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Volume 3, Issue 5

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Build Your Own Ball Mill

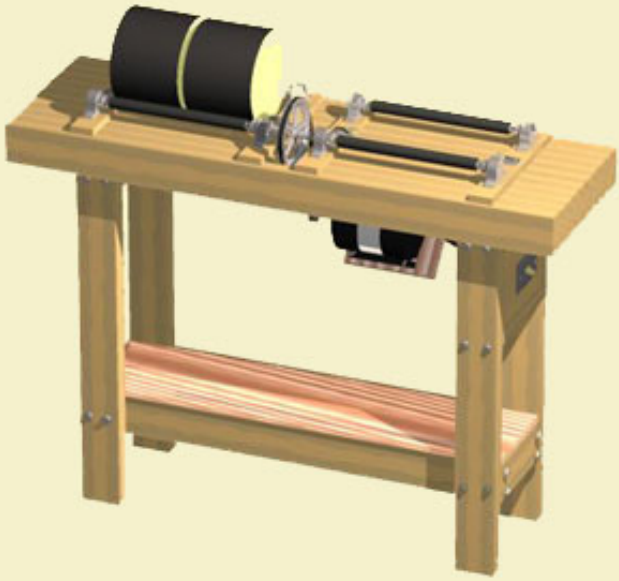

Figure 1: A sturdy ball mill that will last for years.

Materials:

- (8) 8ft 2x4s
- (1) 9" x 37" x 1/2" plywood
- (2) 9" x 5" x 1/2" plywood
- (1) 12" x 9-1/2" x 1/2" plywood
- (4) 1-1/2" x 12" x 3/4" wood
- (32) 1/4" x 3" long lag screws
- (32) 1/4" washers
- (2) 4" hinges
- (8) 5/8" base mount bearings
- (8) 5/8" shaft collars
- (1) 5/8" dia. x 36" long steel rod
- (2) 5/8" dia. x 16-1/2" long steel rod
- (4) 13" long 5/8" rubber heater hose
- (1) 6" dia. pulley
- (1) 2" dia. pulley
- (1) 31" long drive belt (4L310)
- (1) 1145 RPM, 1/2 HP AC motor
- (1) AC switch w/face plate
- (1) 6 ft. power cord

Unmeasured:

1" wood screws, wood glue

Introduction:

One of the first tools any serious pyrotechnic hobbyist will need to obtain is a good ball mill. Good quality meal powder is so essential to many aspects of fireworks making that you will not be able to do much without it. While commercial Meal D can be purchased for this purpose, the quantities you will be needing combined with the difficulties and costs of purchasing commercial powder makes milling your own far more attractive.

While small rock tumblers are often used by hobbyists for milling powder, a much more rugged mill with higher capacity can be built for about the same price or less. The mill shown in Figure 1 is a very solid, vibration resistant design with a simple gravity tensioned pulley drive system. A 13" long set of rollers on each side of the drive wheel can run two standard 10" long Sponen jars at once, or even up to four 8" diameter x 6" long "pancake" jars for potentially milling up to seven pounds of BP at a time.

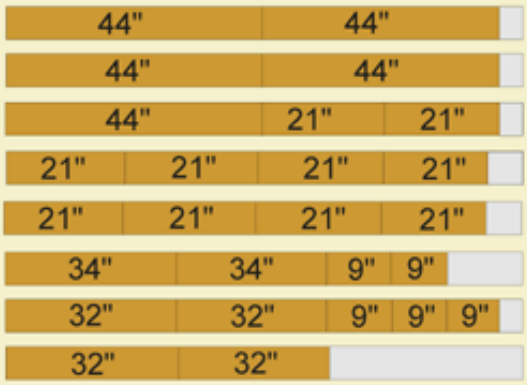

Figure 2: Cutsheet for the eight 2x4s.

