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Maltese Driver Ramming Tool

by **Kyle Kepley**

Materials:

- (2) 8" x 18" plywood, 3/4" thick
- (2) 6-5/8" x 18" plywood, 3/4" thick
- (2) 2" wide x 54" long x 3/4" thick red oak
- (2) 2" wide x 36" long x 3/4" thick red oak
- (2) 2" wide x 16-1/2" long x 3/4" thick red oak
- (1) 2" wide x 8-7/8" long x 3/4" thick red oak (trim to size)
- (2) 1/4" wide x 10-3/8" long x 3/4" thick red oak
- (1) 2" wide x 4" long x 3/4" thick red oak
- (1) 6" wide x 5-7/8" long x 3/4" thick red oak (trim to size)
- (2) 11-3/8" long 5/16" threaded rod
- (4) 5/16" nut
- (4) 5/16" washers
- (1) 7" or longer 3" I.D. PVC pipe
- (1) 1-1/2" long 10-32 taper head machine screw
- (1) 10-32 nut
- (2) 1-1/2" long 1/4" dia aluminum rod
- (1) 2" long 1/4" dia aluminum rod
- (1) 2" long 1/8" brass rod
- (1) 1-1/2" long 1/8" dia brass rod
- (1) 42" long 3/4" dia aluminum rod
- (1) aluminum soda can
- (1) 1/4" eyelet
- (1) 44" long bungie cord
- (1) 3-3/4" wide x 8" long piece of aluminum flashing
- (1) plastic funnel, 7/8" O.D. and just over 3/4" I.D. at throat
- (1) 1/2" thick polyethylene chopping block
- (2) 6" hose clamps
- 10 lbs lead
- 40 lbs concrete

Figure 1: Pieces cut for the base box that will hold the concrete.

Introduction:

I am calling this tool a "Maltese" driver rammer because I first saw the design in a video produced by Toni Busuttil, who uses it to ram thousands of drivers each year for the large wheels used in Maltese festivals. It could very well be a common case loading concept used by many manufacturers in many countries, I just don't know the history behind it. In principle, it is really just a very large and somewhat automated version of the rod and funnel method used to charge lance tubes. The ram rod is both the consolidation piston and the "hammer," using the momentum of the rod itself to create the ramming force.

This tool will allow you to load drivers in about half the time required by either hand ramming or pressing. The reason why it is so fast is that no time is wasted picking up and putting down tools, extracting

Figure 2: Clamping the opposing sides of the base box together when drilling the 5/16" tie-rod holes.

Figure 3: After the box is glued together, the bottom is closed with a scrap of thin wood to hold in the wet concrete when the box is filled.

Figure 4: The two tie rods are run through the side holes prior to filling the box.

rammers, scooping powder from a bowl and leveling it off etc. You simply flip a lever to dispense a measured amount of powder into the funnel, then give six to eight whacks on what is essentially an impact hammer. Once the case is locked into the fixture, the clay nozzle, 14 increments of fuel plus the clay end plug can be rammed in about three minutes.

The design shown here was made specifically for 3/4" I.D. drivers, although you could easily modify it for other case sizes. I find that the 3/4" I.D. driver is the most useful size for wheels, girandolas, end burning rockets and large tourbillions, all of which can be produced on this one machine. Thus I did not find the need to complicate the design with the ability to handle other rammer sizes or adjustable powder increment sizes. Like Toni's machine, it is designed to do one thing at one size and do it very well!

While Toni's machine was made from metal, I have produced one using wood and standard hardware store parts in order to make the tool more accessible to the average pyro hobbyist. This is not an exact replica of Toni's machine, as I just built it from memory using the basic concepts as seen in the video.

The rammer consists of a sturdy frame made from red oak, which is fixed to a heavy concrete block encased in plywood. Red oak was chosen for its strength and dimensional stability, thus it should not be substituted with pine, poplar or other light weight woods prone to warping or splitting. The ram rod is a ¾" O.D. aluminum rod obtained from a scrap yard, but brass, stainless steel or other non-sparking metal could also be used. The most difficult to find component may actually be the funnel, which must have a nozzle that conforms to the size you need. I purchased mine from U.S. Plastics, although I was not able to locate it on their website at the time of this writing.

Building the Base:

The base on which the frame is built consists of an 18" tall block of concrete, which provides a rock solid and vibration free surface to ram against. The heavy weight also helps keep the frame from rocking, moving or tipping over easily, making support legs or tie-downs unnecessary.

