

Physics Lecture 16 - Car Lubrication Part 1 - Axles

Introduction - Now that **Lectures 14** and **15** have shown detail on car construction, this lecture continues on with the lubrication of the car- it uses the recommended products from the [Speed Package](#) , (see **Fig1A**). It also identifies where the items from the free [Grab Bag](#) are used in the lube procedure..



Car Construction E-Book - Lube Chapter



Let the Cub do as much of the hands-on work as possible
and always practice safety first. Work as a team.



1. Lube Materials

- To get a professional quality lube job, one should understand that how you apply the compounds is just as important as the compounds themselves.
- A summary of the reasons this Speed Package (**Fig. 1A**) is effective is given in the website descriptions at [Speed Package](#).
- About the only thing not provided in the Speed Package that you will need is a bottle of 91% isopropyl alcohol, also know as rubbing alcohol. Almost every drug store carries the 91%. It is more effective than the 70%.

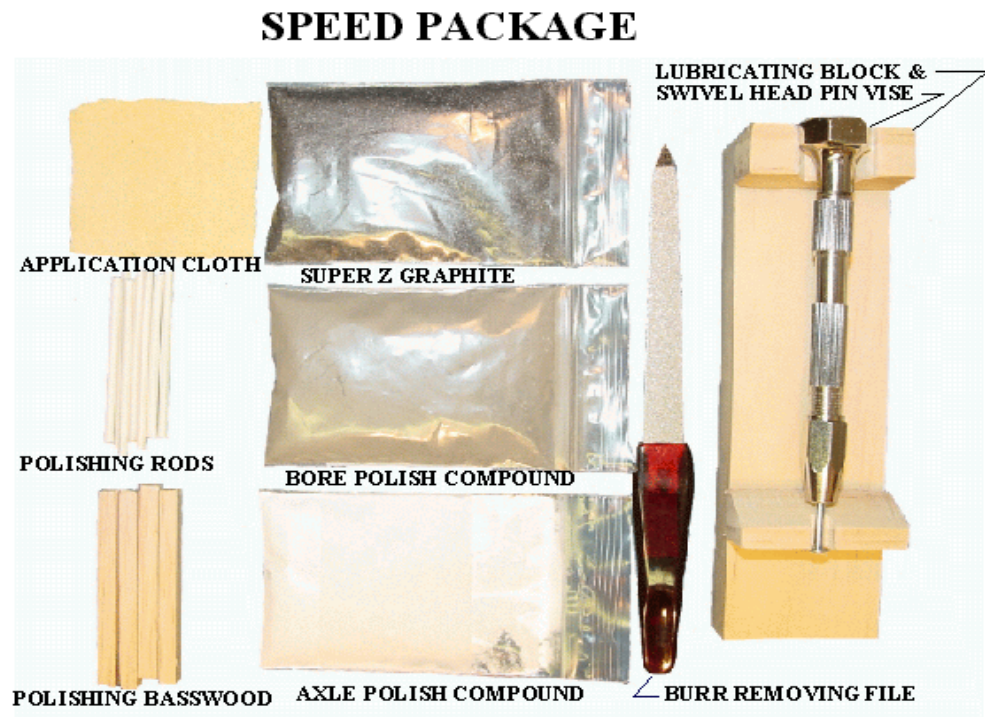


Figure 1A - Materials in the Speed Package

● The Grab Bag materials are given free with an order of the Complete, Basic, or Speed Packages. They are not that expensive, but having them handy as you polish and lube your wheels/axles can save you a few trips to a hobby store or Wal-Mart. As you go through this lubrication lecture, the items in **Fig. 1B** from the Grab Bag will be apparent in the photos.

1. Two sample cups for holding alcohol or Super Z Graphite.
2. Small container with lid for holding bore polish mixture.
3. Eye dropper for adding water to bore polish mixture in 2. Above.
4. Small paint brush for painting bore polish onto the white cardboard shafts already provided in the bore polish package.
5. 800 grit very fine emery paper for first axle polish.
6. Heavy cotton twine with twisted brass wire for threading string through wheel bore hole for cleaning. Also extra twine for axle cleaning.
7. Mini dowels, 3/32" inch, for use in axle holes as explained in Car Construction Lecture 15.
8. Chamois leather strip for final axle polishing
9. Brass spatula for dipping out Super Z Graphite and putting in wheel bore hole.

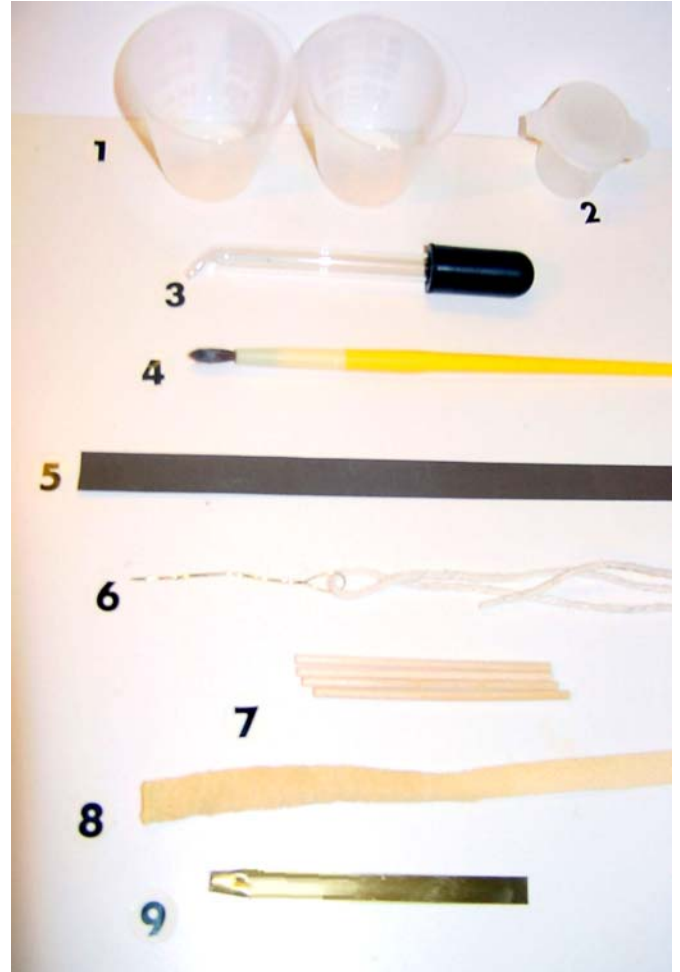


Figure 1B - Grab Bag Contents.

Note: In the bore polish package there are 4 cardboard shafts which should polish up to 10 wheel bores. In the Super Z Graphite package there is one cardboard shaft which can be used many times for adding a graphite coating to the wheel bore surface.



