

# Using the Ghost Gunner to Mill an 80% AR15 Lower

## 1 Preparing a less than 80% Lower

All 80% lowers are not created the same. In order to use an 80% lower in the Ghost Gunner it must have the rear takedown slot milled. Some 80% lowers will have this slot pre-cut and some (I call them 78% lowers) will not. However, if you get a lower that doesn't have the rear takedown slot milled despair not, using a drill press you can easily mill the slot yourself. I suggest using a full or table top drill press and an X-Y capable vise.

To prepare a 78% lower for use in the Ghost Gunner you will need a  $\frac{1}{2}$  inch drill bit or  $\frac{1}{2}$  inch end mill capable of boring down to  $\frac{5}{8}$ " deep. Figure 1 shows the blueprint that shows the rear takedown pin pocket.

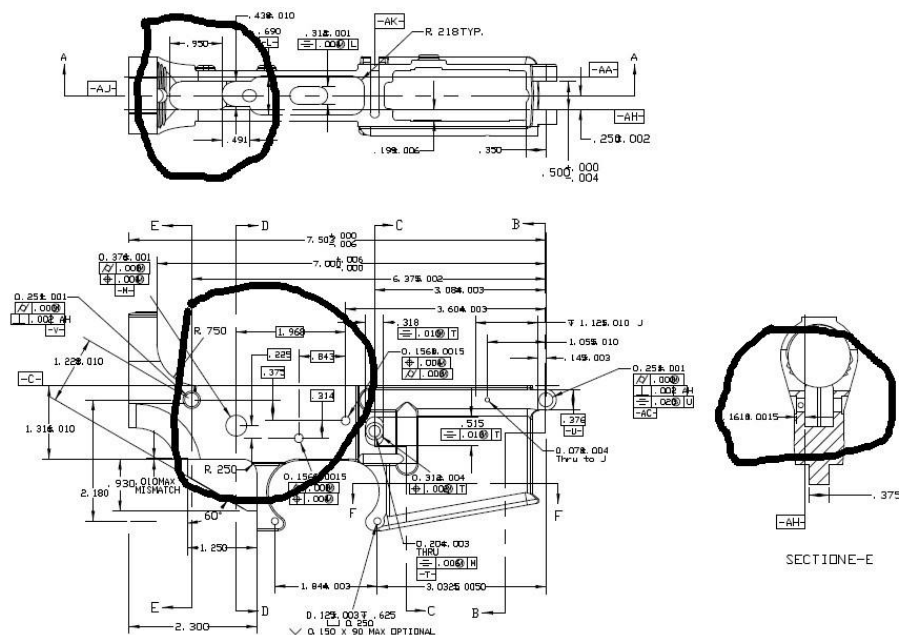
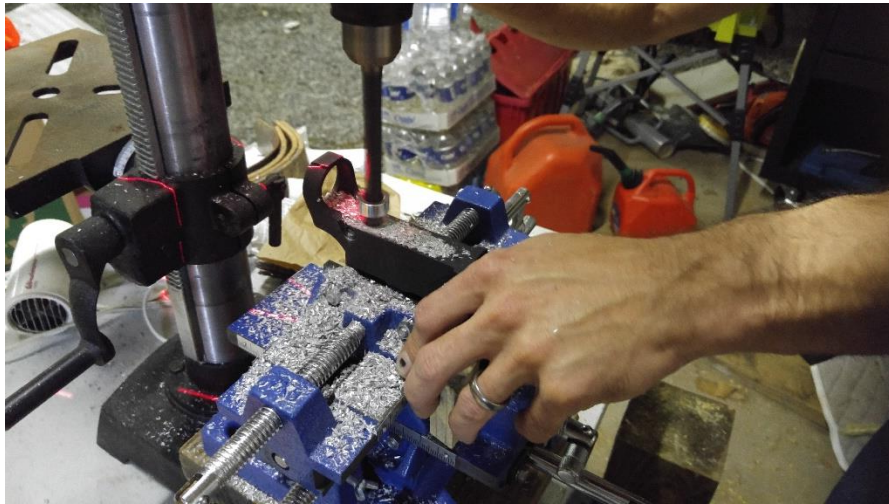


Figure 1: Blueprint showing rear takedown pin pocket details

The important thing about the pocket is that it be centered, about  $\frac{1}{16}$  inch in front of the buffer retainer pin pocket (the round hole at the base of the buffer/buttstock attachment port) and have the dimensions  $\frac{1}{2}$ " wide,  $\frac{5}{8}$ " deep and  $\frac{15}{16}$ " long. This is a  $\frac{1}{2}$  drill hole which is overlapped by a second by  $\frac{1}{16}$ ". Collars that attach around the bit or mill to set the exact depth needed make establishing the depth easy. Figure 2 shows a drill press using the depth collar. Using an X-Y axis vise once the second hole is drilled simply by slowly adjusting the drill position with the drill running at the proper depth back to the original hole will result in a milled slot just the right width and depth. If

you can use a 1/2 inch end mill bit your slot will have a nice flat bottom, otherwise you will have a curved bottom matching the contour of the drill bit. Either a flat or curved bottom will work fine as long as the depth is 5/8" and width is 1/2".



*Figure 2: Using a depth collar*

If needed a Dremel with a milling bit can be used to widen the rear of the milled slot if the rear retainer lug on the AR15-upper doesn't quite fit. Figure 3 shows the X-Y vise, the 78% lower and the drill press after the slot has been milled. Be careful on the side with the retaining pin and spring port not to make the side wall too thin or you can rupture the pocket when you insert the retaining pin and put sideways pressure on the port walls.



*Figure 3: 78% Lower after being milled for the rear takedown slot.*

Once the lower has a rear takedown slot, the Ghost Gunner is used to complete the precision milling needed to create a 100% AR15 lower receiver.

## 2 Setting up the Ghost Gunner

The Ghost Gunner comes with a thumb drive that contains the needed files to mill the 80% lower. Figure 3 shows the contents. Ghost Gunner's embedded 328p microcontroller requires the open source *Arduino* driver for proper enumeration. Connect the Ghost gunner to power 110 volt power and to the computer using the supplied USB cable.

The DDCut program will attempt to find the proper com link but if it doesn't it can be selected from a drop down list in the interface.

The simplest method to install the required driver is to run the "install.bat" file included with Ghost Gunner. An alternate method to obtain the driver is to download and install Arduino IDE 1.0.5 or later from here:

<http://www.arduino.cc/en/Main/Software>

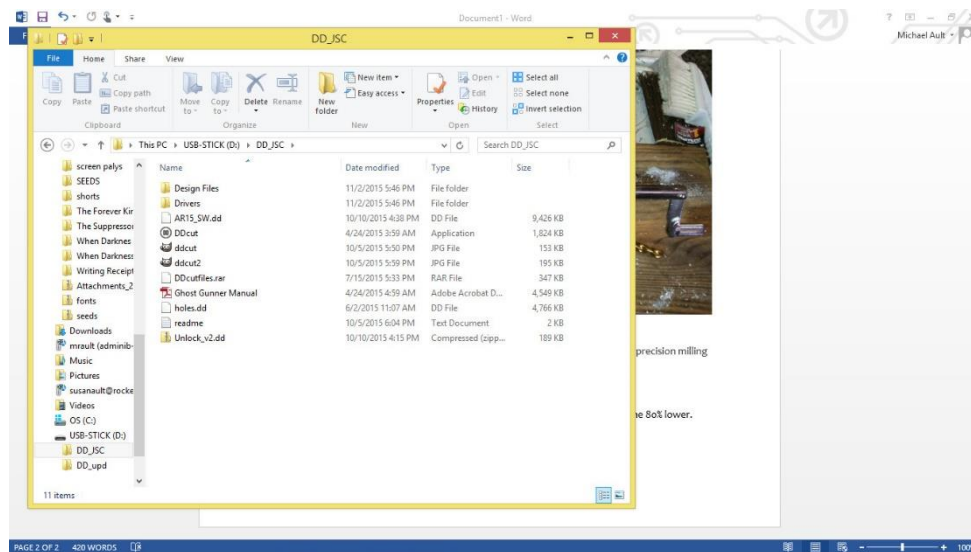


Figure 4: Contents of the enclosed thumb drive

The *Arduino* drivers and the *install.bat* file are located in the Drivers directory. Note that sometime during shipping stray EMF fields can cause some of the basic settings to be corrupted. I would suggest getting the reset codes from Ghost Gunner and the GRBL controller program and reset the baselines before starting your milling project. I nearly ruined my first lower because of corruption of the base codes. Resetting the baselines solved my issues. DD support can email the files to you (the best option) or you can download the basic GRBL program from:

<https://github.com/grbl/grbl>

Copy the thumb drive to a directory on the computer you want to use. I suggest making a gold copy directory and a running copy directory.

Once the *Arduino* codes and baselines are setup in accordance with the Ghost Gunner manual you are ready to begin milling your 80% lower.



The first step is to zero the machine, this is done using the DDCut application and the AR15\_SW.dd program. This was where my Ghost Gunner hung up after the first couple of attempts on a 78% lower (before I realized the rear takedown pin pocket had to be there). Essentially it runs the platform and tool head to known settings against the limit switches to give the machine references, then does a plunge to allow you to install the 1/4 inch collet and mill bit.

Figure 5 shows the opening screen of the DDCut application. It is a simple translation interface that takes the movement commands from the dd file and translates them to the Ghost Gunner. Use the interface to select the AR15\_SW.dd file from the code running directory.