The concrete will be cast in a plywood form box, which is left in place once the concrete is dry. Figure 1 shows the four pieces cut to the dimensions given in the material list. Note that two sides have a 3/4" wide trough located 1/4" from each edge, which the other two sides will slide into. Before gluing the box together, clamp the two side pieces together and drill a 11/32" hole centered and 4" from the edge of both the top and bottom, as seen in Figure 2. The holes should run all the way through both pieces, and will allow two 5/16" threaded tie rods to pass through the box before the cement is cast.

After the box is glued together with wood glue, the bottom is covered by stapling a small scrap of thin wood or thick cardboard to keep the cement from seeping out during the pour. Figure 3 shows the bottom cover stapled in place.

Next you will need to cut two pieces of 5/16" threaded rods that are 11-3/8" long, then pass them through the holes in the side of your

Figure 5: Mixing 40 lbs of cement in a plastic tub using a shovel.

Figure 6: The box is filled to about 3/8" from the top.

Figure 7: A sheet of thin plastic food wrap is placed over the wet cement, then the top block is tapped into place using a rubber mallet.

box so that equal amounts protrude from each side. The rod should stick out a minimum of 1-3/4" beyond the edge of the box. Be sure there are no problems threading the nuts onto both ends of the rod before pouring the cement, because there is no hope of replacing them once the concrete is cast. Figure 4 shows the completed box ready to be poured.

You will need to mix up about 40 pounds of concrete to fill the box, which will consume a little less than one gallon of water. It is easiest to do this in a plastic tub, using a shovel to mix the concrete. Don't be tempted to mix the cement with your hands as it will burn your skin.

Once the cement is mixed to a muddy consistency, simply shovel it into the box and occasionally rock the box back and forth to settle out any air bubbles. Do not fill the box completely flush with the top, leave a little space of about 3/8" for the top cover to fit into, as seen in Figure 6.

Once the box is filled, place a sheet of thin plastic food wrap over the top and use a rubber mallet to tap in a precisely fitting block of oak. Use the mallet to help consolidate the concrete while making sure the top block is level before leaving the cement to dry overnight. You will need to remove this top block later, so leave some sticking up to get a grip on rather than pounding it flush with the box top.

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Figure 8: Clamping the 54" long and 36" long frame pairs together when drilling the tie-rod holes.

Figure 9: Using wood glue to laminate the 36" and 54" long frame members together.

Building the Frame:
The frame is constructed out of 2" wide boards cut from standard 3/4" thick red oak. You may be tempted to use the stock 1-1/2" wide boards in order to avoid having to rip 2" wide pieces from a wider board, but this will leave you only 3/8" of wood on each side of the 3/4" diameter holes in the cross member pieces. This may not cause a problem, but I just wanted the extra 1/4" buffer for added strength. Thus I used an 8 ft long 1x8 as the material to build the frame. Cut off a foot long piece of the 1x8 to use for the top block and the powder dispenser lid, then rip the remaining 7 foot board into three 2" wide pieces. One of these boards will be cut into two 36" long pieces, then the other two will each be cut to produce the 54" and 16-1/2" long pieces.

Take the 54" long pieces and place them next to the base block so that you can mark where the threaded rod holes will need to be drilled. Once the center lines for the tie rod holes are marked, clamp the 36" piece to the 54" piece and drill through both of them with an 11/32" bit as seen in Figure 8.

Next place the 36" long board of each pair onto the tie rods. Test fit the 54" long piece to make sure everything lines up, then remove it and spread wood glue on the entire outer face of the 36" piece as seen in Figure 9. Now install the 54" long piece onto this glued area and secure with a washer and nut for each of the two tie rods. Use C-clamps or bar clamps to secure the two pieces of wood together while the glue dries, as seen in Figure 11.

You will need to prepare the two cross member pieces before gluing the 16-1/2" piece onto the side frame. These pieces measured 8-7/8" long for me, but could be slightly different based on how wide your base box turned out to be. Just measure the distance between the inside of the two 54" long boards right above the base to see how long you need to cut the two cross member pieces. These cross members will be set into place as spacers when attaching the 16-1/2" vertical frame member, so don't make the mistake of gluing them or allowing glue from laminating the vertical pieces to squeeze out onto the cross members and effectively glue them in place. Figure 11 shows the two cross members set in place with various clamps being used to hold the pairs of vertical frame members together.

