arms), and
- Altering the discharge port to allow smaller, threshed material to pass through a 3/8 to ¾ inch screen while retaining larger materials
- (Optional) if electricity is accessible, the gas engine can be replaced with a ½ to ¾ horsepower capacitor start electric motor (1725 rpm).

Materials:

- A 5 horsepower, 2800 rpm "Roto-Hoe model 500" leaf shredder/wood chipper is used (Figure 1). Additional parts include:
- Four 2-inch C clamps (A),
- Six 5/8 x 3 inch bolts (B),
- Six 1/8 x 1 inch cotter pins (C),
- One 5/8 inch inside diameter x 18 inch drip irrigation tubing or garden hose (D) as spacers between hammers, and
- One 8 x 10 inch sheet metal or cardboard (E) to block the slotted portion of the leaf shredder/wood chipper exit port.

Modification:

The "Roto-Hoe" shredder has six sets of three free swinging hammers (F). Convert the six sets of hammers into six rasp bars as follows:

- Cut the 5/8-inch tubing (D) in segments to fit between the free-swinging hammers (F).
- Tie the free swinging hammers (F) together by inserting the 5/8 inch bolt (B) into the hole of the first hammer, followed by a segment of tubing (D) as spacer, then another hammer, followed by a second segment of tubing, followed by the third hammer.
- Drill a 5/32-inch hole on the threaded portion of the bolt that protrudes from the third hammer.
- Reassemble the bolt, hammers, and spacers together and lock the bolt in place with the cotter pin (C) installed in the 5/32-inch hole. This assembly constitutes a rasp bar.
- Repeat the above procedure and tie together the remaining five sets of free-swinging hammers.
- Manually rotate the rasp bars and check for clearance between the rasp bars and the walls of the threshing chamber. If there is insufficient clearance, adjust the bolt position, grind the bolt head, or cut the bolt length to obtain the necessary clearance between the rasp bars and the walls.

The Roto-Hoe shredder exit port consists of a slotted section and a 3/4-inch diameter punched-hole screen. Use the sheet metal or cardboard (E) and C clamps (A) to block the slotted portion of the exit port (G). The threshed grain exits through the 3/4-inch holes. Start the engine and spin the rasp bars. Again, check for clearance between the rasp bars and the walls of the threshing chamber. If there is a knocking sound, grind the bolt down to obtain the necessary clearance.

Operation:
Start the engine and spin the rasp bars. Dried plant materials with vines, stems, and leaves are fed in batches through the hopper. After threshing for 1 to 3 seconds, open the top door to eject the longer vines, stems, and leaves that have not been chopped up. Seeds and small bits of plant material exit through the punched holes at the bottom. The mixture of seeds and plant material must be separated after threshing.

The 3/4-inch diameter holes in the exit port are suitable for larger seeds (e.g. beans) and seeds with loosely attached husks (e.g. wheat, bok choy, and amaranth). Small seeds and seeds with tight husk or pods (e.g. barley, clover and radish) require smaller diameter exit holes to retain the larger unthreshed materials while passing the smaller threshed grains. This can be achieved by attaching a screen with smaller openings under the 3/4-inch diameter punched holes.

Larger seeds crack easier than smaller seeds. Reduce the rasp bar speed to decrease the percentage of cracked seeds. Use a larger pulley (H) and/or reduce the engine speed to achieve the desire rasp bar speed:

- 250-400 rpm for beans and large seeds
- 400-800 rpm coriander, radish, sunflower
- 600-1400 rpm wheat, oats, barley, rice and small seeds

Typical threshing rates are:

- Seeds Pounds of seeds per hour,
- Amaranth 66
- Bok Choy 22 to 30
- Oats 94
- Pinto bean 117
- Soy bean 81 to 127