2. Axle Burrs_30X

- Below in **Fig. 2** is a magnified view (about 30X) of an axle nail showing one of the stamp marks right under the nail head. There are two of these on opposite sides. They need to be filed down as shown in the next topic below.
- There are also 3 marks on the shaft made during stamping that show up as ridges. These can be smoothed OK during polishing when the 800 Emery strip is applied. It is a good idea anyway to turn them to the top during axle installation and they will for sure not affect performance since only the axle bottom rests on the bottom of the wheel bore hole.

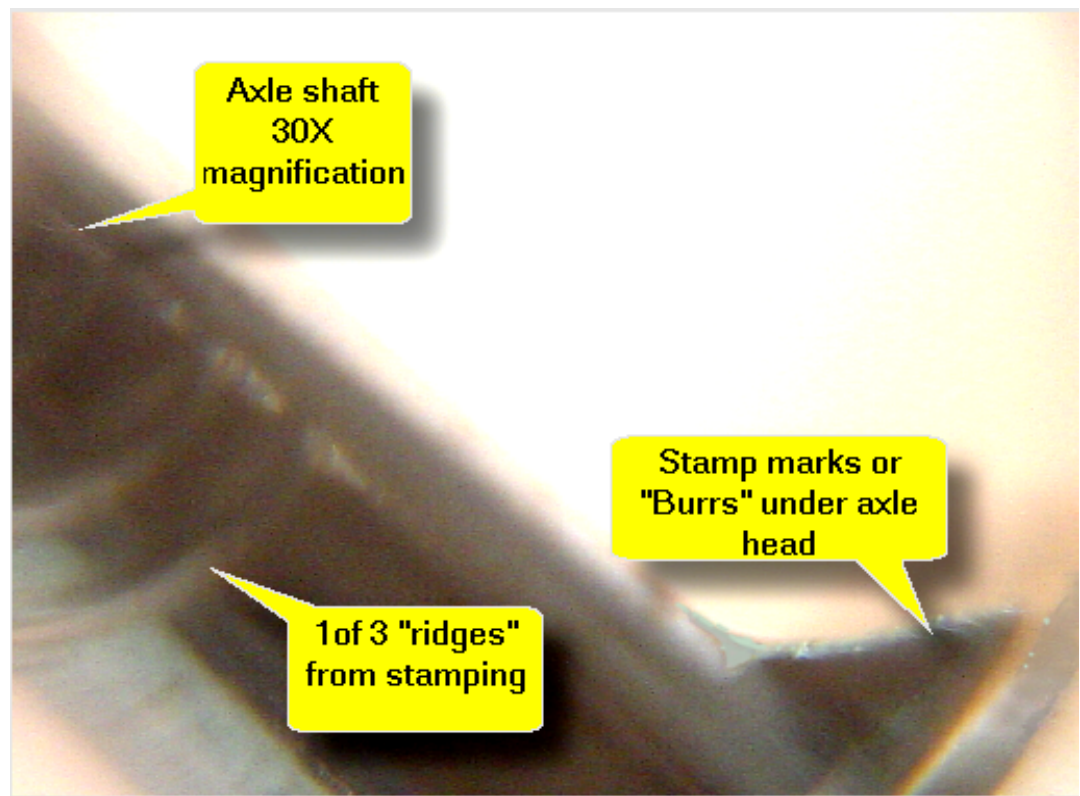


Figure 2 - Magnified view of an axle from a BSA kit showing



3. Axle Tip Smoothing

- In **Fig. 3** you can see 4 places where the chisel point stamping during manufacture raised opposite sharp edges are farther apart (about 0.093") than the shaft diameter itself (which is about 0.089"), and can get close to the bore diameter (about 0.094 to 0.095"). Thus the act of inserting an axle through the bore could damage the bore surface.
- File down these sharp parts of the axle shaft. The sapphire file will remove these sharp edges with just a few swipes. Examine results with a magnifying glass.

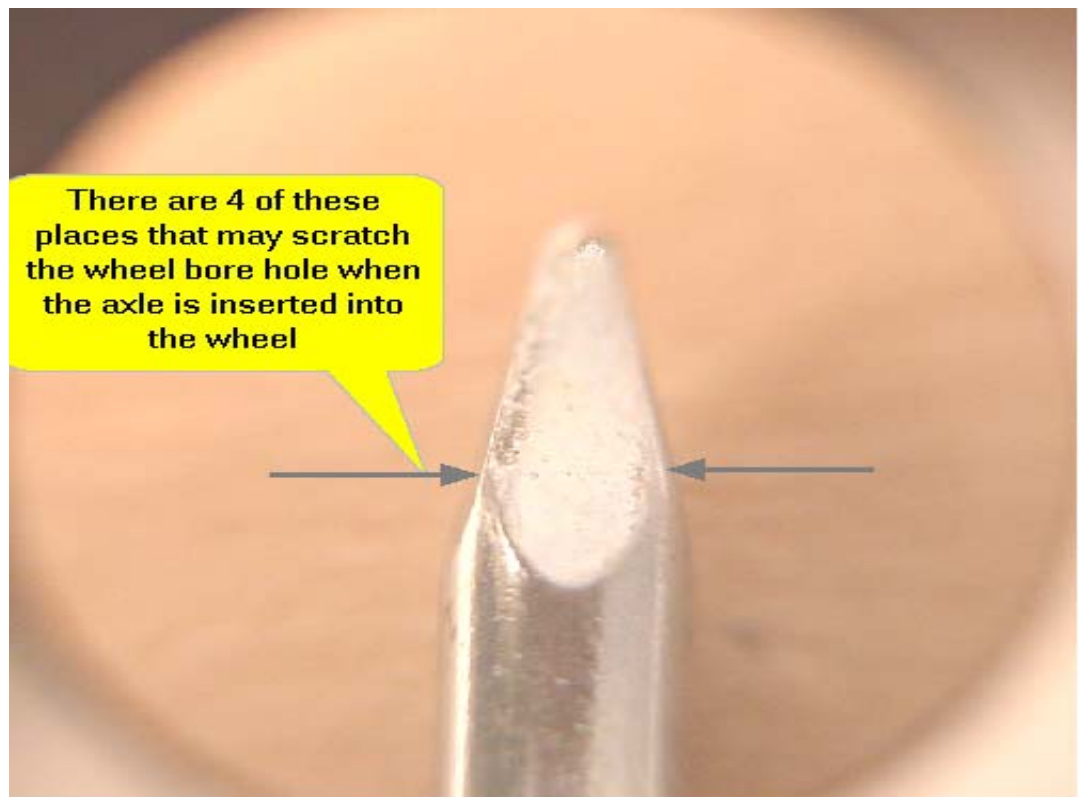


Figure 3 - Magnified view of an axle from a BSA kit showing the sharp raised edges that may scratch the inner wheel bore surface.