Before proceeding to the next step, you will want to be sure your ram rod will fit through a 3/4" hole drilled through a scrap piece of your oak. If the rod binds, you will either need to have your rod turned down on a metal lathe or drill a slightly larger hole. The problem with making a slightly larger hole is that wood boring bits are not available

Figure 10: The tie rods are used to clamp down the side members using a washer and nut on each one.

Figure 11: The 16-1/2" segments are now glued and clamped into place, while the unglued cross members are laid in place for spacing purposes.

in small enough increments to find the next size up you would need, since you only want the hole to be something like 1/32" over the diameter of your rod. One way to get a slightly larger hole out of a spade bit is to chuck it up and whack it slightly with a hammer so it is no longer perfectly straight. This causes it so spin off center and drill a slightly over sized hole, albeit in a crude and unmeasured way that should only be done if you don't mind sacrificing your drill bit to the cause. Many times these spade bits manage to get tweaked and spin off center on their own through normal use, as mine did.

Once the glue between the vertical frame members has dried, remove the cross members and clamp them in a stack as seen in Figure 12. A third shorter block will be used as a template when making the funnel block, which can be seen on top of the stack. Drill a centered 3/4" hole through all three blocks as seen in Figure 12. Be sure to mark a line across the front face of all blocks so that you can orient them in the frame to match the same order and position they were drilled at.

Next you will install the two cross members back into the frame using two screws running through the side of the frame to secure them. It is important to run the rammer rod through both cross members so that they are aligned correctly before drilling the screw holes and securing them in place. Failure to do this may result in misalignment that causes the rod to bind when passing through both holes.

The top block on the ramming base now needs to be modified so that it can accept interchangeable bases. This is done by cutting a hole out of it which will match the diameter of the ramming nipple bases that you plan to make. I chose a diameter of 2-7/8" because it matches the diameter of the aluminum base on my rocket tooling spindles made by Rich Wolter, just in case I ever modify this rammer to handle interchangeable rocket drifts. It is important that this hole be centered at the point where your ram rod will strike the board, so the first step is to slam the rod into the board to create a marker, then find the center point of the resulting 3/4" indentation. To cut the hole, I drilled a 1/16" hole at the center mark and then used a pin jig on a router table to cut the hole. A hole saw can also be used if you don't need odd sized holes like the one I needed.

Since this ramming tool is designed specifically for producing 3/4" I. D. end burning drivers, a simple base is constructed as seen in Figure 14. A 1-1/8" long segment of 3/4" dowel rod is rounded off at one end and fitted with a brass center pin so that the resulting end plug will have a centered indentation in the clay to make drilling out the vent easier. A small hole is drilled through the side of the wooden dowel and through the brass pin, which is fitted with a small nail to keep the pin from pulling out. The wooden plug is then glued into the base to finish this home-made ramming base. If you prefer to use more sophisticated choke designs for end burning rockets or other devices, then you will need to have your tooling on hand to proceed to the next step.

The last component required to finish the frame is a hinged funnel plate as seen in Figure 16. This piece is made from a 4" long segment of 2" wide wood that has two 1/4" wide support bars glued to each side. The hole in the center is actually two holes with

Figure 12: The three cross members are clamped together and drilled all at once to insure proper hole alignment and avoid binding the rammer.

Figure 13: A hole is cut at the rammer center point on the base top plate so that interchangeable ramming bases can be used.

Figure 14: Components of a 3/4" ramming base with center marker for making drivers. Note small nail holding the brass center pin in place.

different diameters: the top one is 7/8" so that the funnel will tightly fit in place, while the bottom hole is 1-1/8" diameter or whatever O.D. your driver casings require. Since common wood boring bits go from 1" to 1-1/8" with nothing in between, I just hand roll my drivers to be 1-1/8" O.D. when they dry.

Drilling the double set of holes for the funnel plate can be a bit tricky. You must first mark the center point using the hole template you created in Figure 12, which is done by clamping the template to the bottom of the piece to be drilled and using your 3/4" bit to pass through the template hole and mark the center on the board to be drilled out. Don't go very far with the 3/4" bit, you only need it to mark a center point for the next bit you will be drilling with. Next remove the template block and use a 1-1/8" diameter bit to drill half way through the block. Finally you will finish the hole with the 7/8" bit going the rest of the way through the wood. It is helpful to start with a longer piece of wood when drilling the holes so that the clamps do not get in the way when the template block is in place, then cutting the block down to the desired 4" length once the holes are finished.

