

PROJECT: Collapsible Shovel

Special thanks to J. Allen & B. Fromhart!

The Purpose...

In this activity you will fabricate a portable, collapsible shovel - perfect for camping, hiking, snowboarding and more! Can you dig it?

The Preparation...

For this activity you will need the following:

MATERIALS

- 16ga steel sheet 6" x 9"
- 1" x 1/8" flat bar 22" long
- 1/2" 16ga square tube 8" long
- 1-1/2 x 1-1/2" 1/8" angle iron 3" long
- 1-1/2" aluminum round 2" long

FASTENERS

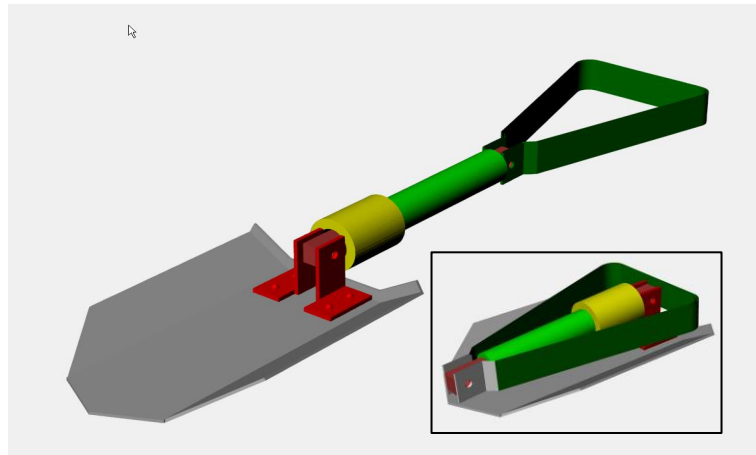
- 1"-8UNC threaded rod 5-3/4" long
- 1/4-20 x 1-1/4" capscrew (two)
- 1/4"-20 Nyloc® nut (two)
- 1/2" flat washer
- 3/16 solid rivets (4)

TOOLS

- Scriber, Ruler and Protractor
- Hacksaw
- Drill press
- Lathe
- Foot Shear
- Box & Pan brake
- Hammer and Centerpunch
- Vice
- Files

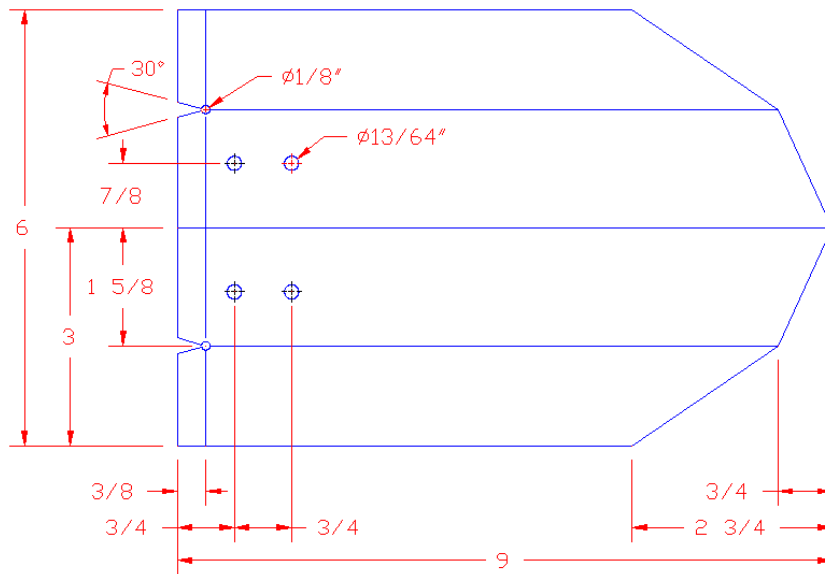
The Procedure...

1. Blade
2. handle
3. Shaft
4. Brackets
5. Sleeve
6. Nut



1 The Shovel Blade

If you are not sure how to do any of the steps on this sheet, or how to use any of the tools, ask!