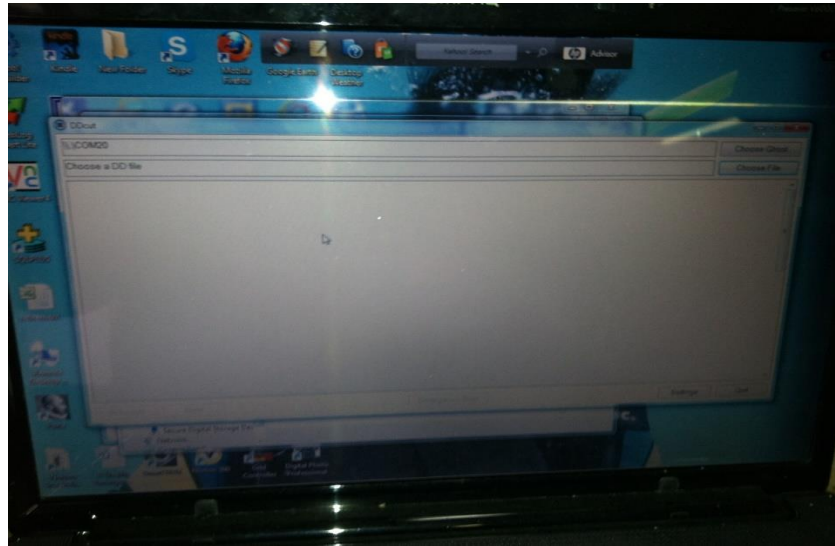


Figure 5: DDCut display screen

Figure 6 shows the directory with the AR15\_SW.dd file.

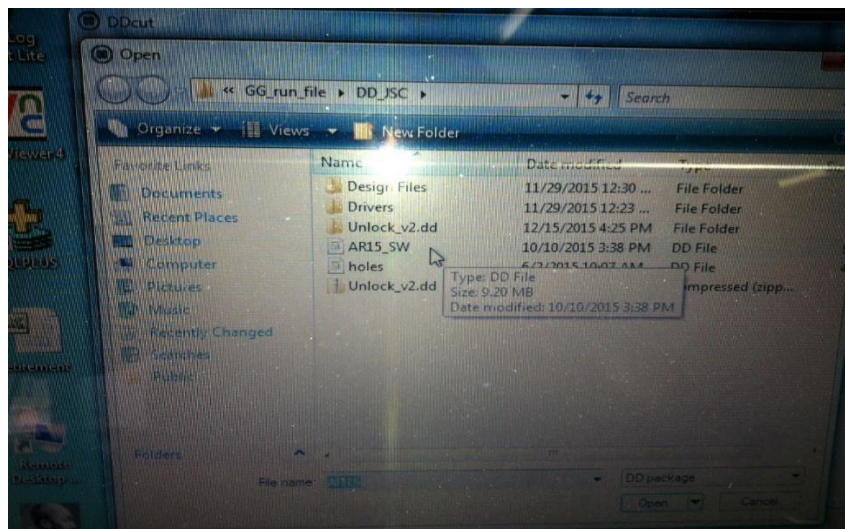


Figure 6: AR15\_SW.dd file directory

Next remove all tools and make sure the Ghost Gunner is empty. The next step will cause stage movement and tool head movement. Click Next then OK. Note that all steps will be shown on the dd screen, I will not show all dd screen shots, but please step through them as you go.

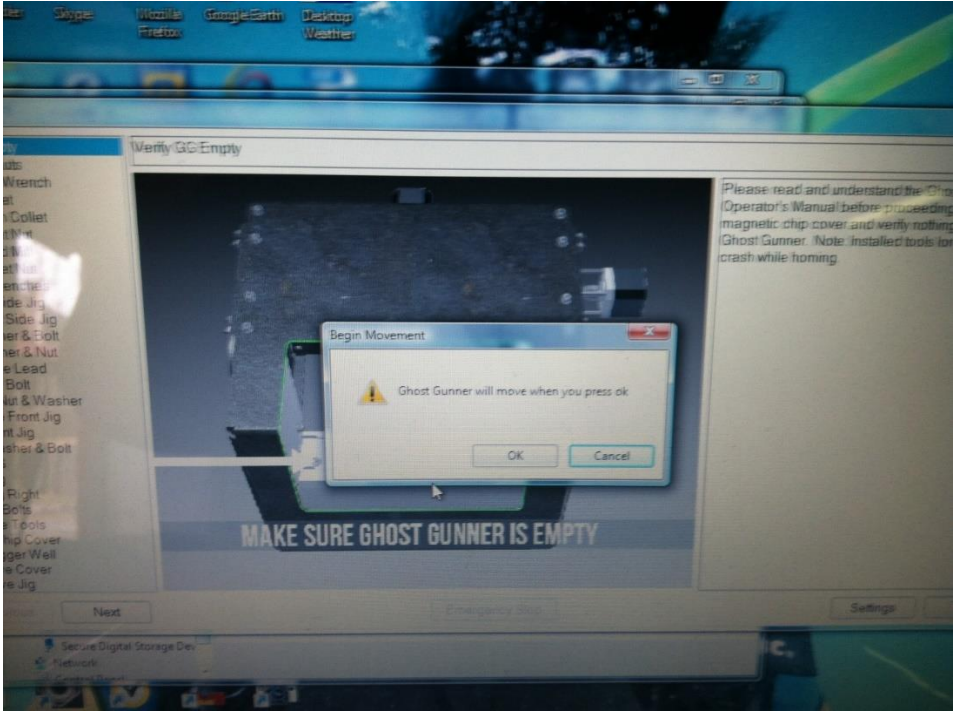


Figure 7: Clicking OK will energize the Ghost Gunner



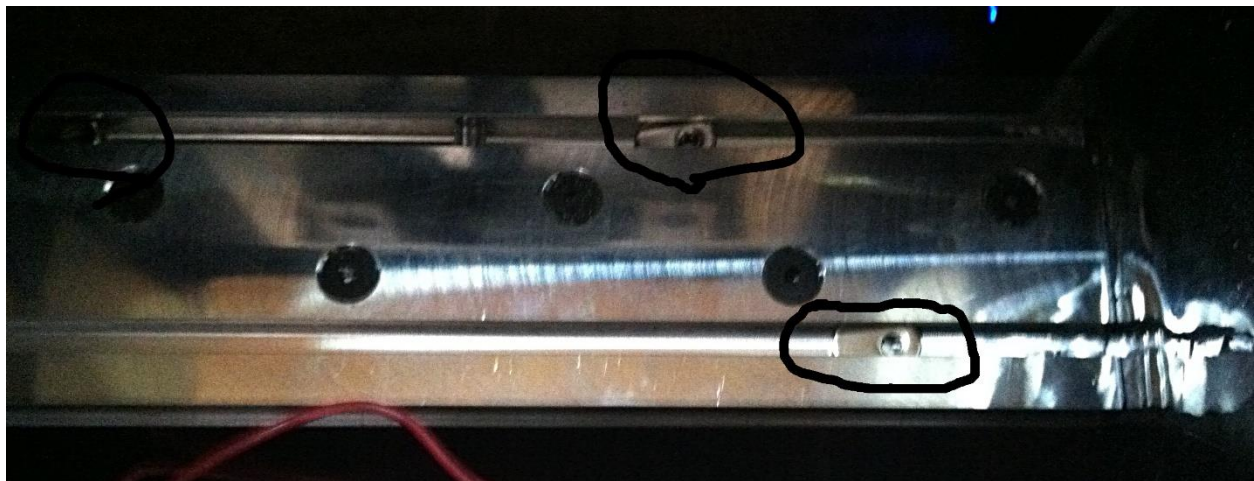
Figure 8: Needed tools, 13, 17mm wrenches, 3mm Allen wrench and flat blade screw driver

Next step will be to slide the T-slot nuts in to the rails, two in the front rail and one in the rear rail. Place the T-slot nuts so the smooth side is up and long tail to the right or else the bolts may not engage them properly.



*Figure 9: Inserting T-slot nuts*

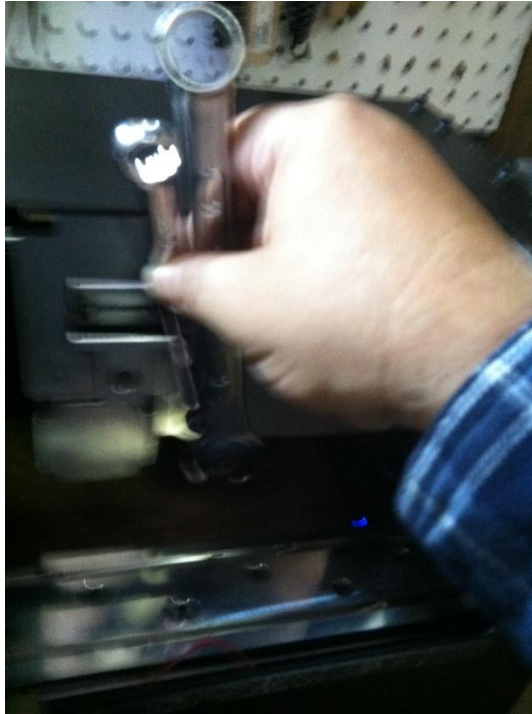
Figure 10 shows the T-slot nuts inserted into the stage T-slots. I suggest using a slotted screw driver that has a magnetized tip to help move and position the nuts, and it can also be used to retrieve dropped parts.