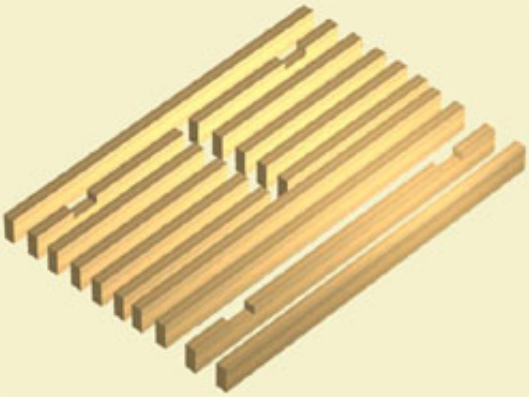

Figure 3: The 2x4s cut to size and positioned for gluing.

Figure 4: Using bar clamps to compress the boards together while drying.

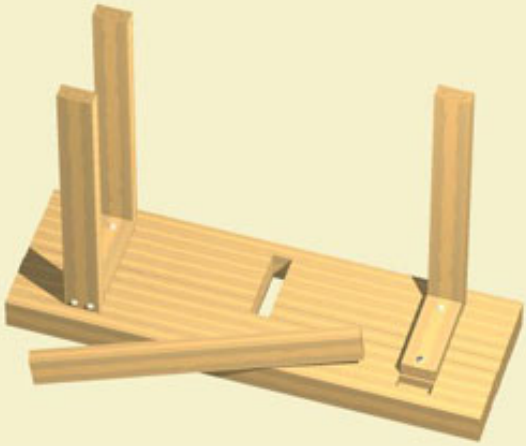

Figure 5: Assembling the table legs.

The bench for mounting the hardware is built mainly from 2x4s, which greatly reduces the amount of power tools and wood working skills required to build this mill. About 90% of the cut work can be done with a hand held circular saw for cutting 2x4s to size. The butcher-block style work surface is ideal for solidly mounting your hardware and absorbing vibration and sound as compared with plywood models.

Begin by cutting all the 2x4s as directed by the cut sheet in Figure 2. All the 44" and 21" boards will be laminated to form the table top, as seen in Figure 3. The notches shown one board in from each side are optional and make assembly a little easier. These are cut 3.5" from the ends of the boards and measure 3.5" wide by 1.5" deep. The end of a 2x4 should fit easily into the slots, since these are where the table legs will fit into. Notches of this type are easy to make by cutting many parallel cuts using your circular saw set to a depth of 1.5 inches, with the cuts being roughly 1/2" apart. A chisel is then used to knock out all the slices of wood, leaving you with a nice notch.

Because a flat surface makes powder spills easier to clean up, you may not want the big gaps between the 2x4s on the top surface. These are caused by the rounded edges that 2x4s have. The easiest way to fix this problem is to laminate a sheet of Formica over the top after the table has been glued together, then use a router to trim out the Formica around the center slot. Otherwise you can use a table saw to shave 1/2" from the top edge of each board prior to assembly. After assembly you will still need to smooth it out with a power sander to remove all uneven edges and saw marks.

Wood glue is applied liberally between each piece of wood and then they are all clamped together using 4 or more bar clamps as shown in Figure 4. Be sure the boards are all resting flat on the bars to prevent an uneven table surface. Make sure the slot at the center is aligned good, since you can sand the ends of the finished table but sanding inside the slot would be very difficult.

After 24 hours of dry time, the clamps are removed and the 32" legs are assembled as shown in Figure 5. Two 9" cross members are what actually get bolted to the table, while the legs fit into the notched holes and are then bolted to the cross members. It is best to fasten one screw into each leg first, then use a square to make sure the legs are perpendicular before drilling the pilot holes for the second screw.

Figure 6 shows the pre-assembly of the lower shelf, which gives you a place to store your mill jars as well as ties the table legs together for strength. This is a simple frame made from the 9" and 34" 2x4s, then covered with the 9 x 37 piece of 1/2" plywood using 1" wood screws to hold it down.

It is best to turn the table over upright to sit on it's legs before attaching the shelf. Make sure that all four legs will be able to sit square on the floor before attaching the shelf. The shelf is attached about 6" above the floor, which is easiest done by clamping some blocks to the inside of the legs for the shelf to sit on while drilling pilot holes and ratcheting in the lag screws. The temporary blocks are

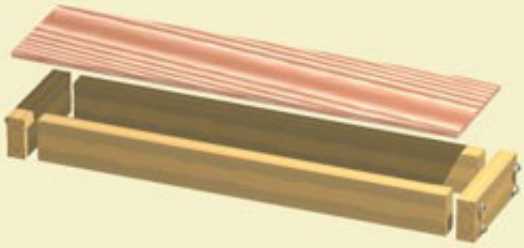

Figure 6: Making the leg support storage shelf.

then removed once the shelf is secured.