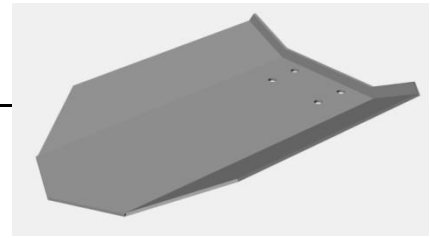


LAYOUT

1. Cut out a 6" x 9" piece of 16ga sheet steel
2. SCRIBE lengthwise the exact middle of the blade
3. SCRIBE lines 1-5/8" on either side of center
4. Pick your best edge for the back of the blade
5. SCRIBE a line 3/8" in from the back, along the entire width
6. CENTERPUNCH the 1/8" relief holes for the pie cuts at the back
7. Reference the BACK EDGE with a protractor to scribe the 30° cutouts
NOTE: You only draw 15° at a time.
8. SCRIBE the two tapers at the front of the blade
9. SCRIBE and CENTERPUNCH the locations of the bracket holes 7/8" away from center, and 3/4" away from the back edge and each other.
10. Let me check your layout – It's easier to change before you cut.

CUTOUT

1. Drill the 1/8" relief holes - these give you something to cut ~into~, and provide a stress-relief for the V-Cut.
2. Use a hacksaw or Hand Shear to cut the pie cuts
3. Use the Hand Shear to cut the front tapers; the Hand Shear will try to suck the metal in – don't let it.
4. DRILL the bracket holes 13/64"
5. COUNTERSINK the *backside* of the bracket holes with a 1/2" bit- leave about 1/3 of the original hole still there – DO NOT enlarge the holes!
6. Use the Box & Pan brake to bend the back edge up to 90°
7. Use the Box & Pan brake to fold both sides up until pie cuts are closed
8. REMOVE all sharp edges with a file



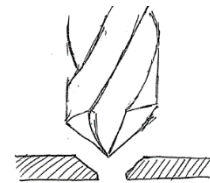
Put your initials on
your parts!
Theft is a reality!

This blade
design too
boring?

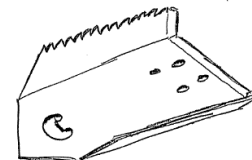
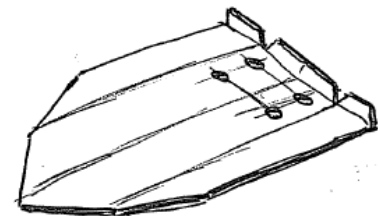
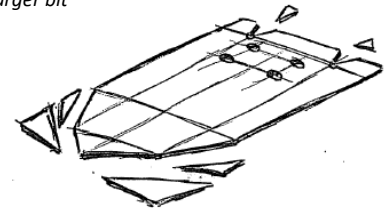
Got a really
cool blade
idea?

Talk to me!

Be
Creative!



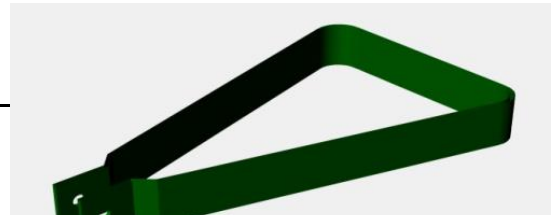
Countersinking with a
larger bit



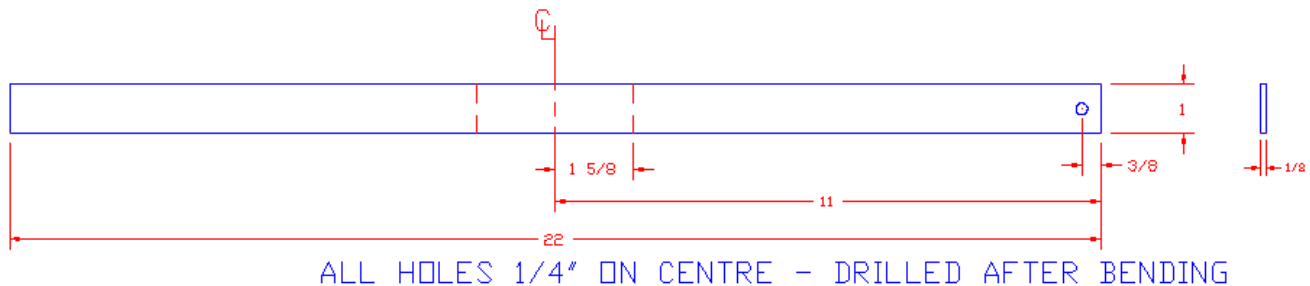
Do something unique!
Saw teeth?
Bottle opener?