Two 1/4" wide strips of oak must next be cut from some leftover scraps of oak in order to make the support bars for the funnel block. I find it easiest to use a band saw to slice thin strips of wood like this. The length of the strips should reach the full width of your frame as seen in Figure 16. Use wood glue and clamps to fasten the two wood strips on either side of the funnel block as shown.

The funnel used here must be slightly larger than 3/4" I.D. at the throat so that the rod can easily pass through it, and preferably not have much angle to the sides of the throat. I had to cut the throat length back on this one because it closed off at less than 3/4". Just find a funnel that is pretty close to the right size, insert the rammer and make a mark at the point where the rammer jams in the throat, then cut the nozzle back to this mark. If the funnel doesn't fit very tightly into the hole you drilled, use hot glue to lock it in place. Otherwise the rammer bar will occasionally catch it on the way up and knock the funnel out.

The funnel block is mounted using a set of 1/4" diameter aluminum pins on the left side which allow it to pivot up out of the way when loading and removing casings. The right hand side uses just a single removable pin on the front, which has a T-handle to make pulling it out easier. Without this pin to lock the funnel block down, the ram rod may occasionally rub against the side and lift the funnel block up off the case during use.

This arrangement is a simple design that is fast to use, but is setup for one specific length of driver tube. You would need to make a new set of pin holes for each different length of tube that you plan to work with. For my own tubes I am using a length of 7-1/2".

When drilling the holes for your pivot pins, you must first have a casing of the exact length that you plan to use. Place the casing on your ramming block and then insert it into the bottom hole on the funnel block so that the funnel block is sitting at the proper level that it needs to be at. Drop the ram rod down through the funnel and to the bottom of the driver tube, bringing everything into alignment.

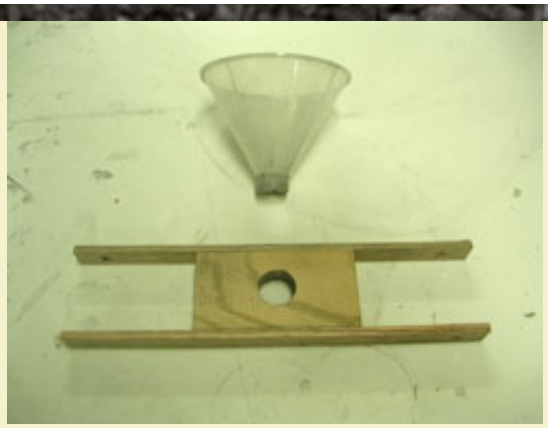

Figure 15: The funnel plate is made using the shorter cross member in Figure 12 as a drill guide. Two ¼" wide support bars are glued to each edge.

Make sure the funnel block is level, then clamp it down so that it doesn't move when drilling the pin holes. The pin holes are 1/4" diameter and run about 3/4" deep.

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Figure 16: The hinged funnel plate set in place with the right-hand lock pin.

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Figure 17: A hole is drilled through the top of the ramming rod so that it accepts a nail. The top of a soda can is cut off so it can be used as the form for casting the top weight.

Figure 18: The bottom of the soda can is fitted with an eyelet so that it can be suspended from bungee cords or springs.

Casting the Rammer Weight:
Since the ramming rod is both the rammer and the "hammer" with this type of machine, the weight of the rod needs to be increased in order to give it enough mass to compact the powder well. In order to give the rammer an overall weight of about 10 lbs, a lead weight is cast onto the top of the rod using a soda can as the form. Simply take any soda can and cut off the top, then fill it with lead while holding the rod at its center and you will have a 10 lb rammer. To insure that the rod never pulls free of the lead, a nail is placed through the rod at the end as seen in Figure 17. An optional eyelet can also be fixed into the bottom of the can prior to pouring the lead. This eyelet can be used to suspend the rod from springs or a bungee cord in order to make lifting the rammer easier on your arm. I personally find the overhead suspension unnecessary as it doesn't seem to change the amount of work required by much but does undesirably reduce the impact of the rammer.

Lead can be easily melted on a Coleman propane camping stove. I prefer to bury the tank in the ground so that it can't tip over, then surround the melting pot with bricks so that it also can not fall off the stove and create a lead splashing hazard. Be sure to do this out doors, as lead fumes are likely given off during the melting.