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Figure 7: Table with legs framed out for switch box.

Figure 7 shows the completed table with an extra 9" cross member located 5" down from the top on one side. This frame will hold the switch box and wiring.

Next you will assemble the rollers and other components that fasten to the top of the table. The mounting bearings can add up in price quickly, as even cheaper ones with stamped housings can cost around $10 apiece. I opted to make my own by mounting $3 ball bearings into wood blocks to save money. You can save money on the shaft collars by using the strain relief collars used for electrical conduit. These often come with a coupling that screws into an outlet box which must be cut off with a hacksaw to get the collar with the set screw that fits over your 5/8" shaft. With a surplus motor, this mill can actually be built for under $100 using these cost cutting methods.

Be careful when buying your 5/8" dia. bar stock from home supply hardware stores. The rods sold there are often oversized or bent. Bring your bearings with you to the store and make sure they fit over the rods first. Also roll the rod on the floor and sight down it while spinning it to make sure it isn't bent. Sometimes you have to search through the entire bin just to find the two rods you need!

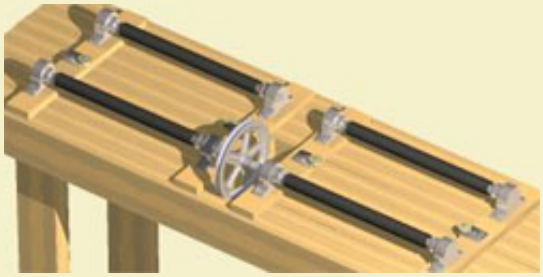

Figure 8: Working surface details.

The two 16-1/2" long roller bars are assembled by first slipping a 13" piece of heater hose over the shaft. This hose will fit very tightly, so the trick is to get it started and then push down on the end of the hose so that it compresses to make the inner diameter wider.

The 36" long drive shaft is built by first slipping a 13" piece of heater hose on one end. Then you will need to stack components onto the shaft above this hose in the following order: shaft collar, left hand bearing, 6" pulley wheel, right hand bearing, collar and finally the other 13" heater hose. Getting things out of order may cause you to have to remove the heater hose after it is already on the shaft, which is not fun! If you do have to remove the hose, find a piece of tubing that fits over the shaft and push the hose off using the tubing. Trying to pull the hose off will not work, as this stretches the hose and makes it fit tighter the harder you pull!

Fasten your pillow block bearings with the rollers installed onto slats of wood screwed to the surface of the bench, as seen in Figure 8. Fasten the drive shaft first, making sure that the pulley wheel has clearance on both sides of the slot hole. NOTE: Make sure you slip the drive belt over the 6" pulley before fastening the bearings down, otherwise you will have to take them up again to put the belt in place! Locate the idle rollers parallel to the drive shaft and about 5-1/2" between center points of the rollers.

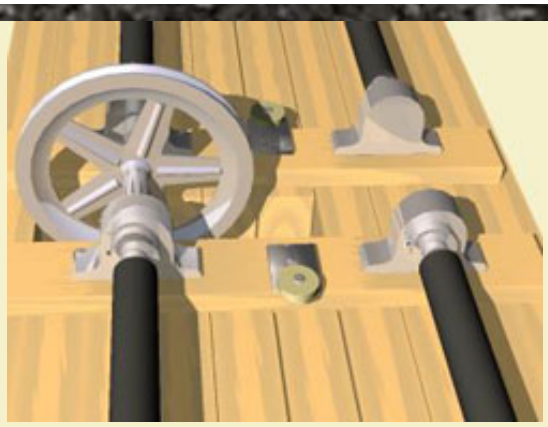

Figure 9: Note use of rollers to prevent jars from traveling off the rollers.