2 Shovel Handle

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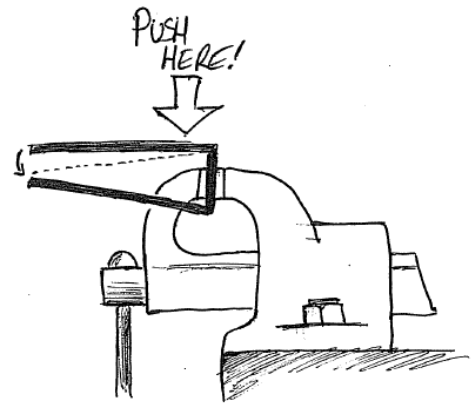


HANDLE



1. Cut a piece of 1" x 1/8" flat bar, 22" long
2. Knock any sharp edges off with a file
3. Find and scribe a line at the exact center
4. Scribe two lines 1-5/8" on either side of center
5. Centerpunch and use a Hand Drill to drill a 1/4" through ONE END ONLY (use a slow drill speed, but use pressure)
6. Use the Box & Pan Brake to bend both ends of the handle at the scribed lines until the free ends are touching
 - Looks like a triangle
 - One end might need a tweak (bend in a vise as shown)
 - If the ends are uneven, file them to length

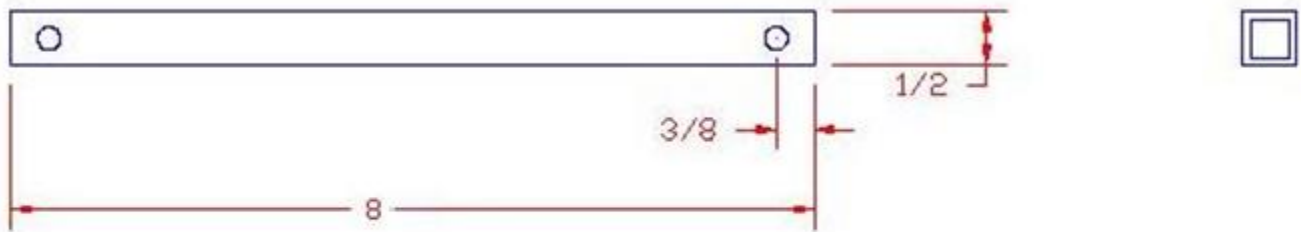
Put your initials on your parts!



7. Clamp BOTH tips together sticking about 1/2" into a vise, and bend slightly back and forth until the tips of the free ends stay parallel (this will not be very much bending!).
8. Clamp in a vise again, such that you can use the drilled hole to help drill all the way through the handle ends.

3 Shovel Shaft

If you are not sure how to do any of the steps on this sheet, or how to use any of the tools, ask!



ALL HOLES 1/4" ON CENTRE

LAYOUT

1. Cut a piece of 1/2" 16ga square tube 8" long
2. Knock all sharp edges off with a file
3. Look inside the tube, and locate the WELDED SEAM – avoid this; the weld is the hardest metal to drill through, and the weakest part of the tube
4. SCRIBE the holes for each end
 - 3/8" from both ends, centered, **ON BOTH SIDES**
 - **DO NOT** mark the side with the weld seam

Put your
initials on
your parts!

You need to be very accurate with the holes – slight misalignment will result in a crooked shovel

CUTOUT

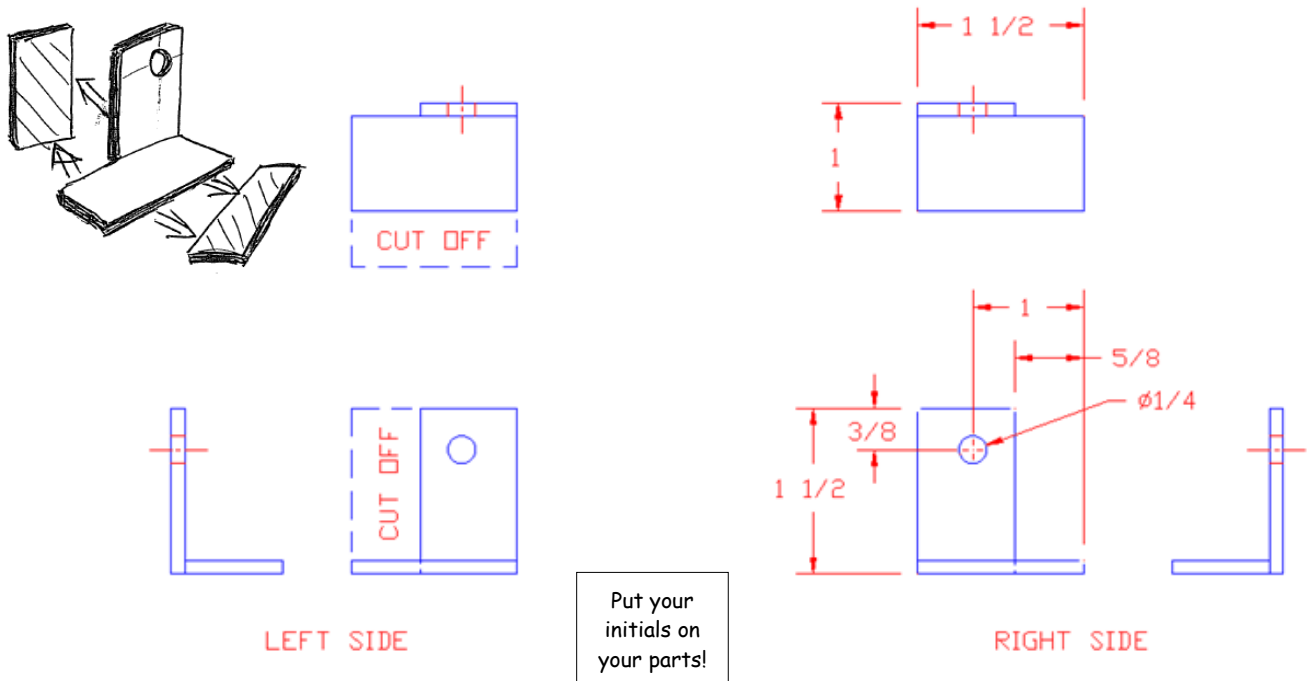
1. Use a drill press to drill the two 1/4" holes
2. Drill from EACH SIDE, from the outside into the middle only