Bury the soda can to be filled in the ground as seen in Figure 20, which helps insure that it won't spill once filled with molten lead. The ram rod is held in place while the lead is poured in around it, then held for about five minutes until the lead solidifies. The solidified weight can then be pulled from the ground and submerged in a bucket of water to cool it off. Be sure to wear long pants, long sleeve shirt, gloves and safety goggles while working with molten lead.

Making the Powder Dispenser:
The powder dispenser is an extra accessory that gives an added measure of efficiency to the loading process when using this machine. It is not a necessary component if you just want to measure out your increments by hand and dump them into the funnel in between rammings. However, when you are doing 14 increments per driver and making many drivers at a time, the small bits of time saved with the powder dispenser add up to a substantial overall time savings. The powder dispenser also gives you an added measure of safety, since the powder being used to load the drivers is totally enclosed during the whole process, as opposed to an open bucket of powder required when scooping out increments by hand.

The powder dispenser shown here is designed to quickly dispense a 1/2 table spoon increment of granulated powder each time a lever is

Figure 19: Using a Coleman propane burner to melt 10 lbs of lead out doors.

Figure 20: The nail end of the ramming rod is placed into the buried soda can, which is then filled to the top with lead.

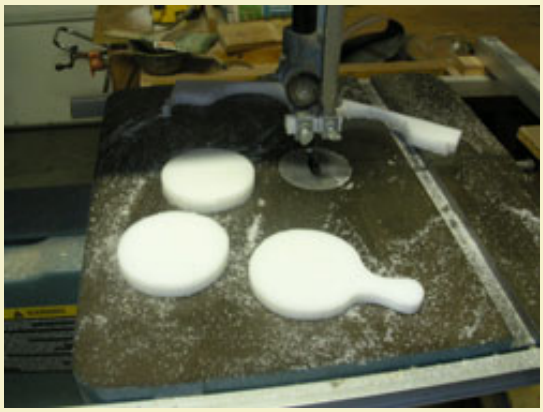

Figure 21: Cutting the 3" diameter disk set out of the chopping block material, which will be used to make the powder dispenser.

flipped. The powder must not contain metal additives such as titanium or iron filings, otherwise jamming or damage to the dispenser could result if hard metal particles worked their way between the rotating disks. The dispenser is designed to fit into the bottom of a 3" I.D. PVC pipe, which will serve as the powder store that feeds the dispenser.

The dispenser is constructed from three disks cut from 1/2" thick polyethylene chopping blocks sold in Home Depot. You can use a compass to draw out a 3" diameter circle, or you can use the inside of a short segment of your PVC as a circle template to be sure you have the exact size that will fit snug into the pipe (since the I.D. of PVC can vary by small amounts and is not perfectly round). One of the disks will have a small lever coming off one side, which you can free hand to any shape you desire. Figure 21 shows the three components after they were free-hand cut on a band saw.

Once you have your three disks cut, you can clean up the edges on a sander and then stack them on top of each other using squares of double sided carpet tape between them so they don't slide around. The tape is only a temporary method of holding them together during the drilling process and works much better than trying to clamp the pieces together somehow.

The first step is to drill your center hole, which will be a small hole about 1/8" or 3/32" to hold the machine screw used as the central pivot point. The machine screw should be long enough to extend beyond the bottom of the three disks by enough to thread a nut onto it. If you used the PVC circle template to draw your circles, you will need to locate the center point of the top disk so you know where to drill. This is best done by drawing a 3" circle onto a sheet of cardboard and cutting it out, then centering the paper disk over your center-less plastic disks and punching a nail through the paper and into the plastic to mark the center, as seen in Figure 22.

Once your center hole is drilled, drop the machine screw into it and proceed to drill a 1-1/8" diameter powder increment hole through all three disks. This 1-1/8" hole will give you a 1/2 table spoon increment of powder as long as you are using 1/2" thick plastic. If you are using a different thickness of plastic or want a different increment size, you will need to trial and error the correct size hole before doing this step.