*Figure 10: Shot of T-slot nuts after installation*

Once the T-slot nuts are in place put the 13 mm wrench onto the chuck shaft and using the 17 mm wrench on the collet nut, remove the collet nut.





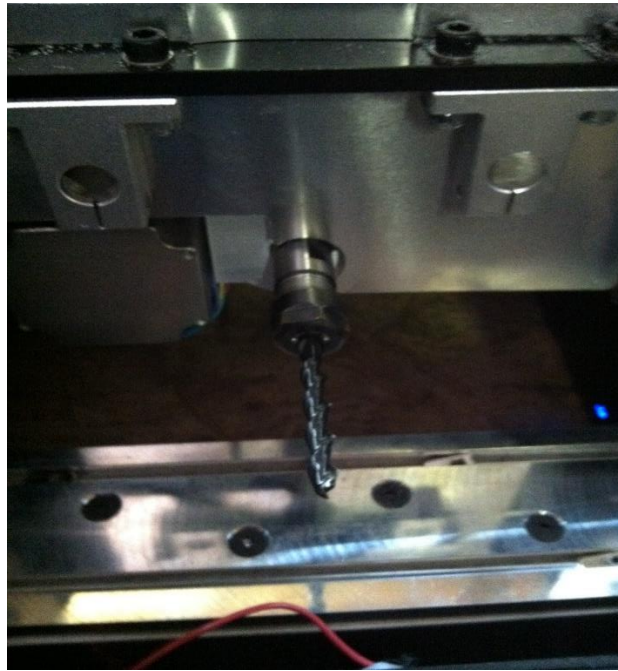
*Figure 11: Removing the Collet Nut*

The collet will be snapped into the collet nut, remove it and replace it if needed with the ¼ inch collet. The fat end of the collet snaps into the collet nut the tapered end faces the shaft.



*Figure 12: The Collet nut with collet installed and second collet.*

The collet nut with collet is now threaded back onto the shaft. Be careful when threading the collet nut as the threads are very fine and cross threading must be avoided. Insert the 3 inch by ¼ inch end mill bit into the collet pushing it all the way until it stops and use the wrenches to tighten the collet nut. It will be readily apparent when the collet begins to snug down against the shaft of the mill bit, don't over tighten but make sure the bit is tightly held. The length of the exposed bit cannot exceed 3 inches or damage to the bit, stage or tool head may occur when it slams into the stage. Figure 13 shows a properly installed bit.



*Figure 13: Properly installed 3 by ¼ inch end mill bit*

Next, snap the left hand jig onto the left side of the 80% lower. The left hand jig is shown in Figure 14.



*Figure 14: The left hand jig*



Figure 15 shows how the left hand jig fits on to the lower.

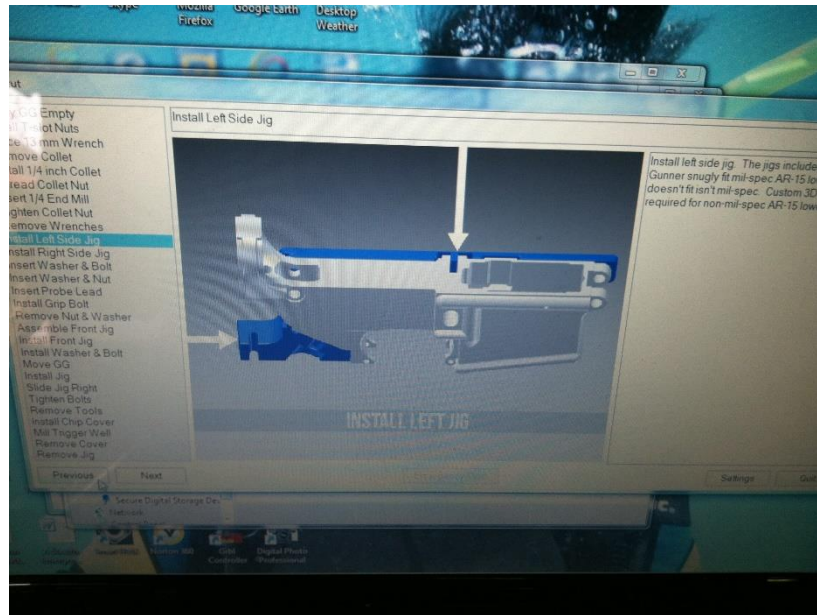


Figure 15: 3D diagram showing left hand jig installed

The files to create the required jigs by using a 3-D printer are provided should the jigs be lost or damaged. Figure 16 shows the jig properly installed on the lower.



Figure 16: Properly installed left hand jig

You may need to lay the lower, lower side down and lightly tap the center of the jig with a rubber mallet to make sure it is properly snugged into place. Figure 17 shows an improperly seated jig.



*Figure 17: Improperly seated left hand jig, note bowing in center*

Figure 18 shows a properly seated jig.



*Figure 18: A properly seated left hand jig.*

Once the left hand jig is properly seated install the right hand jig as shown in the provided image from the Ghost Gunner dd file, Figure 19.



Figure 19: dd File illustration of installed right hand jig.

The jig should closely mate with the left hand jig and the lower. This combination of left and right hand jigs provides for a stable method to hold the lower in position during the milling and drilling operations and electrically isolates the lower receiver blank so the electronic probing will work. Figure 20 shows the right hand jig in place.



Figure 20: Left and right hand jigs in place.



In the next steps you install several bolts, washers and nuts, I suggest using a magnetic parts dish, like the one shown in figure 21, to hold these small parts so it is harder to drop or misplace them.



*Figure 21: Magnetic parts dish*

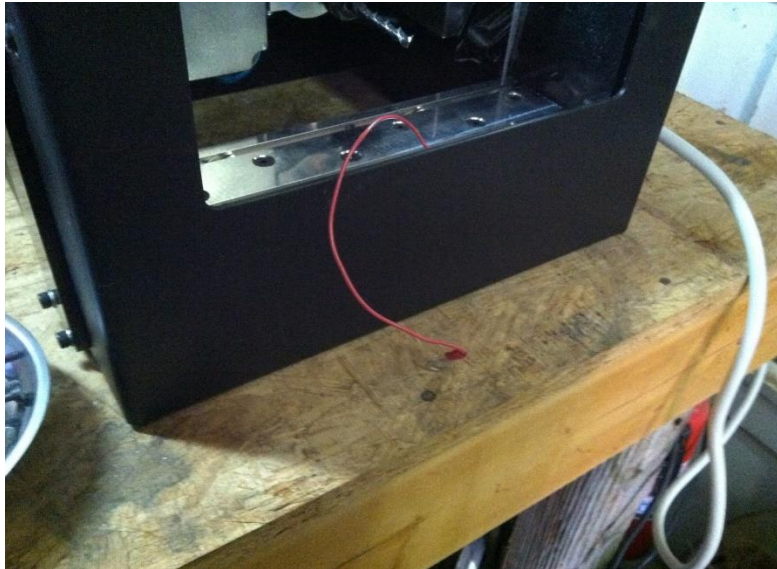
Note near the middle of the dish in Figure 21 is the screw for installing the pistol grip from a lower parts kit. This screw from the pistol grip is not supplied and you must have one, or a screw that is identical to one to continue. The screw will be used to fasten the electrical lead to the lower allowing the sensing circuitry that tells the system what is lower and what is not lower to function.

Next, install the 4x45 bolt and washer and the appropriate nut and washer as shown and snug them down. Figure 22 shows the properly installed bolt, nut and washers.



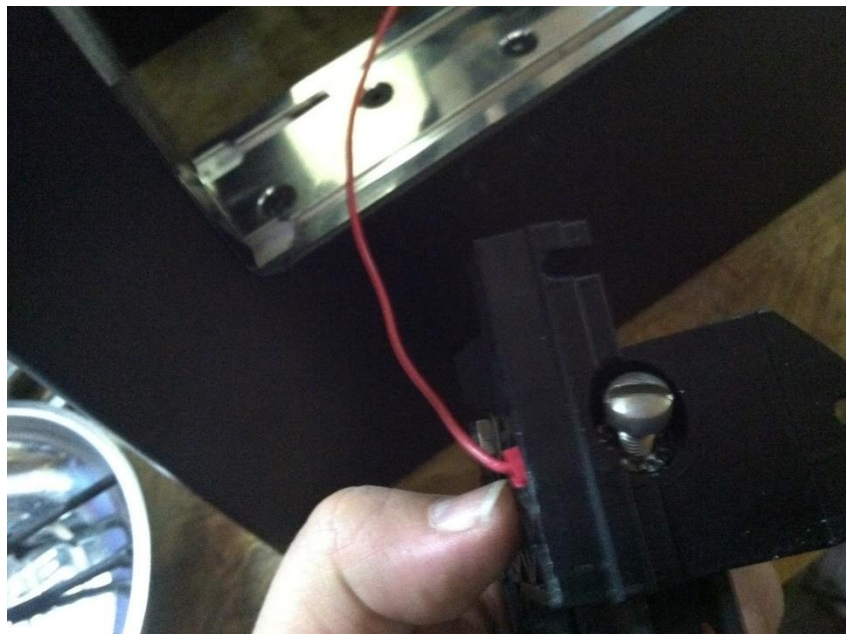
*Figure 22: Properly installed 4x45 bolt, nut and washers.*

This step makes sure the two jigs are properly aligned to install the electrode line using the pistol grip screw. The electrode lead is the red lead as shown in Figure 23.