***You will be tempted to just drill all the way through from one side
>> I guarantee you the hole won't come out in the right place on the other side <<***

3. When drilling the second side, continue the drill bit through the previous hole to ensure they line up

4 Shovel Brackets

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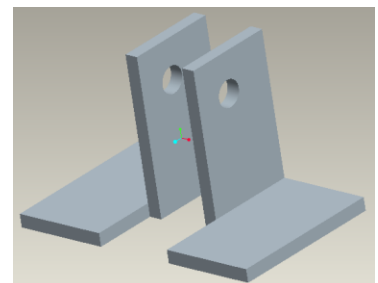
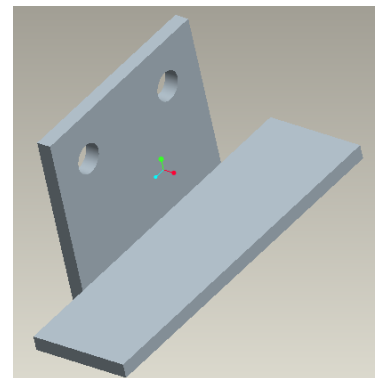


LAYOUT

1. You will need a LEFT and a RIGHT piece. It is easiest to start with a piece of 1-1/2" x 1-1/2" x 1/8" angle iron 3" long
2. Scribe a line 1" from each end, vertically – this is to locate the holes
3. Scribe a line 3/8" from the top – this is also to locate the holes
4. Scribe a line 5/8" from each end, vertically – this is to locate the notch you will remove
5. Scribe a line 1/2" from the long edge of the base – this is to locate the edge you will remove

CUTOUT

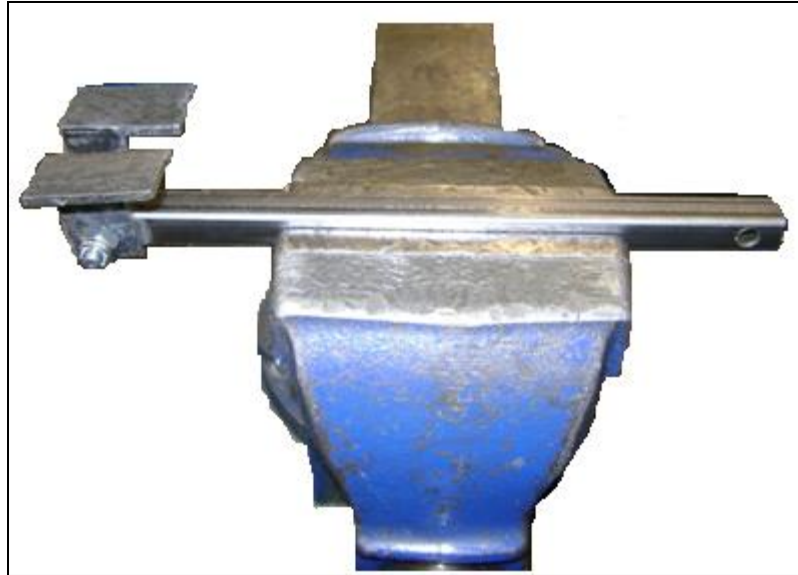
1. Centerpunch and drill the holes 1/4"
2. Use a hacksaw to cut the notch out at the 5/8" scribed line, removing all the way down (notice the "step" on the bottom)
3. Use a hacksaw to cut the bottom edge 1/2" shorter in width
4. Use a hacksaw to separate the two brackets (cut in half)
5. Knock off all sharp edges with a file
6. De-burr the drilled holes
7. Attach the two BRACKETS to the SHOVEL SHAFT with a 1/4"-20 x 1-1/4" bolt and nut.