4. File Under Head

- Below we see the filing down (deburring) of the stamp marks just under the head. The inside of the head must be flat and smooth. The file provided in the Speed Kit contains alundum abrasive and is very effective.
- Instead of rotating the axle by hand, it could be chucked in a electric drill or drill press and deburred at a low rotation speed of 300 to 400 rpm. This is really not necessary as just a few swipes with the alundum (sapphire) grit file will remove the burrs nicely.
- Don't scratch the axle shaft to the right of the file as shown below in **Fig 4**.

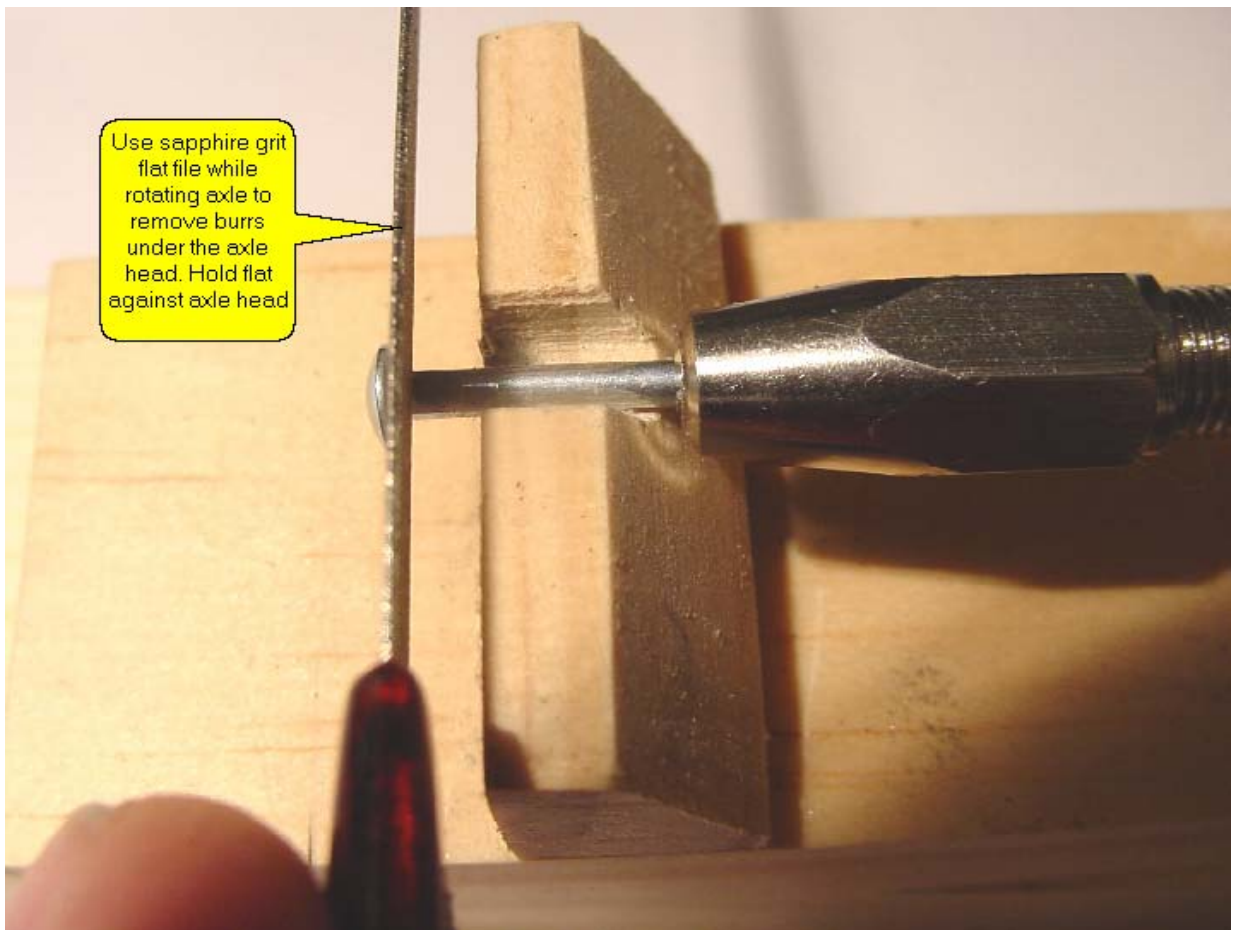


Figure 4 - Magnified view of an axle in the swivel head pin vise placed on the polishing block while filing down the burrs underneath the axle head.



5. Axle Polish 1

- Rotate the axle for polishing by chucking in an electric drill and running at a medium rotation speed.
- The drill should be clamped horizontally to a table top or other level surface.
- Apply the 4/0 emery paper strip (item 5 in the [Grab Bag](#)) for approx. 15 seconds to the shaft as in **Fig. 5**. Then use a basswood block, like the one shown with alumina powder on it here, to force the emery paper flat against the underside of the axle head to smooth down the area, especially file marks from the previous deburring. Do not use fine sandpaper, even 600 grit will scratch the axle surface.
- Only polish the axle shaft part where the wheel bore will run, usually only the ½" just next to the head. The part of the axle that goes into the body next to the point side does not need to be polished.
- Do not worry if the axle is not perfectly round. Improved performance by stamping an axle in a special tool to try to make it more rounded is an old wives' tale. Even an oval cross section will work just fine. See [Lecture 4](#) for proof.