After the increment hole is drilled, the three disks are separated using a screwdriver and the carpet tape is removed. The next step is to cut a special notch in the middle plate, which will allow a brass pin to connect the top and bottom plates together to that they won't rotate when the middle plate rotates. This connecting pin also serves as a stop limit for the rotation range of the middle plate, and the notched area is designed to correctly align the hole in the middle plate over the holes on the top and bottom plate on each side of the increment dispensing cycle. Since there is no easy way to describe how to measure out the dimensions of this large angled notch, I have provided a scale template of all three dispenser disks plus the powder chute: part image. This image also shows the center points for the 1/8" holes that are to be drilled to hold the brass connector pin. The disks on the printed image should measure 3 inches across if scaled correctly, and could very well be something different

Figure 22: The three disks are fastened together using double sided carpet tape so the pieces will not slide during drilling.

Figure 23: After the center hole is drilled, the machine screw is put in place before drilling the 1-1/8" diameter powder increment hole through all three plates.

Figure 24: The completed plate set, with the special slice removed from the inner rotating plate.

depending on your printer. You may have to play around with resizing the image before printing it in order to get the scale to be accurate.

If you are successful in using my blueprints to replicate the the dispenser components, you can now assemble them by inserting the brass pin into the bottom plate, place the middle plate in position, press the top plate down over the brass pin and then connecting them all together with the central machine screw. The excess brass pin is cut off flush with the plate surface. The machine screw is fitted with a make-shift lock nut made by putting a dab of hot glue on the end of the screw and quickly threading the nut onto it. The nut is snugged down, but not hard enough to interfere with the smooth sliding operation of the middle plate. Figure 27 shows the completed powder dispenser. The hole that appears under the notched area of the middle plate is the bottom of the dispenser where powder will be dropped out, which is also the side where your lock nut should be located.

The completed dispenser is not attached to the bottom of a length of 3" I.D. PVC pipe as seen in Figure 28. A bead of hot glue is run around the edge of the top plate and then quickly pressed into the bottom of the pipe. Care must be taken not to press the dispenser in so far that the hot glue buildup around the edge interferes the operation of the dispenser lever.

The length of the PVC pipe can be whatever you find convenient, but I found the 7" long one shown here to be a bit on the small side. A pipe of this size will only hold enough powder to charge three or four drivers before you have to reload it. Something at least twice as long is recommended.

Once the powder dispenser is complete, it is fastened to the left side of the frame using pipe clamps, as seen in Figure 29. Large holes are drilled through the side of the frame so that the pipe clamps can run through it. The bottom of the dispenser is located just below the central cross bar, leaving enough room for your hand to easily access the lever. The dispenser is rotated so that the drop hole is located right against the frame, as seen in Figure 33.

An aluminum guide chute must be used to get the powder from the drop point under the dispenser to the funnel, as seen in Figure 33. This chute can easily be fashioned from a piece of aluminum flashing that is about 3-3/4" wide and 8" long, with the corners on the exit side rounded off. The coated surface of the flashing makes a smooth surface that allows the powder to flow nicely. The flashing is rolled up into a "U" shape and then twisted into a spiral as seen in Figure 31. When the twisted piece is released, it should form the chute seen in Figure 32. The corner of the chute is inserted between the powder dispenser and the frame before the pipe clamp is tightened, which will hold it securely in place once tightened.

Lastly you will need to create a lid for the powder dispenser. I cut a lid from a leftover piece of oak, as seen in Figure 30. There are no PVC fittings that I know of for plugging the inside of a tube, since the inside is irregular and incapable of forming a good seal. All PVC caps fit around the outside of the pipe, which means you would not be able

Figure 25: The brass stop pin serves as a rotation limit as well as a means to keep the bottom plate aligned with the top plate while the inner plate rotates.

Figure 26: The top plate is placed over the bottom plate and used as a template when drilling the brass pin hole so that the two pieces will be correctly aligned.

Figure 27: The completed powder increment device showing the entry hole on top and the exit hole on the bottom.

to clamp the pipe directly against the frame as seen here. Some kind of stand-off would have to be used to space the pipe out away from the frame if you wanted to use standard PVC pipe caps for the lid.

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Figure 28: The powder increment device is hot glued into the bottom of a 3" I.D. PVC pipe, which will be the powder store for granulated composition during use.

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Figure 29: The powder dispenser unit is attached to the left side of the frame using pipe clamps running through holes drilled in the frame.

Figure 30: A wooden lid is made to close off the top of the powder store, since standard PVC caps can not be used.