*Figure 23: Electrode lead*

Locate the lead slot on the lower rear side of the left hand jig, slide the electrode contact into the slot, then use the pistol grip screw to fasten the lead to the lower. Make sure this connection is tight as it provides the needed electrical path between the Ghost Gunner and the lower. This is shown in Figure 24.



*Figure 24: Attaching the electrode lead from the Ghost Gunner to the lower*

Next, install the forward jig as shown in the diagram from the dd file on the Ghost Gunner. Figure 25 shows this diagram.

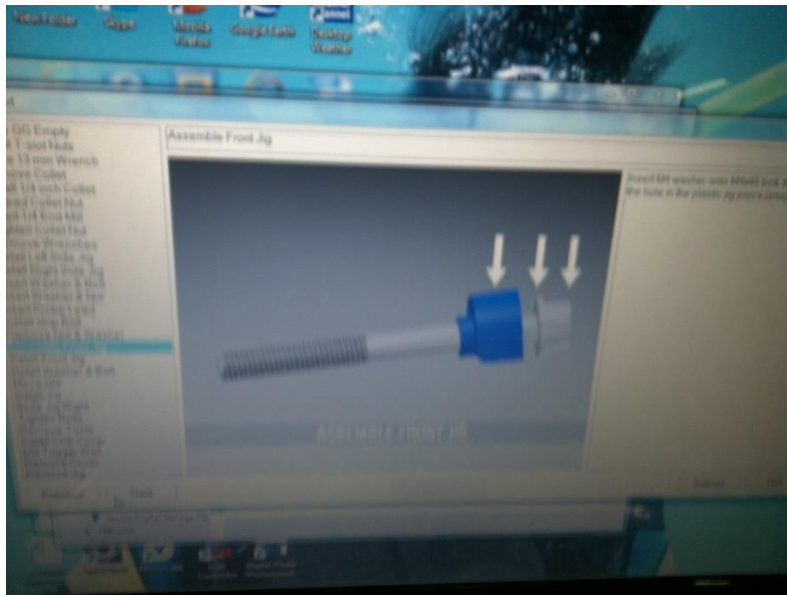


Figure 25: Assembling the front jig and bolt.

Figure 26 shows a properly assembled front jig assembly.

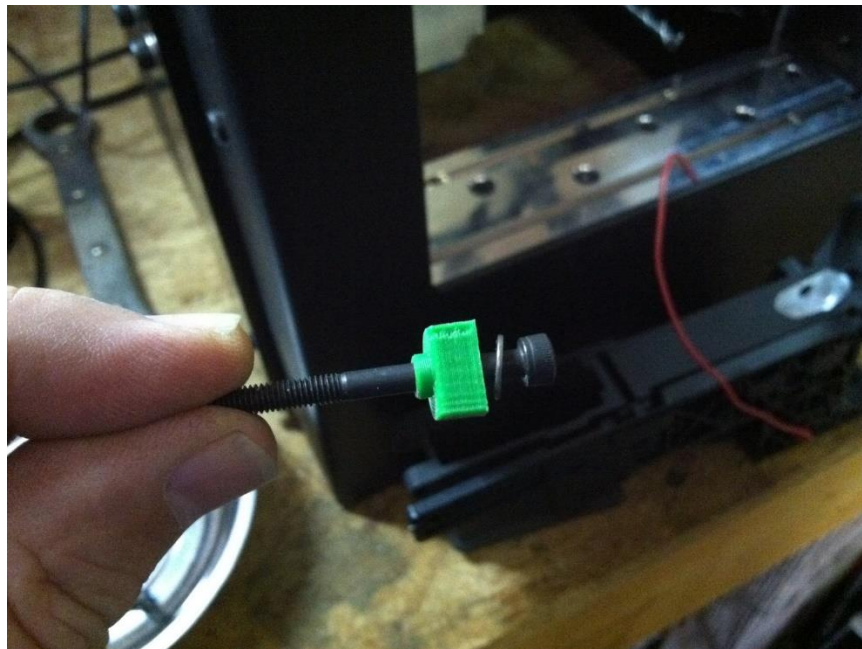


Figure 26: Properly assembled front jig

Install the front jig and bolt as shown in Figure 27 through the forward retaining lug pin hole and the left jig forward hole. Use a nut and washer to snug the fit as needed.





*Figure 27: Properly installed front jig.*

Figure 28 shows the fully setup lower with left, right and front jigs and properly attached electrode lead.



*Figure 28: Lower with all installed jigs (left, right and front)*

At this point you should be at the step just prior to mounting the lower into the machine, to do so the stage and bit must be repositioned. The dd file will prompt you as shown in figure 29 if you have

been properly stepping through the onscreen instructions. Remove any nuts and washers you may have installed on the jig, but leave the bolts and their washers in place.

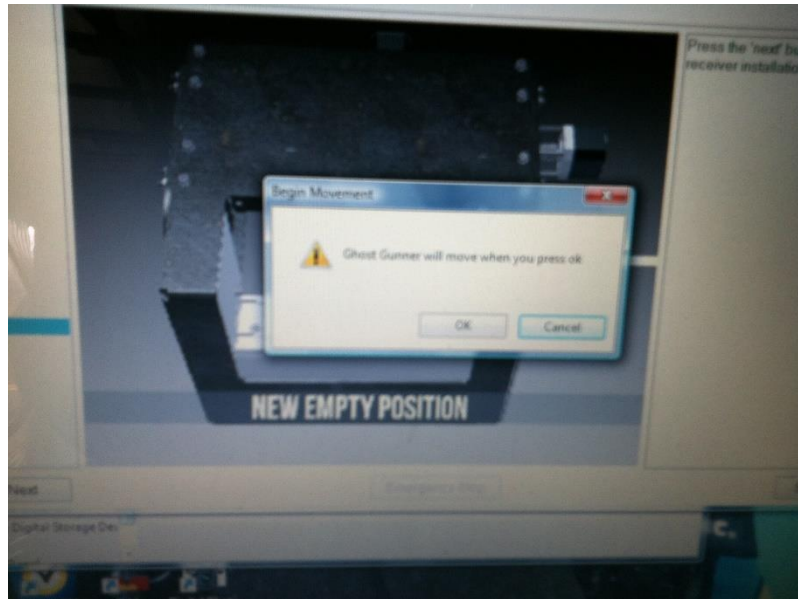


Figure 29: Select OK and the stage and head will move to allow the installation of the lower and jigs.

Figure 30 shows the properly positioned Ghost Gunner ready for insertion of the lower and jig assembly.

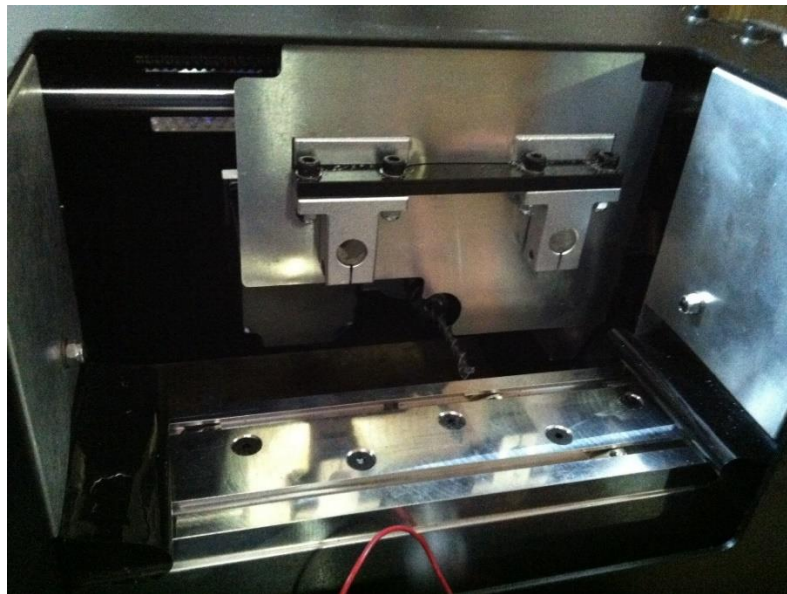


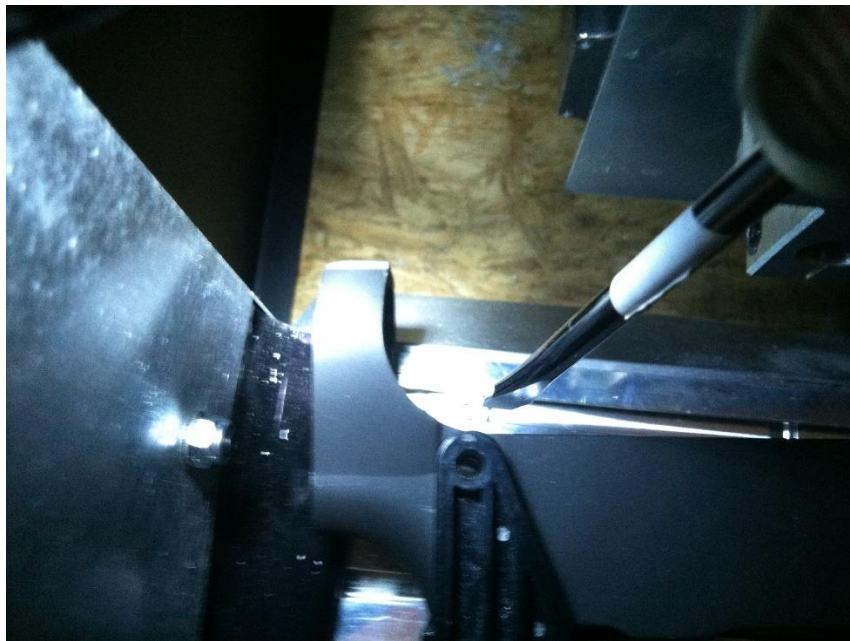
Figure 30: Properly positioned Ghost Gunner

Using the lower assembly and the magnetic tip of the screw driver or end of the Allen wrench, get the holes of the T-slot nuts aligned with the holes of the rig when it is laying with the buffer hole to the left lying face down on the left jig. I have found using a small flashlight and removing the bolts will allow you to sight down the hole and align the hole on the T-slot nut properly.