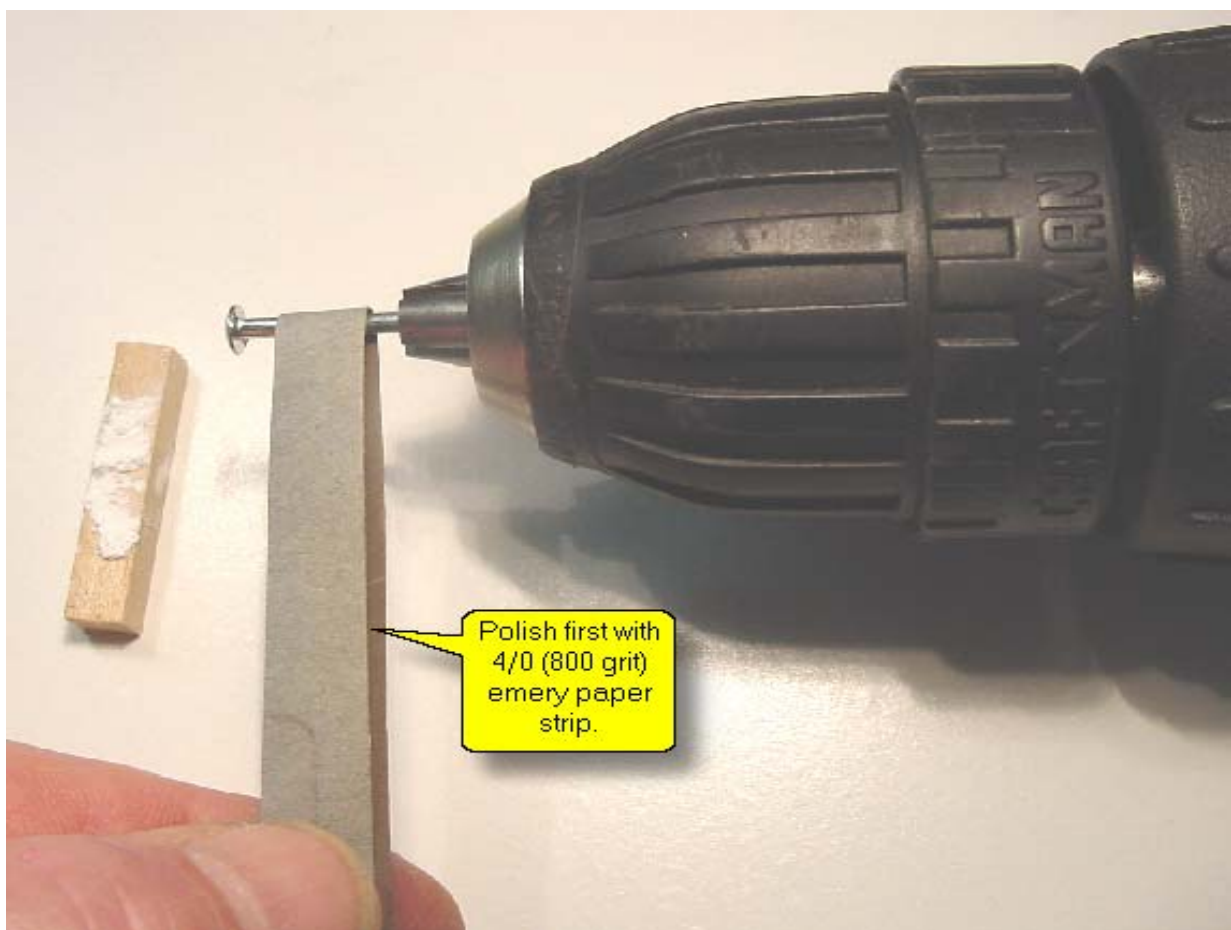


Figure 5 - An electric drill being used to rotate the axle for polishing shown here with the emery paper strip.



6. Axle Polish 2

- Next make a small pile of alundum (also known as alumina or chemically as aluminum oxide which in unground solid form is the semi-precious stone called sapphire) axle polishing compound on top of a basswood square dowel. These small wooden pieces are in the package with the aluminum oxide bag.
- As in **Fig. 6**, rub with mild pressure along the axle shaft and underneath the head for about 15 seconds.
- Caution - Do not rub too hard or excess metal may be removed from the axle surface. If the white powder begins to darken, too much metal has been removed and the axle surface itself may begin to turn dark. The axle coating is zinc which, although not as hard as some metals like nickel and chromium, will nevertheless take on a reasonably good polish.

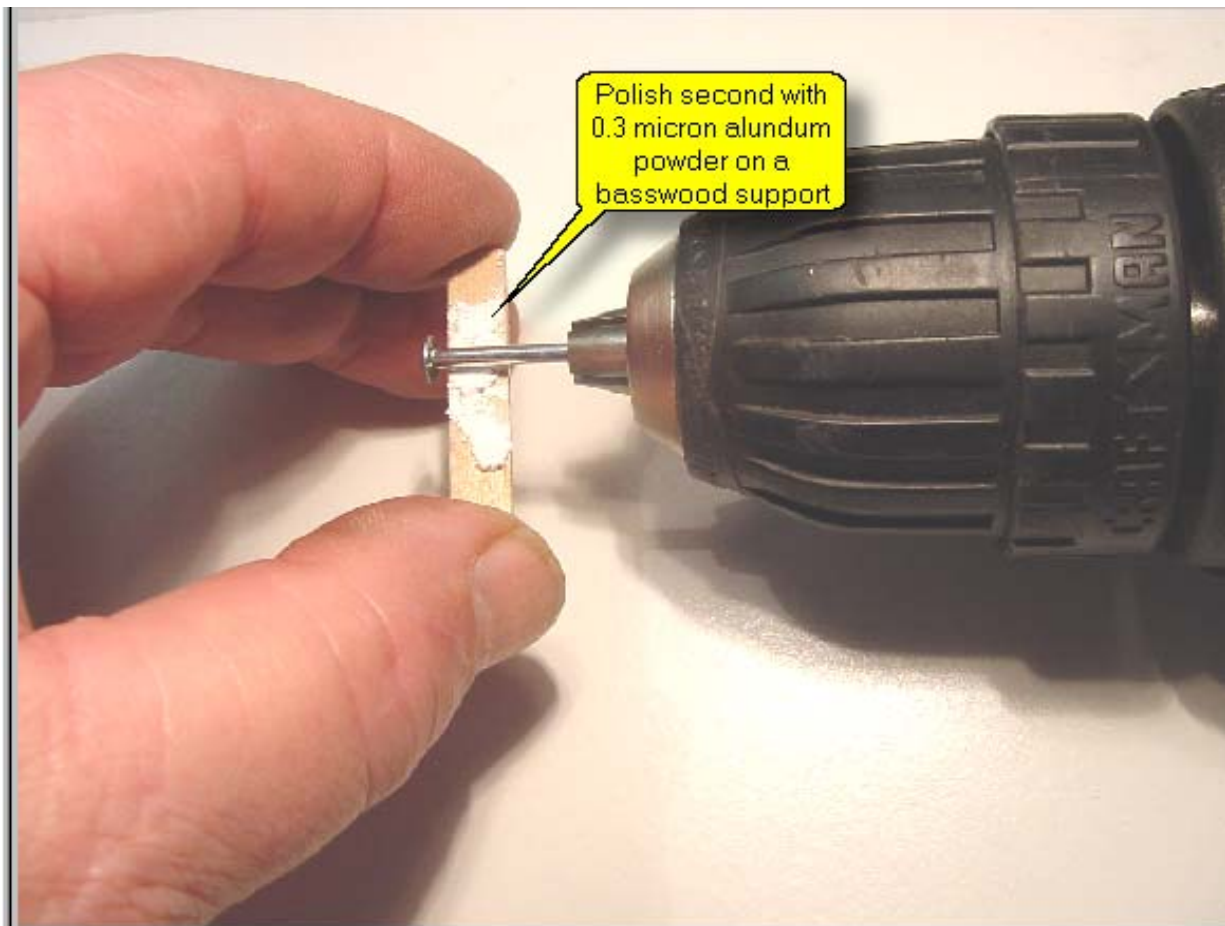


Figure 6 - Applying the aluminum oxide polishing powder. This is a common powder also used to polish precious and semi-precious stones.