Usage Notes:
When I first thought about building this type of ramming tool out of wood, my concern was that wood would be too wobbly or dimensionally unstable to keep the rammer exactly centered above the tube with such tight tolerances. However, the combination of oak and concrete has resulted in a rock solid tool that seems impervious to even Florida's extreme humidity. The rod slides easily through just the holes drilled in the wood without any need for special bearings, and as long as your tube has the correct diameter inside, the rammer will never stick and always stays aligned.

The first step to getting your driver production up and running is to produce or obtain the correct size driver tube. Because this machine requires very specific inside and outside diameters on the tube being loaded, your choices for tubes are more limited. If you don't like rolling your own tubes, you should locate a reliable supplier for the tube you need before building the rammer, then change the rammer diameter and funnel plate hole to match your tubes. The length of the tube is not much of an issue, since you can re-pin the funnel plate to one or more heights to match the tubes you plan to use.

Being the control freak that I am, I prefer to roll my own tubes. I have had bad luck with all but the most expensive virgin kraft tubes when making high powered end burning drivers, but my home made manila paper tubes never fail me. Rolling your own tubes gives you exact control over both the inside and outside diameters of your tubes, and also insures that your tubes will not split from the excessive ramming force that this tool is capable of producing. For example, about five whacks while loading the clay plug in a Skylighter TU1062 recycled kraft tube will bulge the case to the point of tearing. Even if this tube survived the loading process, it will burst under the pressure when fired if built according to the specs below. With hand rolled manila tubes, there is no bulging and no tube blowout problems. There is a tendency for plugs to blow out of manila tubes more easily than recycled kraft tubes however, which is a problem common to any rock-hard tube since there is no bulging of the case wall to help lock in the plug.

Making the Driver Tubes:
To roll your own tubes, you first need to produce a rolling rod that will result in a very slightly oversized tube I.D. This is done by taking a leftover segment of your 3/4" diameter ram rod about 9 inches long and wrapping three turns of 2" wide packing tape around it at side-by-side intervals until the entire length of the rod is covered. There can be slight spacing between the bands of tape, but don't let turns from one band overlap the previous band or you will be creating a high

Figure 31: Twisting a sheet of aluminum flashing to produce the powder chute.

Figure 32: The completed powder chute that will carry powder from the dispenser to the funnel.

Figure 33: Powder chute is pinned between the powder dispenser and the frame.

spot on the rod. Building up the rod diameter like this allows you to fine tune your tube I.D.s until you get the size that works best. If your tube shrinks too much with three turns of tape, try four. You want your ram rod to easily drop into the tube without any binding at all. Once you find the magic number you can always measure the final diameter and have a special rod turned down on a lathe if you don't like the look of your taped up rod. The tape will also likely come off over time and need to be re-applied, so a machined rod would be nice to have for the long run.

The case is rolled from two strips of 14-1/2" long legal size manila file folder paper plus a third strip that is 11" long, with a final two turns of 30lb recycled kraft to keep the tube from unraveling after it is rolled. The strips are rolled one at a time, using a mixture of 50/50 white glue and water brushed onto one side of the paper before it is rolled. This tube will dry to have a 1-1/8" outside diameter that fits snugly into the bottom hole on the funnel plate. Note that it is important not to let the tube telescope while you are rolling it, as this will create a tube that is too long to fit into the loading fixture. It will save you work later if you just unroll a strip that is starting to get out of line and adjust the alignment so that it rolls straight. Tubes that do turn out too long to allow the funnel plate fixture to lock down can be quickly shortened using a fixed belt sander to trim down the ends.

Loading the Clay Plug:

For a driver of this size, it is necessary for the inside surface of the clay plug to have a curved surface in order to avoid problems with burn-through just above the nozzle. To understand why this is, refer to the clay nozzle article published here. What this means is that you can't use the flat-ended powder loading rammer to ram your clay plug. One option is to hand ram your clay plugs using a rounded off ramming drift and then use the loading tool only for ramming the fuel. However, since the ramming tool produces more force than hand ramming is capable of, a clay plug produced on the ramming tool can endure higher pressures before blowing out and thus makes your drivers more reliable. What I opted to do was make a second ramming rod that has a rounded off end to produce the desired curvature on the plug. This is a duplicate of the flat ended rammer, complete with it's own lead soda can weight at the top. The rammers are easily interchanged by pulling them out the top of the frame, so you can use the plug rammer to ram the plugs in a large batch of tubes, then swap out to the fuel charging rammer to finish loading each driver.