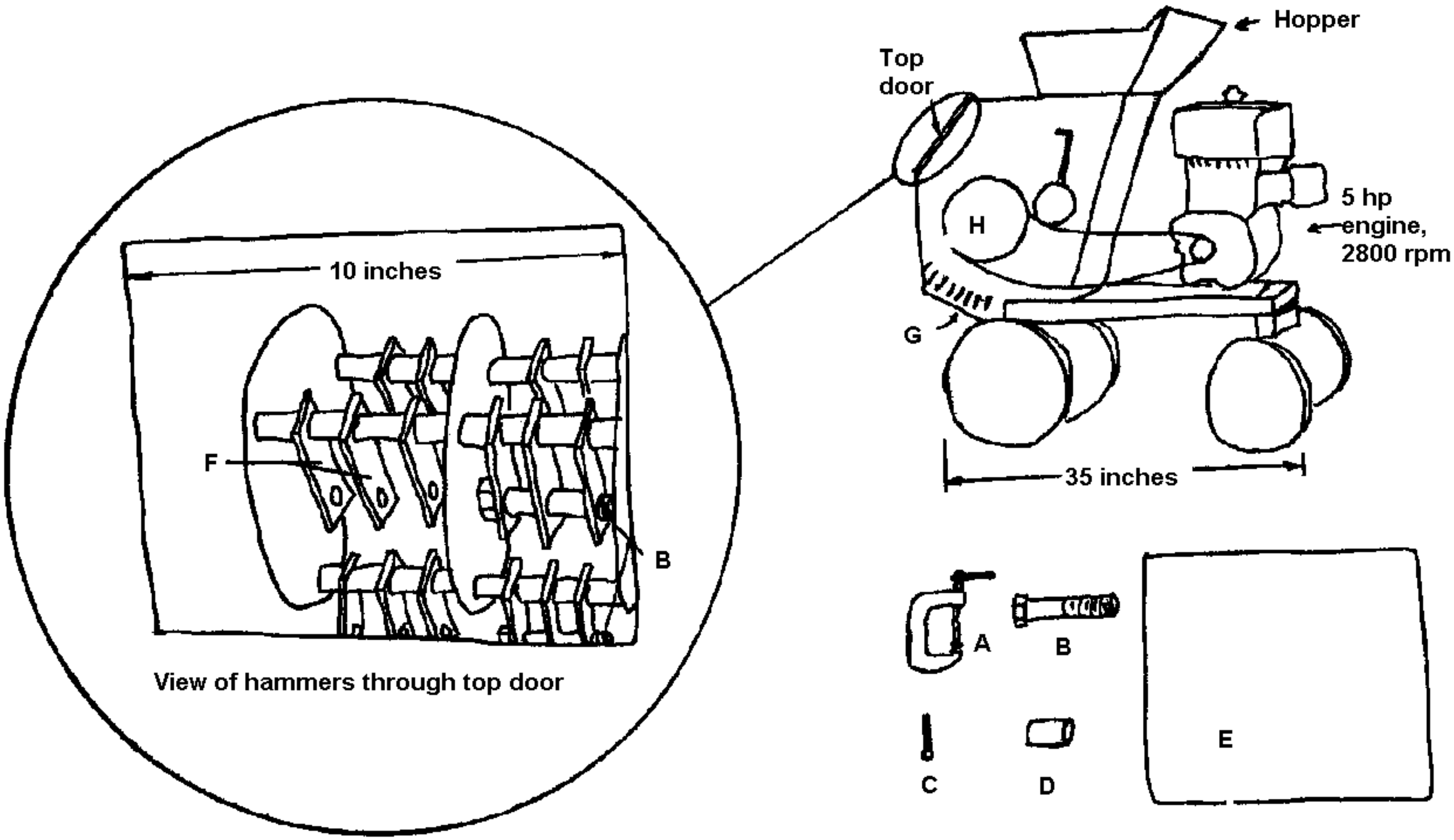

Figure 1. Grain thresher from a leaf shredder

Hand Operated Winnower

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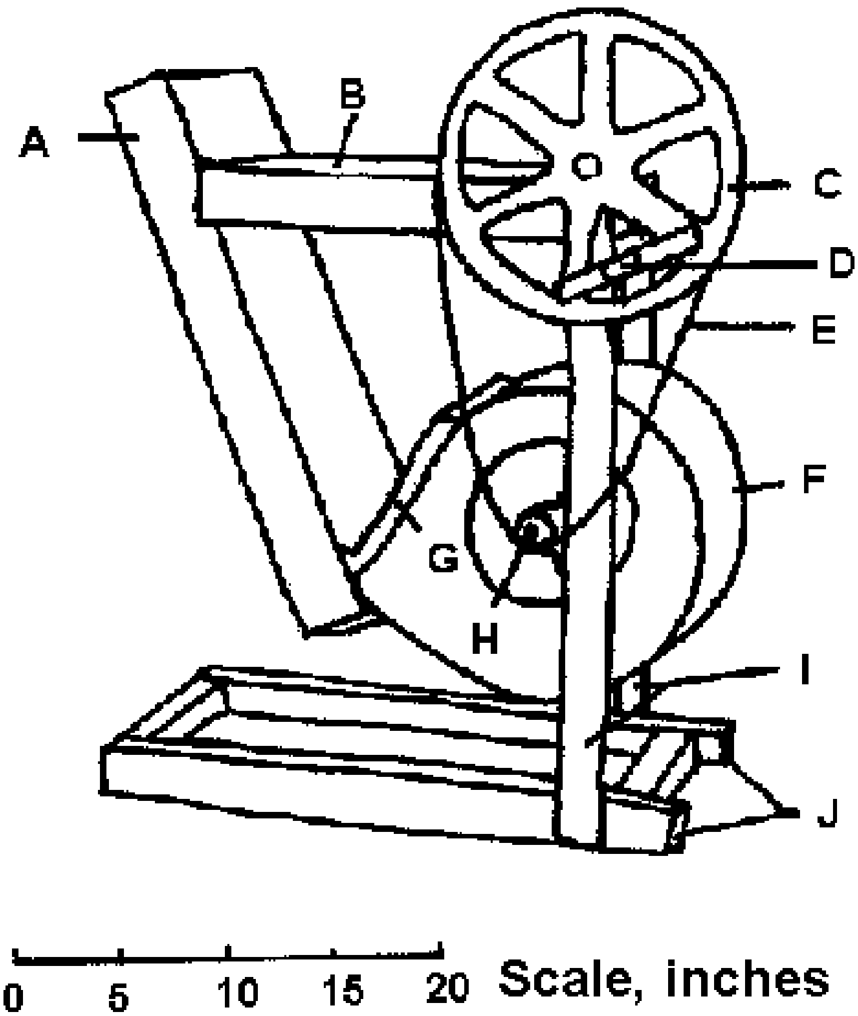