7. Axle Polish 2A

- Here in **Fig. 8** is shown the dark material that is composed of fine microscopic metal particles from the axle shaft surface. As indicated in the photograph, if too much metal is polished off, and too much pressure is applied, the metal particles could become embedded in the surface itself, and thus the axle surface itself will start to turn dark. This should be avoided as it will not provide a smooth continuous metal surface for forming a good monomolecular (very thin) film of graphite.
- An application of graphite (as shown later under **Item 15**) is usually done after 4 or 5 trips down the track. After perhaps 3 or 4 applications of graphite to an axle (12 to 20 runs), the graphite film will become too thick for low friction. The axle should then be repolished as shown here. When the aluminum oxide powder is applied to such a graphited axle surface, you may see a thin partial cylinder of graphite flake off the surface. After polishing and re-graphiting, the original low friction behavior should be regained.

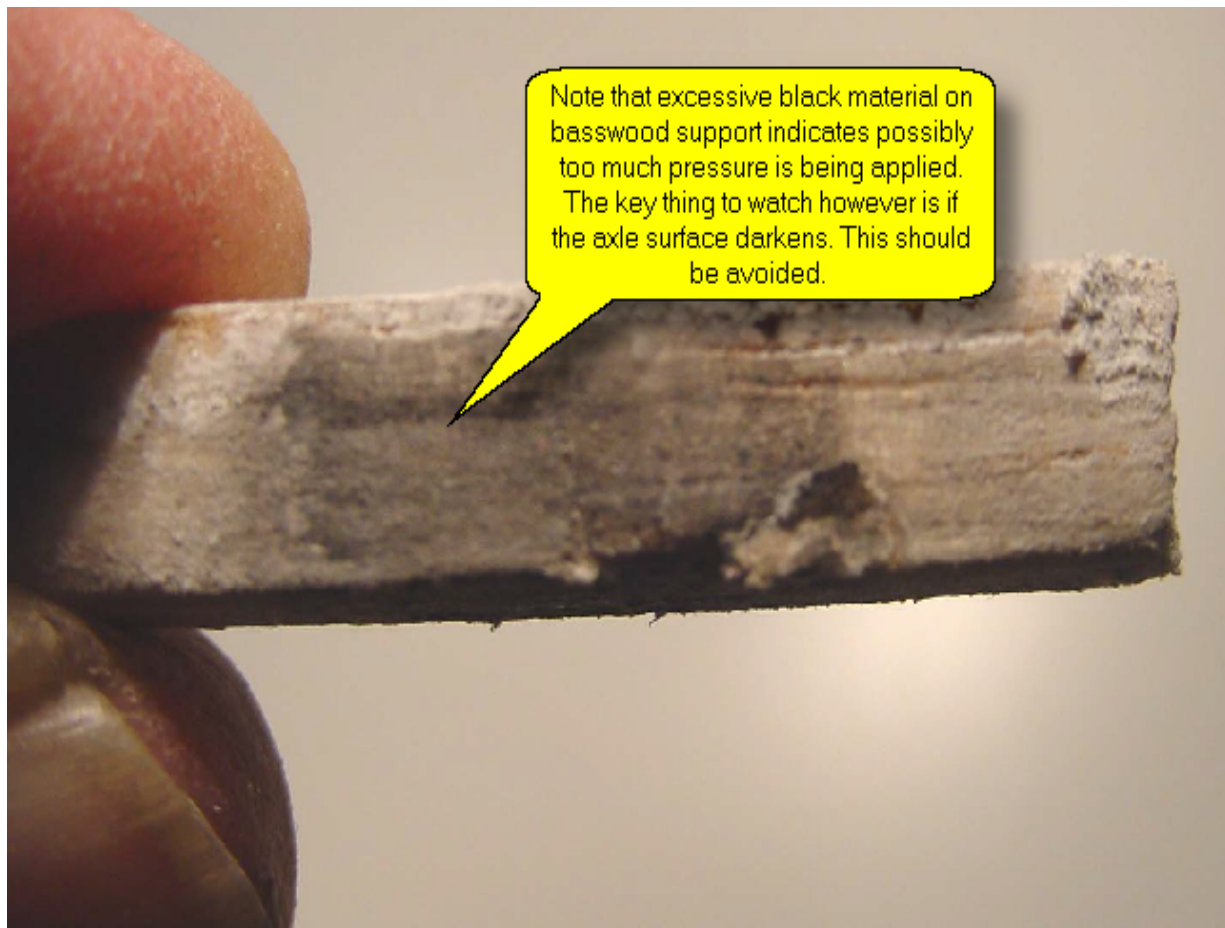


Figure 7 - *Showing the dark material mixed with the alumina powder during axle polishing.*



8. Axle Polish 3

- After the alundum polishing, during rotation clean the axle by pulling fairly hard with a clean cotton heavy string until dark material is no longer rubbed off the axle surface.
- The twine, seen in **Fig. 8**, is provided in the [Grab Bag](#). If you need more, it is usually stocked at a store like Wal-Mart.