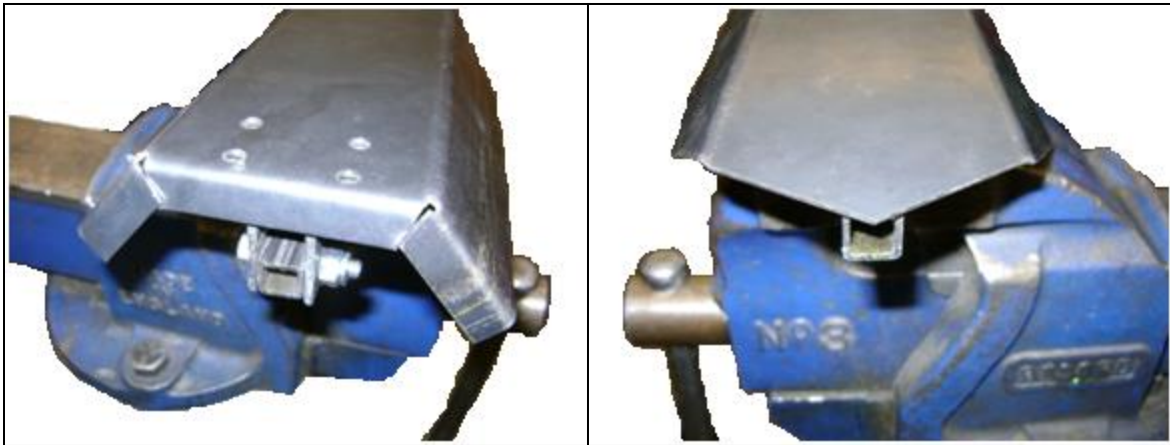
DO NOT TRY TO MAKE THINGS PERFECT WITH THE BENCH GRINDER
>>>> THAT WAS STITCHES FOR ONE KID!!!

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8. Clamp the SHOVEL SHAFT lengthwise in a vice, with the bottom of the SHOVEL BRACKETS sticking up and pointing as shown



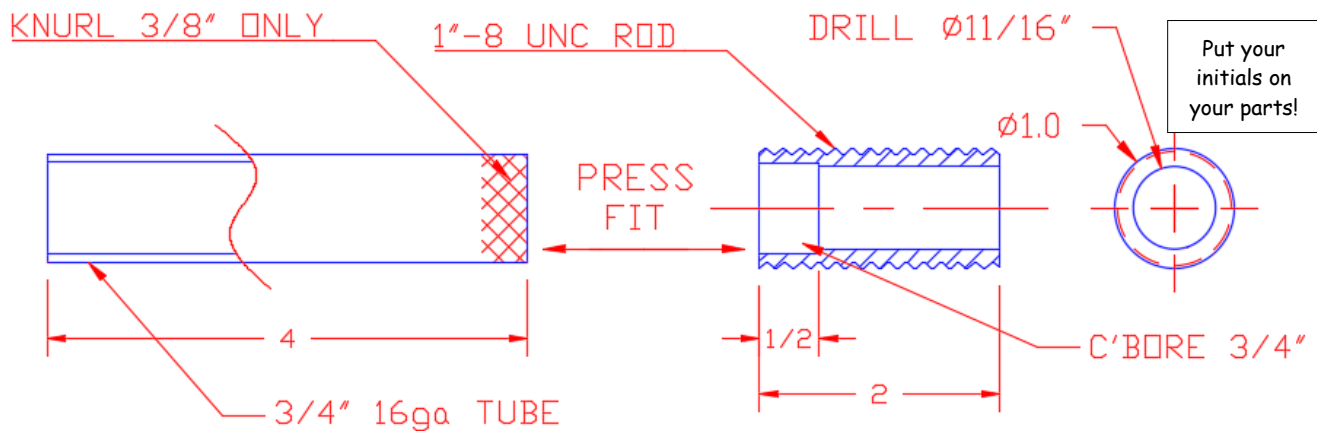
9. Place the SHOVEL BLADE onto the brackets as shown below, and center the blade over the BRACKETS and SHAFT