A. Rectangular sheet metal air duct, 24"long x 10" wide x 3-½"deep, available from heating and ventilation supply houses.
B. Sheet metal tray, make your own.
C. Sheave (V- belt pulley), 14" diameter, available from WW Grainger (3 x 943 or 3 x 942) (1-800-323-0620).
D. Crank handle, make your own.
E. V-belt.
F. Blower with 9-½" diameter wheel (4C589) or larger, available form WW Grainger.
G. Sheet metal cover and adapter to merger blower (F) with air duct (A).
H. Sheave, ½" bore, 1 ½" diameter and a pillow block, ½" diameter bore
I. 1" x 2" steel channel or 2" x 4" wood upright support.
J. 1" x 2" steel channel or 2" x 4" wood base for winnower.

Operation:
The winnower separates seeds from chaff by blowing the less dense chaff away as seeds fall down a column of air. Place the seed and chaff mixture on the tray (B). Turn the crank handle (D) and move the seed mixture into the air duct (A). Manually adjust the crank speed to provide enough airflow to lift the lighter chaff up and out the top of the air duct, while allowing the denser seeds fall through the bottom of the air duct.

Construction (brief description):
The air duct (A) is purchased from a hardware store. Cut a 2” x 9 “ slot across the air duct, 6” from the end. This slot receives the tray (B), and allows seed and chaff on the tray to be introduced into the air duct (A). The tray (B) is made from a 16” x 24”, 20-gauge sheet metal. Fold the three sides up 3” and fold the fourth side down 1” to make a 10” x 20” tray. Trim the fourth side ½” from both ends leaving a 9” lip that inserts and hooks on to the 2” x 9” slot in the air duct (A).

Attach the upright supports (I) to the blower (F) with the blower tilted up 22 ½ degrees, 6” off the ground and the axle of the blower wheel is centered on the pillow block/sheave (H). Make base (J). Attach supports (I) to base (J). If supports (I) and base (J) are made from 2” x 4” wood, add diagonal braces (not shown) to strengthen the join. No additional brace is needed if the upright supports (I) and base (J) are 2” steel channels and are welded together. A spacer is attached across the top of the two upright supports (I), (not visible in diagram). The spacer provides bottom support for the tray (B). The 14” sheave mounts on to the upright support using a rigid pillow block or two self-aligning pillow blocks, one on each side of the upright support.

Make a sheet metal cover and adapter (G) to merge blower (F) with air duct (A) at 45-degree angle between blower and air duct. A 45-degree air duct elbow can be used as part of the adapter. The sheet metal cover leaves a 1-½” gap at the bottom of the blower (F) for air to discharge into the air duct (A). Place a ¼” mesh screen (not visible in diagram) across the 1-½” gap to prevent debris from entering into the blower.

Hand Operated Vacuum Packing System for Seed Storage

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This invention was declared public domain on November 29, 1989, a gift to humanity.

A hand operated vacuum packing system (Figure 1) was developed to facilitate the storage of dry seeds. The system provides a means to seal containers with reduced oxygen content. A sealed container prevents rehydration of seeds, thus extends their viability. The reduced oxygen content suffocates adult insects that are stored with the seeds, and also extends the viability of the seeds by slowing down the seed respiration rate. This system can be used to vacuum pack dry food. Moist food, however, needs to be properly sterilized before it is vacuum packed.

Materials:

- A bicycle tire pump, with the pump plunger seal or cup in reverse (A), and used as a vacuum pump.
- A tire inner tube stem valve (B) is used as a check valve to prevent back flow of air into the vacuum chamber.
- A lid for the vacuum chamber. The lid is made from a rubber stopper(C), a thin sheet metal or plywood (D), and a sheet of rubber made from a tire inner tube (E). The sheet of rubber (E) should be slightly larger than the lid (D) and serves as a lid gasket.
- A glass jar (F) with resealable lid is used as vacuum-sealed container.
- A large food can (G) is used as a vacuum chamber. The can should be wider and taller than the largest glass jar (F).