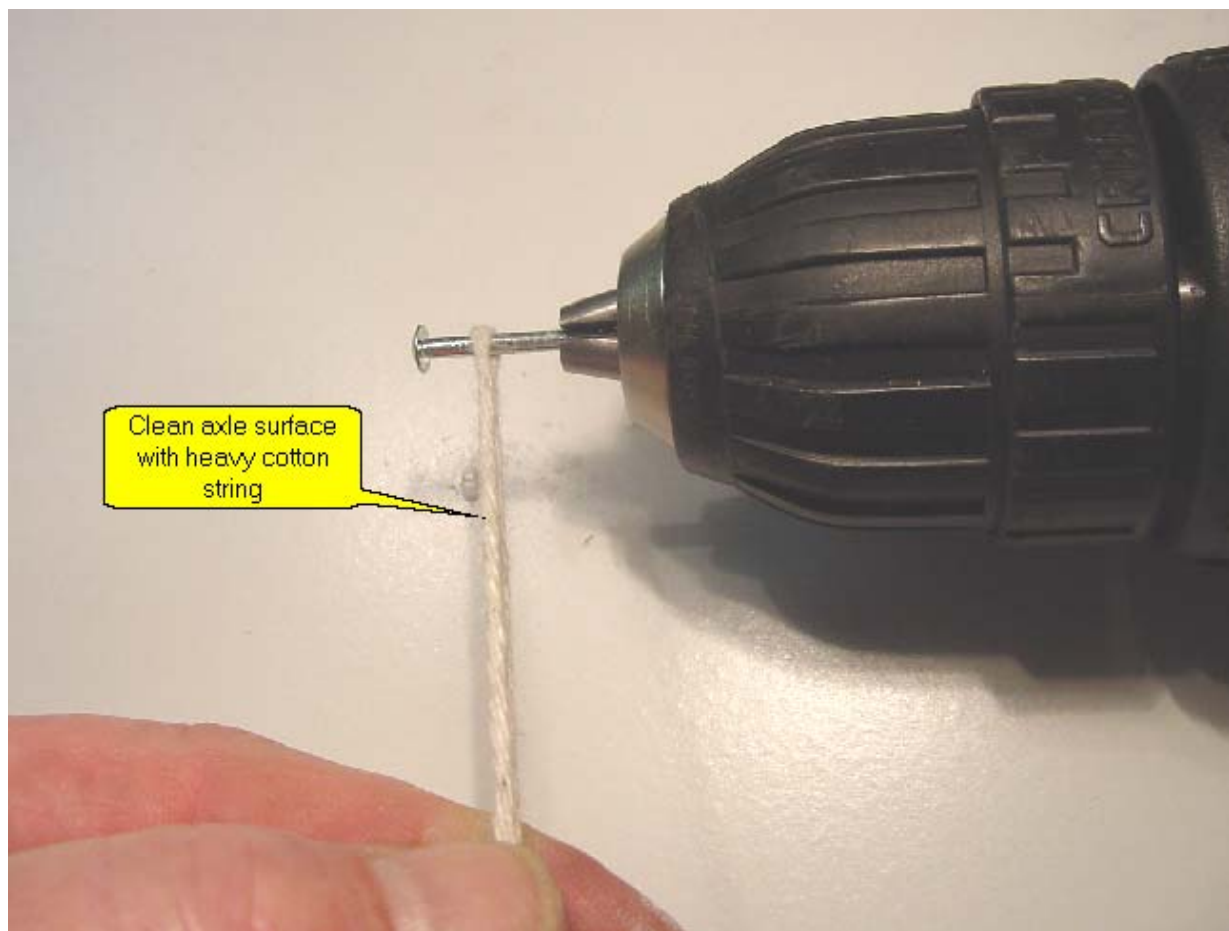


Figure 8 - *Applying cotton twine to clean residual alumina off axle surface.*



9. Axle Polish 4

- The final polish is done with a leather (actually deer hide rather than cow hide) strip. Stropping with leather is always the final step in metal surface honing (that's why in all the old barber shops you would sometimes see the barber vigorously stroking his straight edge razor on a leather strip). The axle shaft is clean when no dark spots appear from spinning the axle on the chamois strip. Do not apply excessive pressure to the strip or let it burn from friction.
- The chamois strip, shown in **Fig. 9**, is item 8 in the [Grab Bag](#).

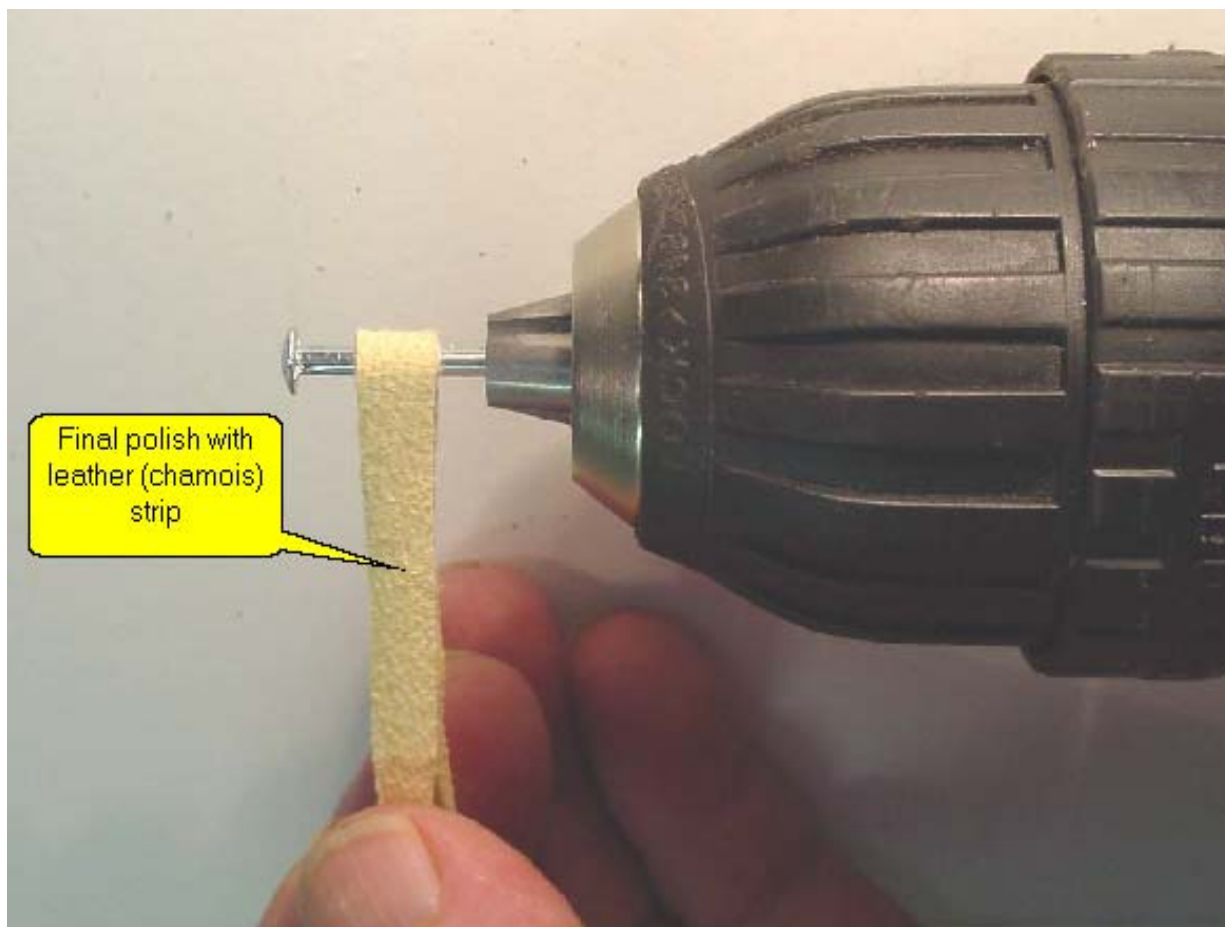


Figure 9 - Honing the axle surface with the chamois strip from the Grab Bag..