10. Using a Sharpie or Scribe, MARK the location of the RIVET HOLES on the bottom of the brackets, through the holes you already drilled in the BLADE
11. CENTERPUNCH and DRILL the holes in the brackets 7/32"

5 Shovel Sleeve

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LAYOUT

1. Cut a piece of 1"-8 UNC threaded rod to 2" long
2. Cut a piece of 3/4" 16 gauge (0.063") tubing to 4" long

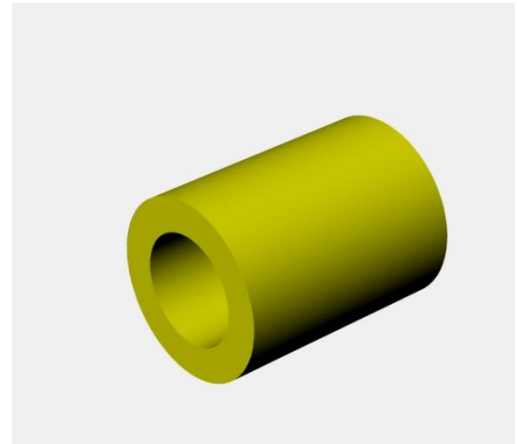
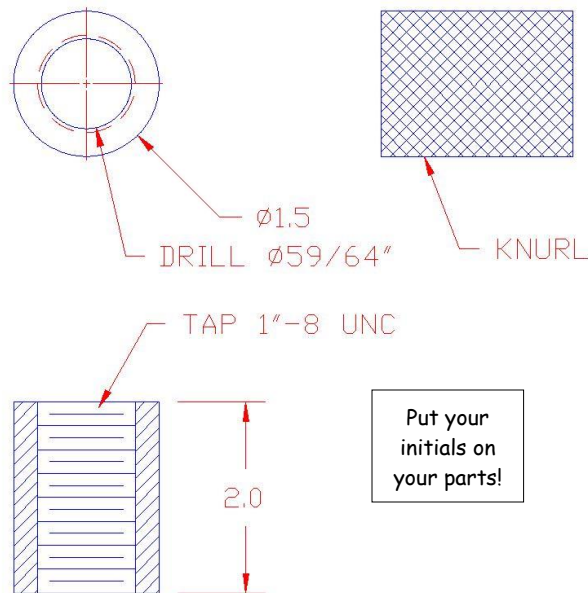
CUTOUT

1. Mount the THREADED ROD in the lathe chuck (stick out only enough to face), and FACE OFF both ends
2. CENTER DRILL, then drill all the way through in stages, both sides
 - You must go in stages: ~1/4" then ~1/2" then 11/16" – lathe speeds are based on DRILL SIZE
 - Use plenty of cutting oil
 - COUNTER BORE (C'BORE) **ONE** end 3/4"
3. Mount the tubing in the lathe chuck, and FACE OFF both ends (if you set the cutter just right, you can also CHAMFER inside and outside edges, saving you the step of deburring)
4. Stick one end of the tube out of the chuck ONLY ENOUGH to make one width of a ROUGH knurl. Knurl that one end.
5. **SLOWLY** and **GENTLY** drill all the way through with 11/16" – lathe speeds are based on DRILL SIZE, if it's screaming at you, go slower. If the metal changes colour, feed slower. You'll want a SHARP bit for this. GO FREAKIN' GENTLE!
6. Knock off all sharp edges with a file
7. GRADUALLY press the knurled end of the tube into the counterbored threaded road using a LARGE vice and occasionally tapping it with a hammer until it bottoms (you will feel this).
8. Clean up damaged threads with a 1"-8 die, thread chaser or triangular file.



6 Shovel Nut

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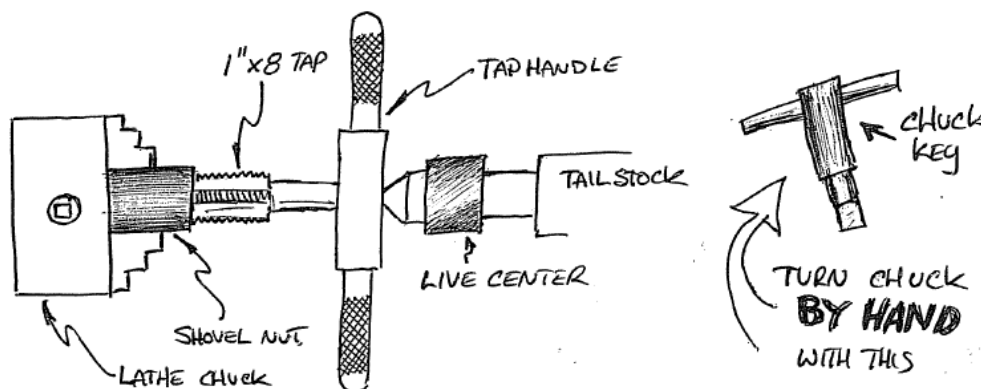