*Figure 31: Using a small flashlight can help with bolt hole alignment with the T-slot nuts.*

Use of a magnetic tip screw driver allows you to easily position the T-slot nuts as shown in Figure 32.

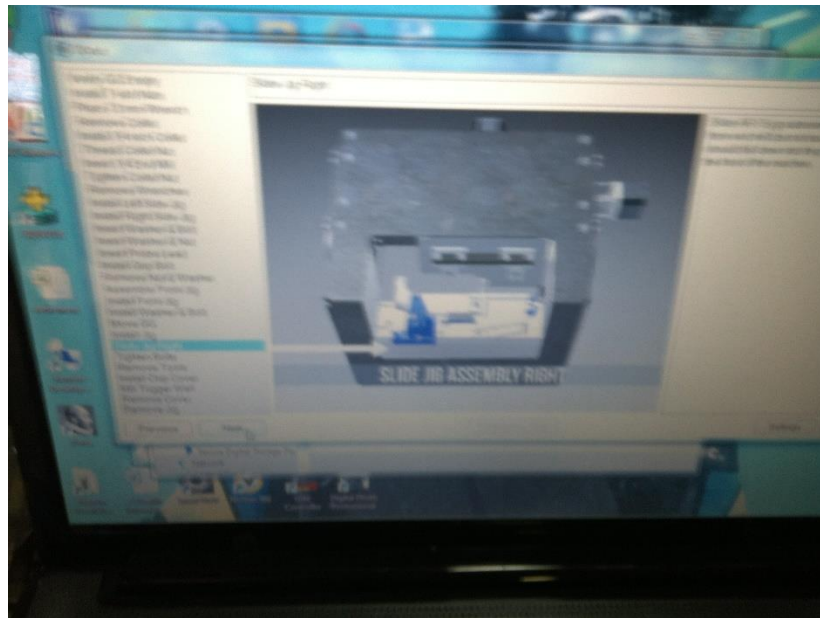


*Figure 32: Using a magnetic tip screw driver to position the T-slot nuts*

The magnetic tip of the screw driver can also aid in retrieving dropped bolts and nuts that fall inside the machine. Using the magnetic tip is easier than lifting the entire machine to retrieve dropped parts. Unfortunately the washers are non-magnetic so be careful not to drop them!



Once all the bolts are engaged in the T-slot nuts just lightly tighten them. In the next step you must slide the mounted assembly to the right until the mag well wall just makes contact with the end mill bit. Figure 33 shows the dd image depicting this.



*Figure 33: dd image of sliding assembly to the right.*

Figure 34 shows what the properly positioned assembly should look like, note position of end mill in relation to the magazine well.



*Figure 34: Properly positioned assembly*

Once the assembly is properly positioned, tighten all of the bolts using the provided Allen wrench. It should be near impossible to over tighten them using the Allen wrench so snug them down good, you want a ridged melding of the assembly and stage to make sure you get an accurate mill of the

trigger pocket. While we could afford a little slop in the rear disconnect slot, the trigger well has to be fairly precise to work well.

Next, tuck the electrode lead inside the front of the machine so that it can't be snagged or broken during machine operations. Figure 35 shows the proper positioning of the lead.



*Figure 35: Electrode lead tucked away.*

Once the lead is safely tucked away it is now time to install the chip guard. Do not allow milling or drilling when the chip guard is not installed unless you want small, sharp-edged pieces of aluminum scattered all over your shop. Figure 36 shows the properly installed chip guard.



*Figure 36: Properly installed chip guard.*

Once the chip guard is installed and the dd procedure has been advanced to the proper step, the next step is to press the Ok which will warm up the machine revving it from 5000 RPM to 10,000 RPM over several minutes. Be patient and allow the machine to warm-up. Figure 37 shows the dd display.

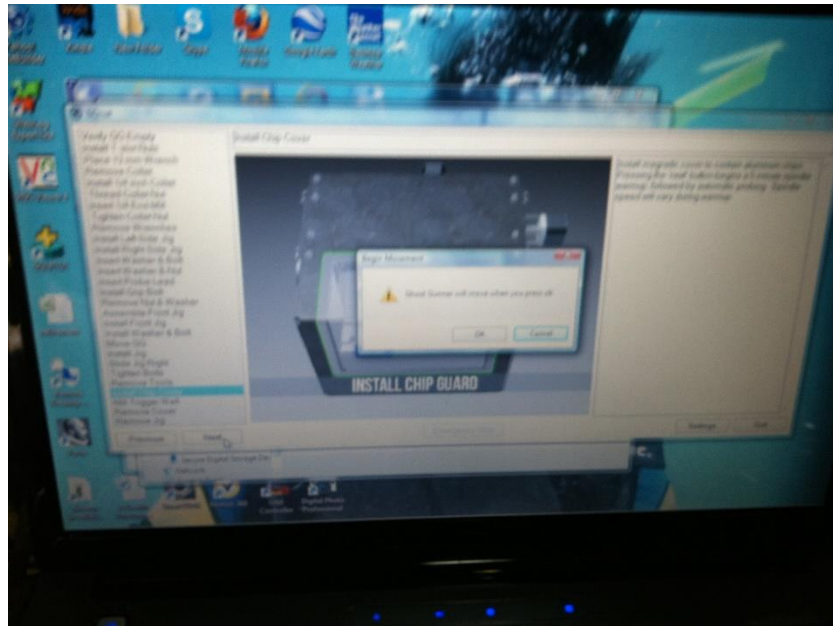


Figure 37: dd display just before warm-up starts

The dd script will display the various commands sent to complete the warm-up of the machine. Figure 38 shows this set of commands.

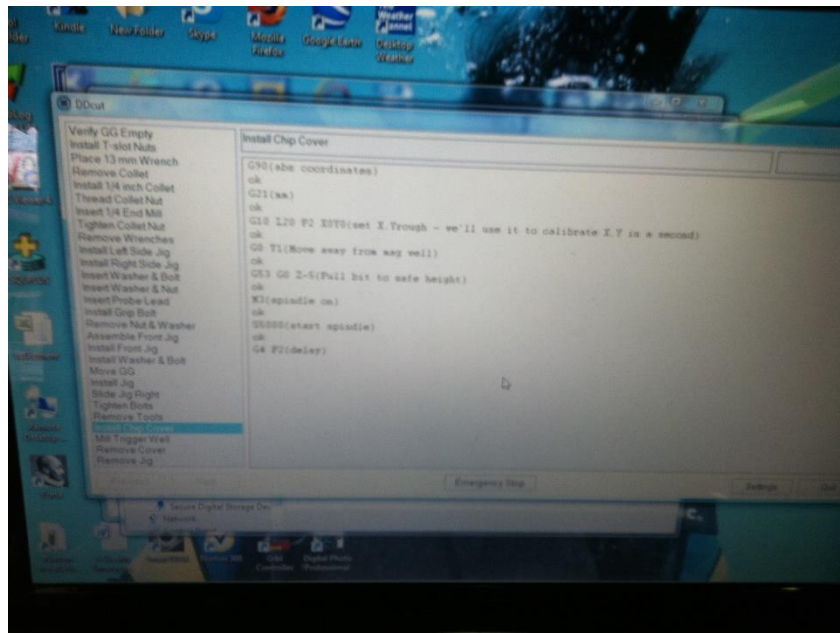


Figure 38: dd commands to warm up Ghost Gunner

Once the Ghost Gunner motors are sufficiently warmed, it is ready to actually start milling the trigger pocket. Note: You must have a true 80% lower with the rear takedown lug pocket already milled or the mill will go into a start-probe-stop-move-repeat operation and your upper will look like Figure 39 when it times out.





Figure 39: Result of attempting to machine a 78% lower (no rear takedown lug slot)

If this happens to you in spite of my warnings, don't despair, while it may not be the prettiest AR15 lower you can still mill out the rear takedown lug slot as described at the start and make a completely functional rifle.

The Ghost Gunner will admonish you to put the chip guard in place and then prompt you to select Ok again to actually start milling the trigger well as in Figure 40.