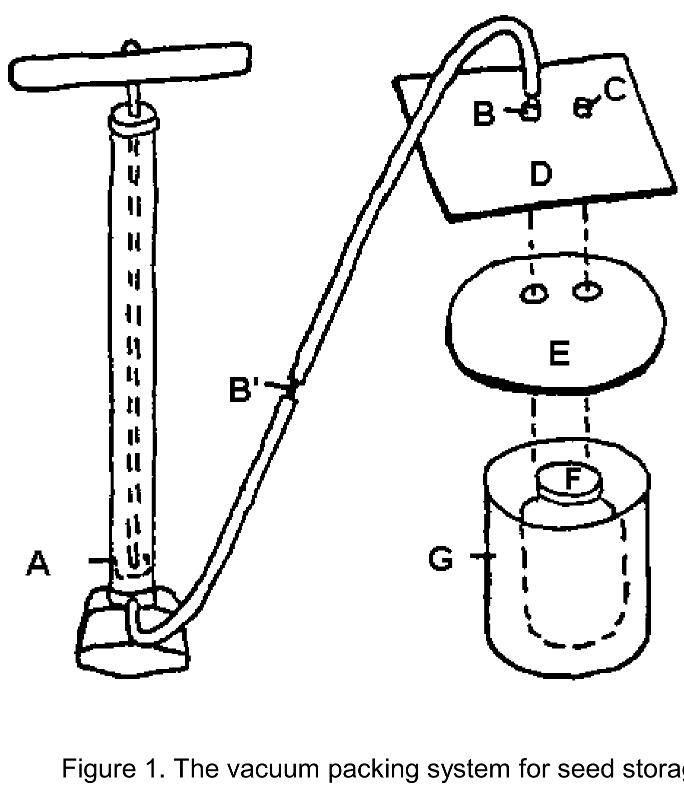

Figure 1. The vacuum packing system for seed storage.

Construction:

1. Disassemble the bicycle pump and reverse the leather or rubber cup on the end of the plunger rod (A).

2. Remove the check valve in the bicycle pump because it checks the airflow in the opposite direction. This check valve is located at or near either end of the hose. In some cases, the check valve can be disengaged by removing the valve, inverting it and reinserting the valve in the pump for storage.

3. Attach a "Presta" type bicycle inner tube stem valve (B) on the lid (D) or attach a "Schrader" type check valve (B') in-line with the hose that connects the modified bicycle pump to the lid (D). The "Schrader" valve core has spring tension. For ease of pumping, disable the spring tension by cutting and removing the spring. The "Presta" valve core does not have spring tension. The body of the "Presta" valve is threaded, which provides for ease of attachment on the lid (D). Both "Presta" and "Schrader" check valves must be attached in the proper direction to allow air to be evacuated from the vacuum chamber (G).

4. Drill or cut 2 holes in the lid (D) and rubber gasket (E). One hole is for the "Presta" valve or for a hose nipple when using an in-line "Schrader" valve. The other hole is for a rubber stopper (C). The lid should be thin and slightly flexible to facilitate the sealing of the uneven surface of the food can (G) with the gasket (E). A gasket (E) made from tire inner tube may have ridges, which provide air passageways and vacuum leakage. These ridges must be filed or sanded down flat.

5. Options:
   a. When using tall food jars (F), construct a taller vacuum chamber (G) by soldering 2 cans together.
   b. A tall cooking pot can be used as the vacuum chamber (G).
   c. A pressure cooker can serve as the lid (D), gasket (E) and vacuum chamber (G).

Operation:

Place seeds in a jar with resealable lid (F) for example, a spaghetti sauce jar with "safety lock" or "pop up" button on the lid or canning jar with mason dome lids. Secure the jar lid by twisting it on snugly but not too tight so air can escape from the jar during evacuation. The jar is placed in the vacuum chamber (G). Cover the vacuum chamber with the rubber gasket (E) and lid (D). Cover the open hole with the rubber stopper (C). Attach the pump hose on to the lid stem valve ("Presta" valve) or hose nipple (when using an in-line "Schrader" valve). Evacuate the chamber and then release the vacuum rapidly by removing the rubber stopper (C). The rapid refilling of air into the chamber will slam the jar lid down and seal the jar.

A 6 inch (16 cm) diameter x 6.5 inch (17 cm) vacuum chamber requires 8 to 20 strokes on the modified bicycle pump 1.6 inch diameter x 24.4 inch (4 cm diameter x 62 cm) to attain a suitable vacuum for sealing. Under these conditions, 15 to 25 inches of mercury (50-to 80 kilopascal) suction can be achieved. Larger vacuum chamber requires more strokes.