LAYOUT

1. Cut a piece of 1-1/2" aluminum round stock to 2" in length

CUTOUT

1. On the LATHE, face off both ends and center drill one end
2. On the Lathe, drill all the way through in increments: 1/4" – 1/2" – 3/4" – 59/64" (check lathe speed)
3. Place the 1"-8UNC tap into the hole you just drilled, and support the end of the tap and handle with the LATHE LIVE CENTER in the tail stock
4. Tap the inside of the nut by turning the chuck BY HAND: DO NOT USE LATHE POWER!!!
 - Remove the lathe cutter so it doesn't bite you
 - Use tapping oil (RED can), and cut 1/2 turn, then back off 1/4 turn to break the chips



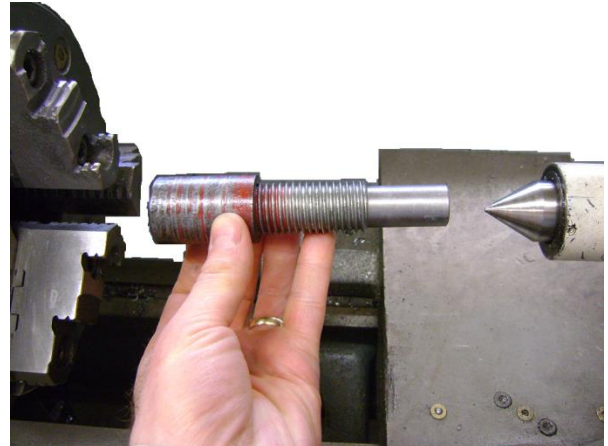
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NO POWER !!

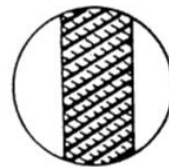
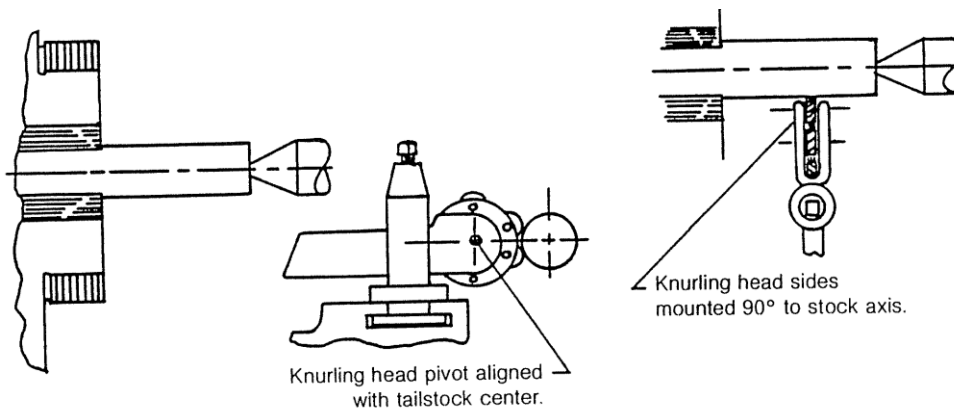
5. USE the jig shown to the right to hold the nut for knurling

Alternatively, you could mount the unthreaded end of the SHOVEL SLEEVE in the lathe chuck

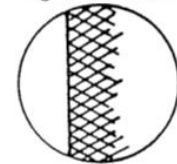
6. GENTLY thread the nut onto the sleeve until it ~just~ stops (do not tighten it!)
7. SUPPORT the free end with the live center
8. CHOOSE a knurl pattern that you like, set up the knurler, and try a light-contact test pattern



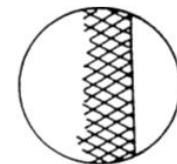
9. KNURL the outside of the nut (slow lathe speed, GREEN oil can)