Figure 9 shows a close-up of the bearing assemblies and a centered idler wheel that is used to keep the milling jars from traveling off the rubber rollers and rubbing against the bearings during operation. These wheels are a type of door roller commonly found in hardware stores, and they consist of a small plastic wheel mounted onto a piece of stamped metal with screw holes that work out quite nicely. You want to position the contact point for these wheels so that the contact the mill jars very close to their bottom edge.

Figure 10 shows an age-old method for mounting pulley drive motors which uses the weight of the motor to tension the belt. This is a simple method that eliminates the need for precise belt lengths and allows the belt to be easily removed when changing pulleys. Drill out the mounting holes on the pivot plate first, then test fit the motor. Screw the hinges onto the plate first and then fasten it to the back side of the table top with the motor removed. Be sure that the motors drive shaft will align with the upper pulley before securing the pivot plate.

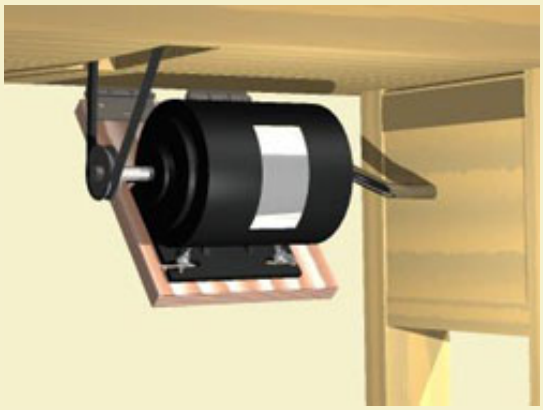

Figure 10: Motor mounted on hinged plate for a gravity tensioned belt.

Motors of the type required for this project can actually be obtained very cheaply from surplus dealers such as MECI, which is where I bought mine. I see a suitable motor on that site for only $16 at the time of this writing (part number 420-0362). While this motor doesn't have a starting capacitor, I have used the same motor in a star roller that turns a 50lb drum without any problems. You can go as low as 1/3 HP, but the trick is finding low RPMs. It is also ideal to try and find a motor with an integrated starting capacitor, since the initial load when starting the motor with a heavy mill jar can be high. The starting capacitor gives the motor an initial burst of power to get it going. Some motors specify the starting capacitor but do not come with it built into the motor. You must then buy the capacitor separately and wire it to the motor if needed.

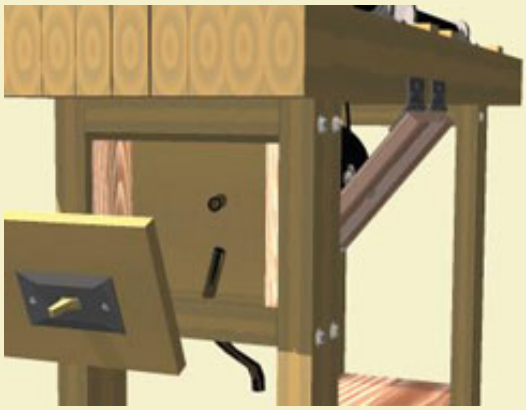

Figure 11: Wiring up the switch box.

With the motor attached, the last step is to assemble the switch box and wire everything into place. The motor will most likely have a wiring diagram labeled on it, which will require you to remove a panel and make some connections. Cut a section from your 8 ft power cord to wire a segment that reaches from the motor to the switch box frame. Be sure to leave extra wire as a "service loop" so that the motor can hang all the way down on the hinge plate without pulling on the wire. Allowing extra wire inside the switch box also allows the switch plate to be removed with enough space to get at everything.

Figure 11 shows how two 2-1/2" boards are screwed to the sides of the switch box so that the plywood face plates have something to fasten down onto. These can be screwed or simply glued into place.

At this point the basic mill is complete, but you may soon discover that ball milling is a rather noisy operation! For quieter milling, you can box in the milling table with a hinged lid that encloses everything. Lining the insides of this box with ceiling tile (including the lid) will dramatically cut down on noise during milling. The thick 2x4 table top makes it very easy to just screw some plywood around the sides for this purpose.

Happy milling!

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