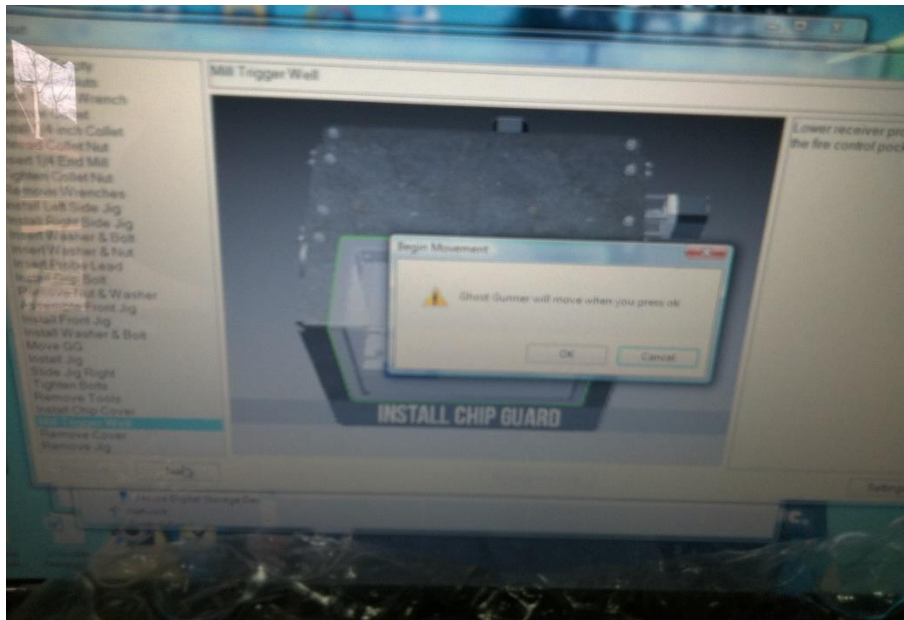


Figure 40: Final Warning before milling trigger well

Pressing the OK will fire up the Ghost Gunner and it will start milling the trigger well. It will make many passes cutting a little at each time. However the noise will get louder and louder the longer it works sounding like someone is sanding an electronic cat's butthole. You will want to do this in a garage, or shop away from civilization, or your wife or significant other. It takes a couple of hours and makes a horrendous amount of noise while it is doing the milling. You have been warned.

### 3 Milling and Drilling the Safety hole and Pin Holes

Once the Ghost Gunner finishes the milling of the trigger pocket it will go idle and wait for you. It will then instruct you to remove the chip guard and vacuum up the aluminum chips. Do not use an air gun or blower as that can force the chips into seals and cause excessive wear. This is shown in Figure 41.



Figure 41: dd instructions

The un-vacuumed Ghost Gunner should look something like Figure 42.



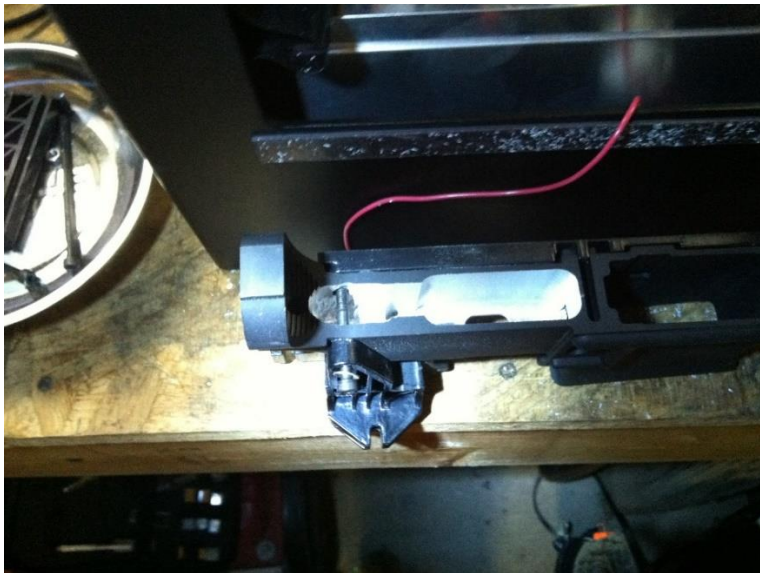
Figure 42: Chip guard removed, not vacuumed

Vacuum up all the chips you can see, especially from the T-slots and the lower assembly. It should look nice and clean when you are finished like Figure 43.



*Figure 43: Cleaned Ghost Gunner*

Notice in Figure 43 that the Allen wrench is installed, the next step is to remove the assembly from the Ghost Gunner so you can prepare for the next set of operations. Figure 44 shows what the finished trigger pocket should look like.



*Figure 44: Finished (milling anyway) trigger pocket*

Figure 45 shows the dd instructions to remove the assembly and vacuum anything under it. This is important since it could cause the assembly not to be perfectly level in reference to the stage which would cause holes to be improperly drilled.





Figure 45: dd Instructions

In the next step move one of the T-slot nuts from the back slot to the front slot as shown in Figure 46.

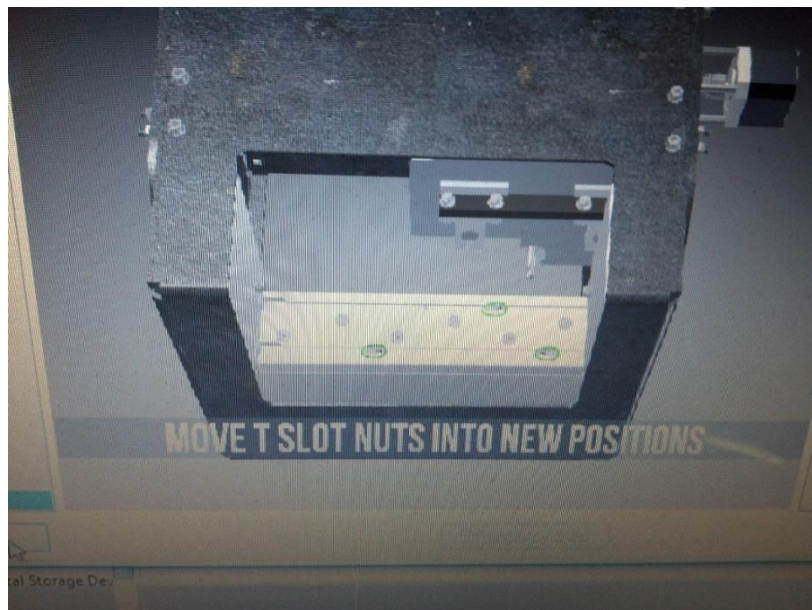
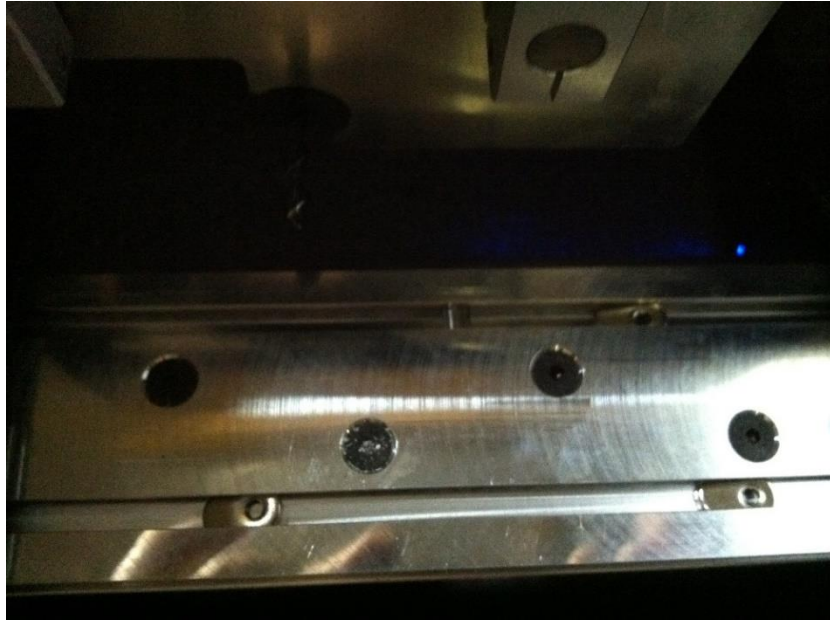


Figure 46: dd T-slot diagram

Figure 47 shows an actual picture of the Ghost Gunner with the T-slot nuts moved.



*Figure 47: Ghost Gunner with T-slot nuts repositioned.*

The left side T-slot nuts need to match the placement of the slots on the lower assembly, as shown in Figure 48.



*Figure 48: Slots on base of lower assembly.*

The dd program will tell you to install the jig next as shown in Figure 49.