The plug formula I prefer is ground up floor tiles or flower pots screened to 25-40 mesh mixed with bentonite in a ratio of 1:3. The bentonite can optionally be treated with 5% wax for moisture proofing if you are worried about the clay absorbing humidity in the air and shrinking.

More...

Figure 34: A tube being loaded into the completed driver rammer.

Maltese Driver Rammer...

Figure 35: Using bungee cords to suspend the rammer from above.

Figure 36: Resting the rammer on the center support while loading driver tubes.

Loading the Fuel:
A good strong driver capable of 500g thrust when using a 3/16" diameter choke hole can be produced using the formula given here. This should be ball milled for two hours, then dampened 20% and granulated through a window screen. This granulation step is crucial, as you can not use the powder dispenser with ungranulated powder or it may jam up. Ungranulated powder will also result in a huge dust problem, far worse than hand ramming will produce. In fact, even granulated powder can cause a dust problem with this type of driver loading tool, since the ram rod falling into the case forces the air to rush past the sides of the rod and carry any loose dust with it. The trick to minimizing the dust problem is to dissolve 1% dextrin into your water when dampening the composition. This dextrin will add some strength to the dried granules so they do not crumble so easily. However, the amount of dextrin used must be minimized to no more than 1%, otherwise you will get granules that are too hard to crush easily when rammed. These uncrushed granules will cause hot spots at your increment boundaries that blow bursts of high pressure as the driver burns. Assuming your choke can even handle these pressure spikes without blowing out, your drivers will sputter with loud bursts each time it hits an increment barrier.

The loading procedure is pretty simple and fast. When loading a driver, the ram rod is pulled up out of the middle support bar and rested on top to hold it out of the way as seen in Figure 36. Once your driver is inserted and locked down, the rammer is reinserted and dropped down into the funnel. Now you simply flip the powder increment lever and let the 1/2 table spoon charge fall into the funnel. The ram rod is lifted out of the funnel so that the charge can fall in, then it is slammed down about 6 to 8 times until the charge is fully compacted. Grab the ram rod just above the middle support bar and lift it so that the rammer comes all the way out of the tube, then throw it down into the tube to give it a good whack.

The charge/ram sequence is repeated about 14 times or until such time that the powder increment can be seen sitting in the funnel throat instead of disappearing into the tube. After ramming this last increment, a final 1/2 table spoon of straight bentonite is used to plug the driver. One nice thing about this kind of loading device is that it lets you fill a tube right up to the top, with the final clay plug being flush with the end of the tube.

Performance Notes:
In my timed tests, which involved loading the plug, comp and end plug into a set of 10 drivers one after the other, the average load time for producing a finished driver is about 3.5 minutes. Of that time, 1

Figure 37: An extended powder store handles about 12 drivers. Note the additional rammer rod for clay plugs.

minute is required for ramming the end plug while 2.5 minutes is required to load the 14 fuel increments plus the end plug. When producing the same size driver by the traditional hand ramming method it takes me about 6 minutes, so this machine almost cuts the time in half.

While this machine saves you considerable time and produces a better quality driver than hand ramming, it does not remove any of the physical labor from the process. In fact, since you are actually doing the same amount of work in half the time, using this machine to do more than a few drivers consecutively can be rather exhausting on your arms. While 10 pounds might not seem like much to lift one time, consider that you have to lift it 130 times to produce one driver! This thing could literally qualify as the first pyrotechnic tool that doubles as an effective exercise machine.

Toni's original machine attempted to get around this arm fatigue problem by suspending the rammer from a spring or bungee cord, such that the operator spends more energy thrusting the bar down into the driver and less energy pulling it back out. A similar setup can be seen in Figure 35, with the bungee looping around a hook in the ceiling joists. The problem I find with this system is that the pull from the spring is seldom exerted exactly in line with the rammer, which causes the rammer to rub against the guide holes. This rubbing causes extra friction that seems to about equal the amount of work you are trying to save with the spring, so I tend not to use it. However, if you don't prefer the bicep workout feature of this tool, I suggest you put the extra effort into getting the overhead spring to function correctly.

All in all, I find this tool a useful edition to my collection. I've always dreaded hand ramming the 18 or so drivers that it takes to make a single mid sized girandola, and now I can be done with that chore in just one hour. Considering that the Maltese pyro clubs use the same design to hammer out several thousand drivers per year, there is probably no faster way of doing it without resorting to more advanced machinery.