Head mounted too high or too low

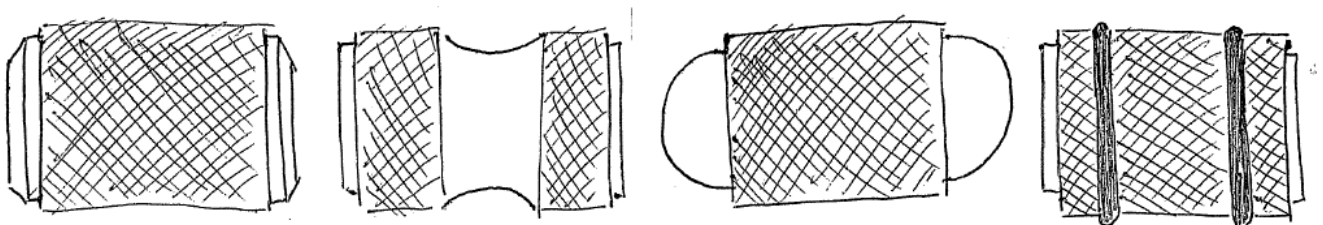


Head mounted less than 90° on chuck side.



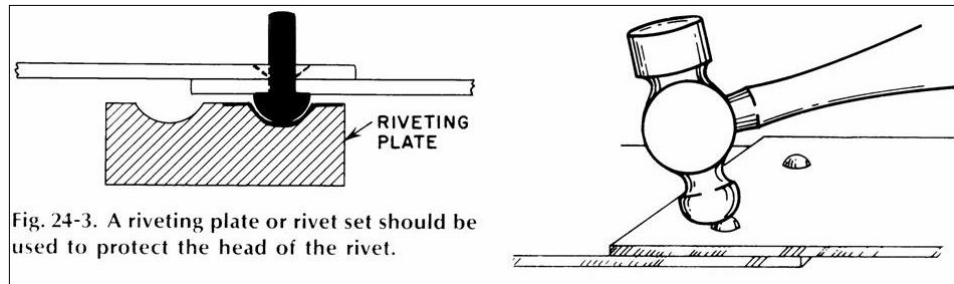
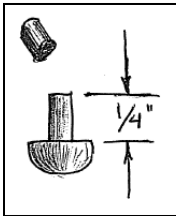
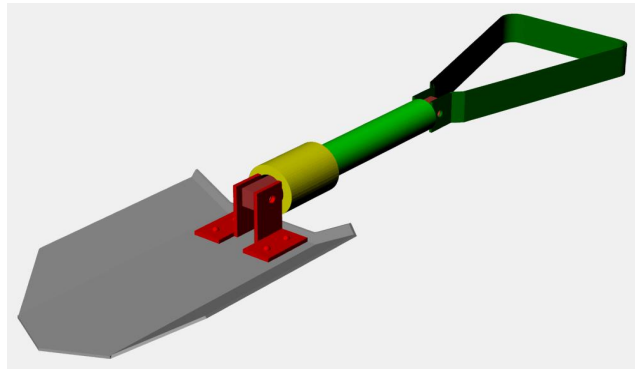
Head mounted more than 90° on chuck side.

10. DO SOMETHING COOL and CREATIVE to the nut, so it is uniquely yours, and full of AWESOME
11. REMOVE nut from Jig. If it's really tight, use a bench vice, a chain wrench, and leather to protect the knurl to remove it.
12. KNOCK off all sharp edges with a file
13. DO SOMETHING COOL to the nut – make it uniquely YOURS and AWESOME!



7 Final Assembly

1. Assemble the shovel as you see in the pictures
2. Use 3/16" solid rivets to attach the brackets to the blade
 - Cut to 1/4" length
 - Inserted from the top side, supported by a Rivet Set in a vise
 - Peened into the countersinks on the backside
 - Filed flat to look awesome



3. Tighten the 1/4" cap screw and lock nut (WITH WRENCHES!) until they just touch the metal
 - Loose enough to move
 - Tight enough not to be sloppy
4. 5/8" Flat Washer goes between the NUT and the BRACKETS
5. Test fit, and make any adjustments necessary for smooth operation
6. Double check that all sharp edges are removed



Mr. Wellwod's
most RIVETING
Demo

The Conclusion...

You are done when you have completed an exceptionally well-built collapsible shovel of high quality that opens and closes smoothly, and when unfolded stays locked in the open position, and when closed stays locked in the closed position. There should be no sharp edges, and your name should be letter-stamped somewhere on the shovel. Number of students who letter-stamped their name on their project: 1 (one).

The Reflection...

1. What did you like best on this project?
2. What did you dislike?
3. What did you learn?
4. If you were to improve the DESIGN of the collapsible shovel, what would you do differently?