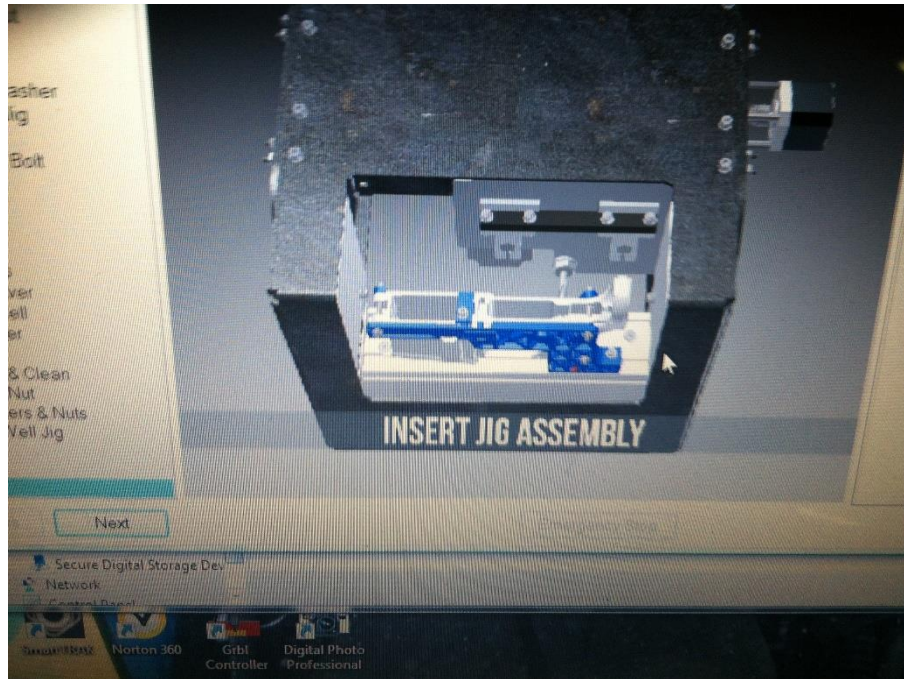


Figure 49: dd lower jig install Instruction

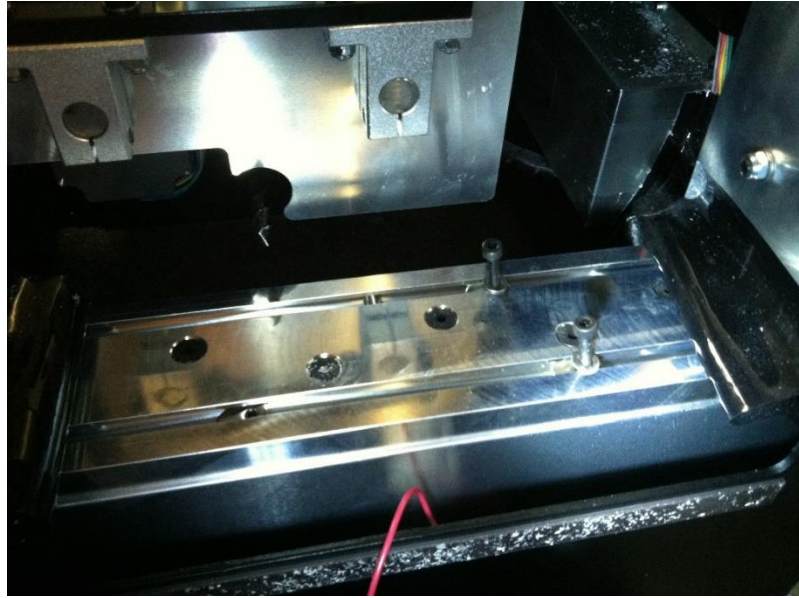
First, put the assembly in with the buffer hole to the right and the lower upright and line up the T-slots with the holes, then place the bolts into the assembly and snug them in. There are three basic methods for placing the T-slot bolts:

1. Place the screws in the slots and try to hold them steady while placing the jig assembly into the Ghost Gunner
2. Place the screws into the T-slot nuts and then try to fit the assembly into them (holding the washers up becomes problematic.)
3. Place the assembly in first then place the screws

Figure 50 shows option 2. I have tried all three and had the best luck with option 3, however, you will probably drop the rear screw into the Ghost Gunner so be prepared to tilt it up if you don't have something magnetic to retrieve it. Also remember that the washer is non-magnetic so when you retrieve it do it shank instead of head first.

Place the nuts and washers on the three in place bolts and snug them up, these will keep the assembly ridged and aligned.





*Figure 50: Option 2 for placing the T-slot bolts, holding the washers up was problematic.*

Once the left side T-slot bolts are in place (just snug, not tight yet) install the magazine well jig, flat side to the wall and the long bolt with washer. Mate it up to the right hand T-slot nut and snug it up. Figure 51 shows the jig and bolt in place.



*Figure 51: Magazine well jig and T-slot bolt in place. Note nut and washer in place on forward takedown lug bolt.*

The dd program will instruct you to slide the assembly left as shown in figure 52.

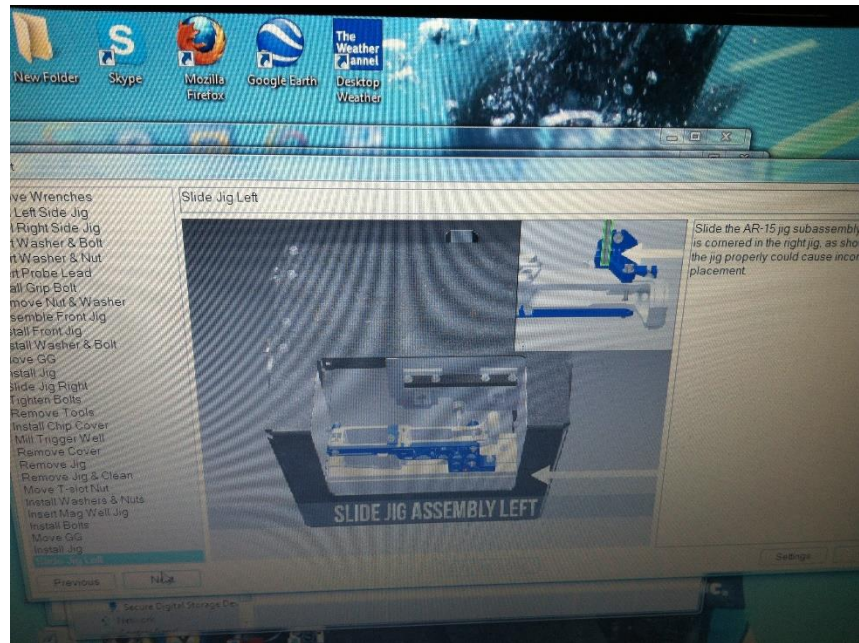


Figure 52: dd Instructions for sliding the assembly.

Now slide the entire assembly to the left, you may need to loosen the forward bolts and magazine well bolt if you over tightened them. Figure 53 shows the assembly with the lower nut and washer in place. Note that if you lose one nut, using the front disconnect bolt and this lower bolt with nuts and washers will produce satisfactory results.



Figure 53: Shows lower assembly bolt with nut and washer.

The rig is properly positioned when the end mill is nestled into the corner of the right hand jig as shown in Figure 54.





Figure 54: End mill is down and to the right nestled into the corner of the right hand jig face.

Remember to tuck in the electrode wire and then install the chip guard as asked by the dd program in Figure 55.



Figure 55: dd Diagram

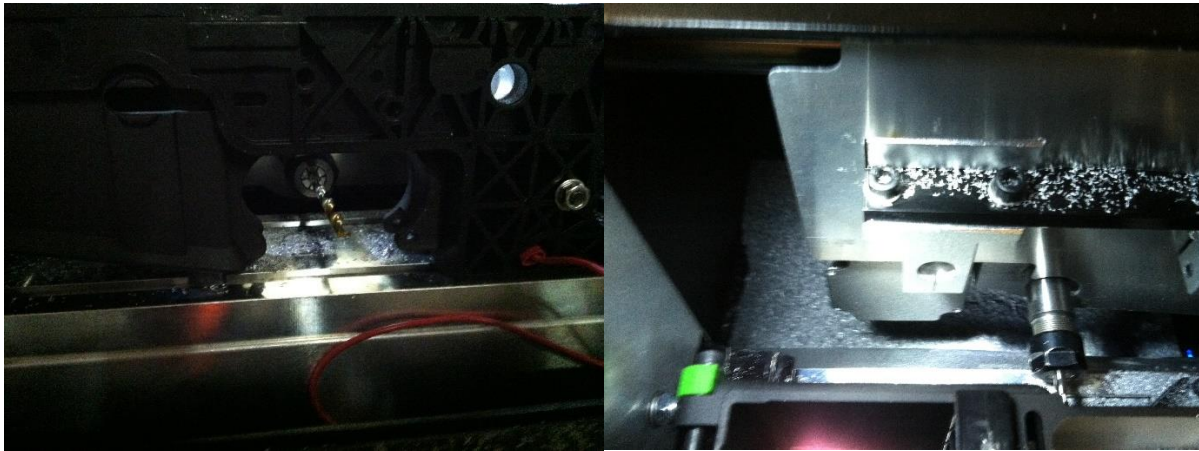
Once you click Next and OK the Ghost Gunner will begin milling the selector hole. Figure 56 shows the Ghost Gunner milling away.





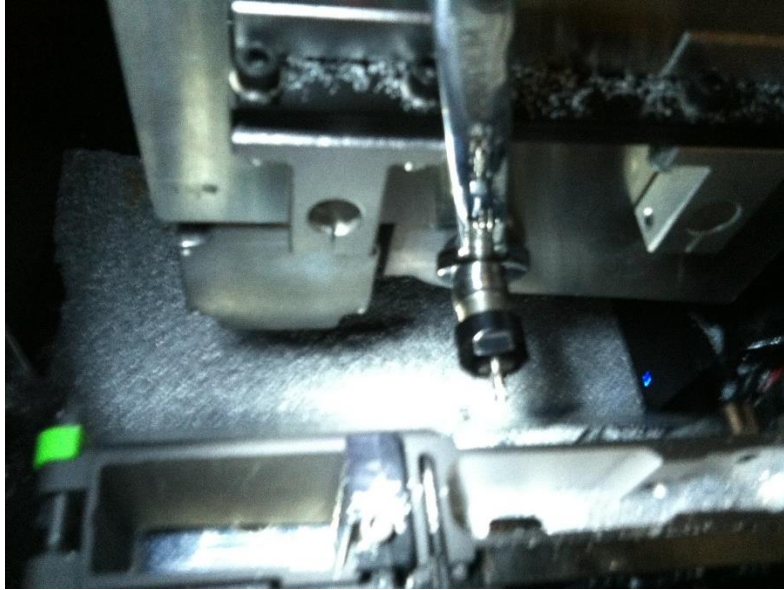
*Figure 56: Ghost Gunner milling the selector hole.*

Once the Ghost Gunner finishes the selector hole it will move to a neutral position. It is time to change to the 5/32 inch drill bit provided to drill the holes for the trigger assembly and hammer assembly retention pins. Press Next and OK until the End Mill bit is positioned inside the trigger well and the shank and collet nut are exposed. As shown in Figure 57.