10. Axle in Alcohol

- After the final axle polish just finished, drop the nail in a 91% isopropyl alcohol (IPA or rubbing alcohol) bath until it is ready for graphite application (**Fig. 10**). This is to prevent oxygen in the air from forming an oxide film on the axle surface. Also, this helps ensure that all alumina particles have been rinsed off the axle surface. When we get to polishing, we want the graphite to be rubbed onto a fresh virgin metal surface that is not contaminated with chemically attached oxygen. (Note that 70% IPA has 30% water which could contain dissolved oxygen. So use 91% IPA from your local drug store)
- The alumina particle size is $1/3$ micron ($1 \text{ micron} = 1 \text{ millionth of a meter}$). But the thickness of a monomolecular film of graphite is 10,000 times smaller than $1/3$ micron. If we expect to have effective “roller bearing” action from surface molecules on top of the graphite film, and these “roller bearing” molecules are also 10,000 times smaller than an alumina particle, you can see how a few alumina particles can mess things up. Its like you were surfing with a surfboard on a level gym floor covered with a layer of marbles ($1/3$ - inch diameter) and you encountered a large jagged rock like 250 feet high. So we really need a clean axle surface free of powder.



Figure 10 - Keep axle in a small cup of 91% IPA after polishing is complete.



11. Axle Lube Apparatus

- Next we should prepare our equipment for axle lubrication as in **Figure 11**.
- Do not use an electric motor driven drill to spin the axle while rubbing on the graphite. This rotation is much too fast and can rub off more graphite than is applied. Slow hand application is required for best results.
- All items below are from the speed package except the brass spatula which is item 9 from the [Grab Bag](#).

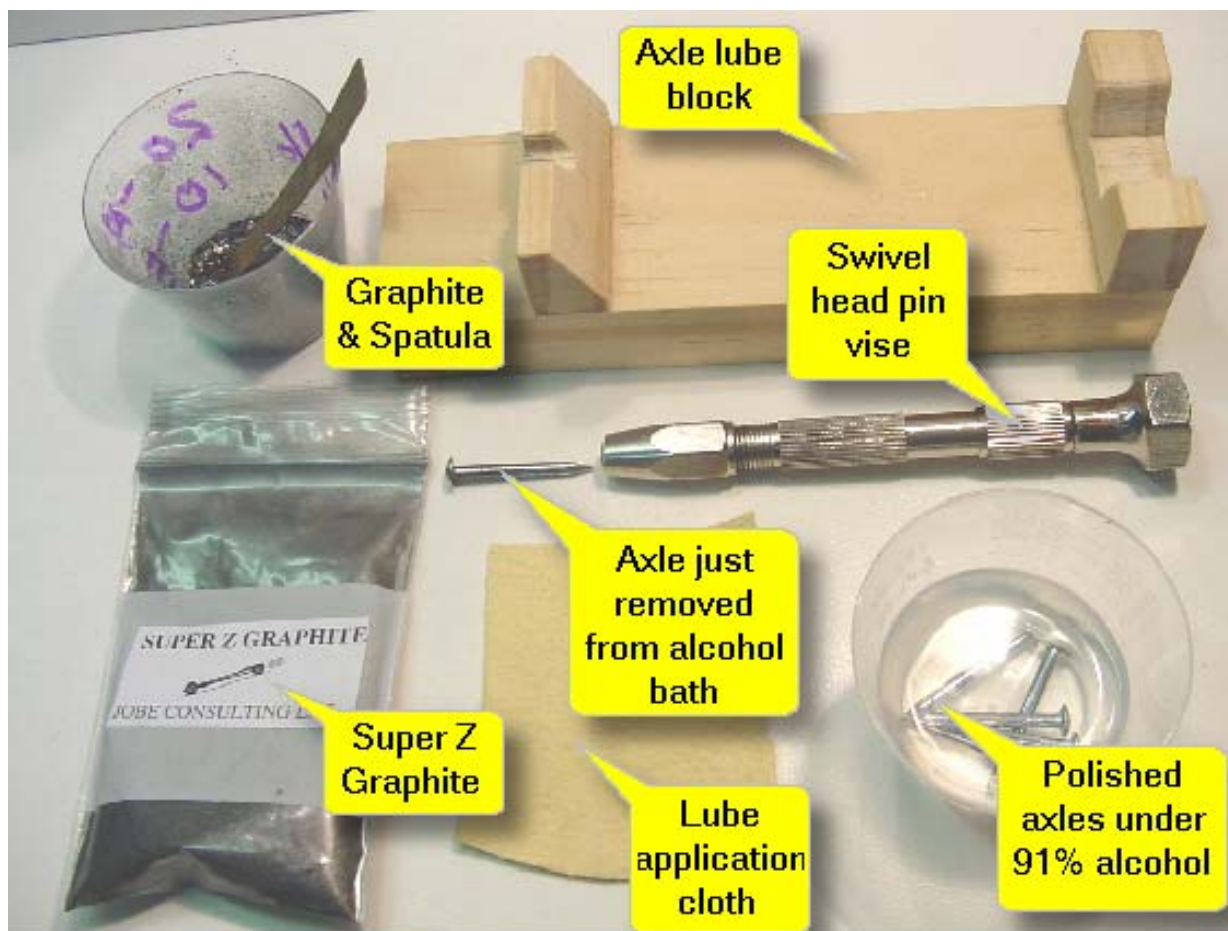


Figure 11 - Setting up the pieces for applying graphite to the axle.



12. Axle Lube on Cloth

- First make a small pile of Super Z graphite on the application cloth as in **Figure 12**.
- Then remove an axle from the alcohol bath and chuck it in the swivel head pin vise with about 1/2" of shaft protruding. You don't need to tighten the hex chuck with a wrench like when you used a drill bit rather than an axle.
- The first thing you notice about the Super Z graphite is how large the flakes are. This is a special high purity (99.9% carbon) virgin flake imported from China. The larger the flake size, the less the edge area compared to the flake surface area. It turns out that the edges adsorb oxygen out of the air so strongly that these molecules can't roll around freely and act more like glue than like tiny roller bearings. However the oxygen molecules from the air that stick slightly to the surface, not the edges, of the flake are fairly mobile and can roll around freely providing lubrication. If you keep grinding these large flakes down and create more edges, the the graphite really starts to lose lubricating ability. At the extreme end of grinding the graphite smaller, you end up with activated carbon, which is almost all sharp edges. And as you know, such activated carbon will suck up and hold firmly all sorts of molecules, and is thus used in gas masks and water purification systems. But such fine carbon is really absolutely sticky and as mentioned acts more like a glue than a lubricant. So the larger the flake, the better the lubrication.