*Figure 57: Position of end mill for removal*

Just like when you replaced the collet, loosen the collet nut and pull out the end mill bit. Do not remove and the collet nut, do not install the new collet and drill bit! If you do you will end up like Figure 58 with a broken bit.



*Figure 58: Broken drill bot from placing it in the chuck too soon.*

Selecting Next will position the empty spindle so it is easy to remove the collet nut and replace the collet with the 4mm one. Then press next again and the spindle will reposition to inside the trigger guard so the drill bit can be inserted. Only insert the drill bit when the spindle has been repositioned to inside the trigger guard or damage to the spindle, stage, bit or lower receiver will result. Figure 59 shows the new bit in the new collet in the proper position to begin the next step.



*Figure 59: Spindle in proper position to insert drill bit.*

Once the drill bit is installed and the collet nut tightened, hit the Next button and the dd program will be ready to begin drilling the trigger and hammer retention pin holes as shown in Figure 60



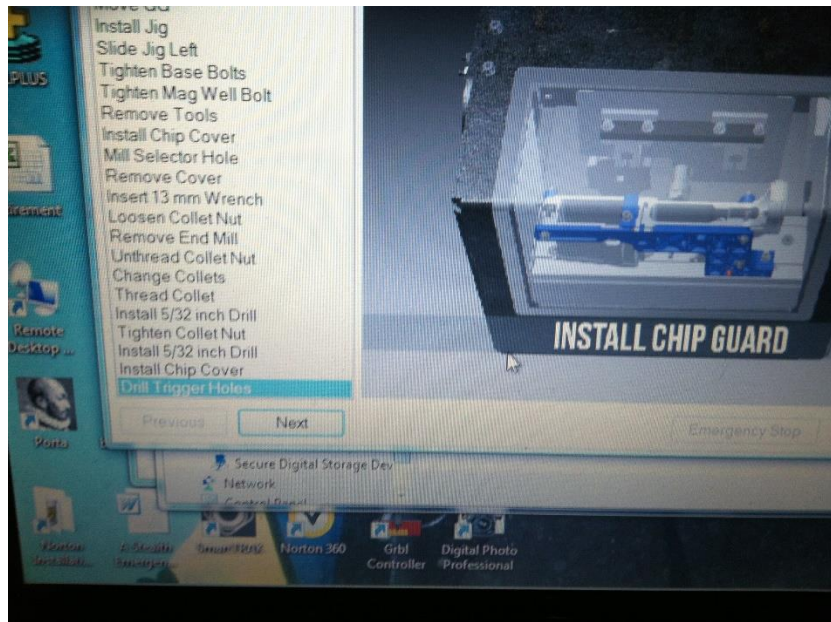


Figure 61: dd Instruction for drilling trigger retention pin hole.

Selecting Next and then OK will start the Ghost Gunner on its final jobs: drilling the trigger and hammer retention pin holes. Figure 62 shows the Ghost Gunner drilling the trigger retention pin hole.



Figure 62: Drilling the trigger retention pin hole

The final step is to drill the hammer retention pin hole, this is shown in Figure 63.





Figure 63: Drilling the final hole

Figure 64 shows the finished 100% lower receiver still mounted in the Ghost Gunner. The final steps are to remove the assembly, carefully pry the jigs (usually the left hand jig will stick) off the lower and clean up the Ghost Gunner.



Figure 64: The Finished lower receiver, or should I say firearm, according to BATF.

Figure 65 shows the aluminum chips that accumulate from a single lower. Be sure to clean up under it as well as inside using a vacuum.



Figure 65: The aluminum chips left after machining.

Figure 66 shows the dd programs last instruction before showing the helmeted skull closing screen, telling you to remove your firearm, good job!

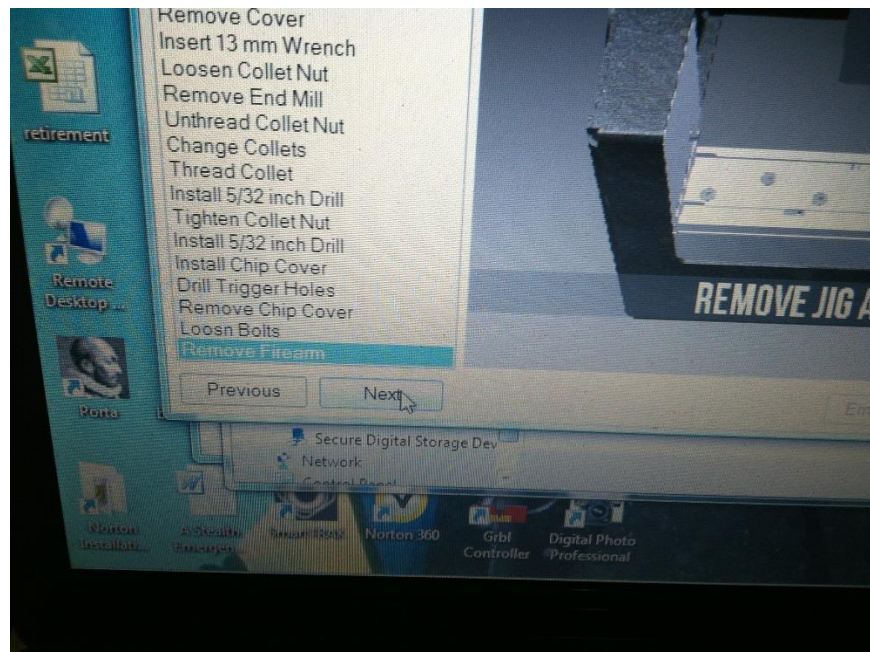


Figure 66: Final dd Instruction

Be sure to vacuum the stage and clean out the T-slots after removing the firearm from the Ghost Gunner. Figure 67 shows the completed lower receiver next to a blank identical to the one I started



with. Now all you have to do is install the lower kit, the buttstock, buffer and spring and snap an upper into place and your AR15 is ready to go!



Figure 67: Completed lower receiver next to 78% blank.

Figure 68 shows one of the Ghost Gunner finished lowers with a kit installed. One thing I had to do with the lowers I had was file a little bit on the walls of the magazine release to allow it to work freely and Dremel out a bit at the rear of the rear retention lug pocket to get a good fit. All in all took about 10 minutes.



Figure 68: Lower with kit installed

Then I mated it with a buttstock, my upper and some optics and was ready for the range as shown in Figure 70.





Figure 70: Completed rifle

If the rifle doubles or triples (fires multiple rounds) then it is probably the disconnecter and you should order a new one. In Figure 71 the left hand disconnecter has a slightly larger notch (see arrow) this caused doubling. Replacing it with the one on the right corrected the problem.



Figure 71: Disconnecter issues

## 4 Summary of Tips

1. If you have to cut your own rear retention lug slot, be careful not to make the wall side with the retaining pin retention pin and spring too thin or side-wall failure can occur. Side wall failure will cause the pin to stick and may result in the retention lug not fitting into the slot, ruining the lower.
2. Get full 80% lower receivers with rear takedown slot already machined
3. Make a good directory where the untouched code is kept and a working directory to store the actual code you run with
4. Reset the Ghost Gunner to its proper settings on receipt.
5. A magnetic tipped screw driver makes placing the T-slot nuts easy as well as the picking up dropped parts.
6. Use a rubber or plastic mallet to properly seat the left hand jig on the lower.
7. To clean the Ghost Gunner use a vacuum not compressed air.
8. Use a magnetic dish to hold bolts, End Mill and drill bit.
9. A small flashlight is handy to use for aligning jig holes and T-slot nuts.
10. When threading the collet nut back on, be very careful not to cross thread the nut.
11. Before moving on to steps where the platform moves, tuck the electrode lead slack inside the front of the machine.
12. The Ghost Gunner is very noisy when it is milling the trigger pocket. Do not do this in the kitchen, den or even the basement unless everyone is OK with loud screeching noises.
13. When changing the bit for drilling the trigger and hammer pin holes, don't put the drill bit in until just before the actual drilling begins.
14. A clean Ghost Gunner is a happy Ghost Gunner, after every machining step vacuum up stray aluminum chips.
15. If you drop a bolt with a washer into the Ghost Gunner, pick it up from the shaft end since the washer is not magnetic.
16. A set of jeweler files and a Dremel tool with a metal cutting burr (shaped like a Christmas tree) come in handy for trimming up the a hand cut rear takedown lug slot and trimming up a sticky magazine release slot.
17. When assembling the kit into the lower put in the release lever before the hammer as it provides additional support for the release lever wall on the hammer side. Dry firing the lower without the release lever in place can result in breaking of the wall nearest the hammer, while not a fatal mistake it does mar the appearance of the finished lower.