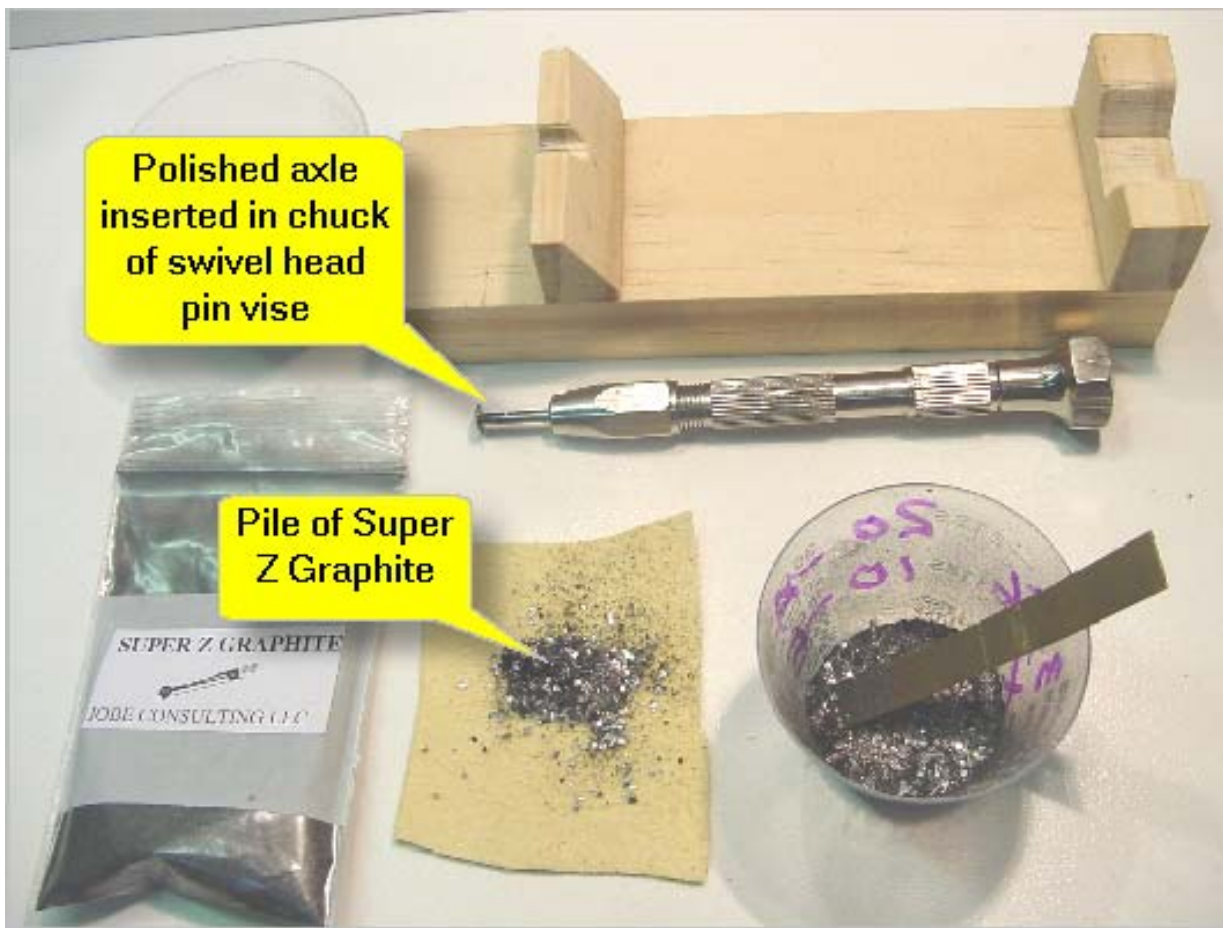


Figure 12 - Chuck axle in swivel-head pin vise and put Super Z graphite on the application cloth..



13. Axle Super Z (20X)

- Lay the application cloth and graphite on the lube block over the notch and then bury the axle shaft in the Super Z in the notch as shown in **Fig. 13**.

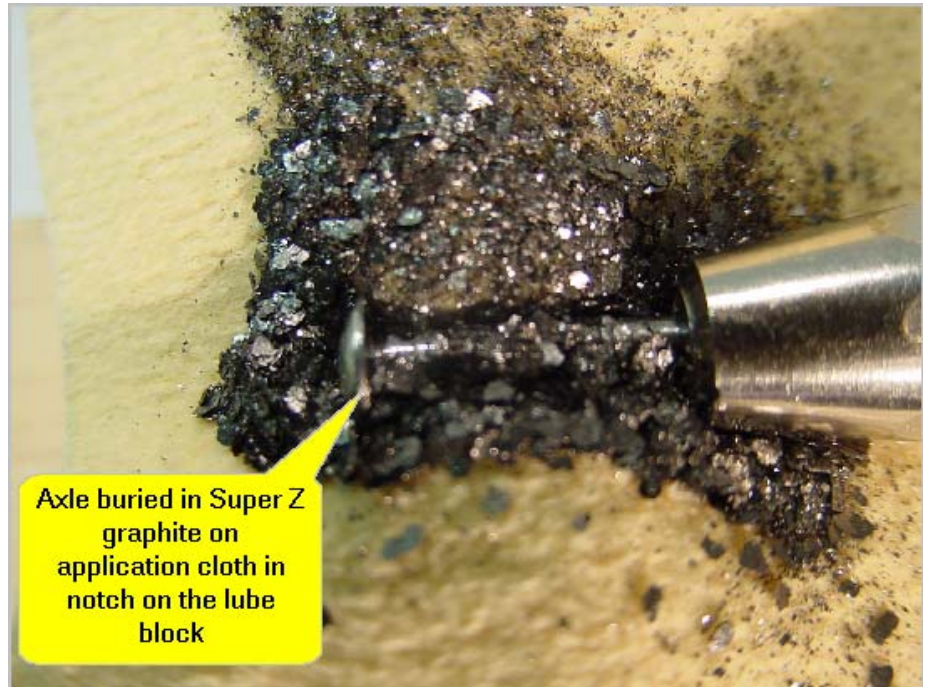


Figure 13 - Chuck axle in swivel-head pin vise and put Super Z graphite on the application cloth..



14. Axle Roll

- Then lay the fingers of the right hand on top of the swivel head pin vise and roll briskly back and forth while pressing down as in **Fig. 14**.
- What this is doing is putting a very thin invisible coat of graphite molecules on the axle surface.

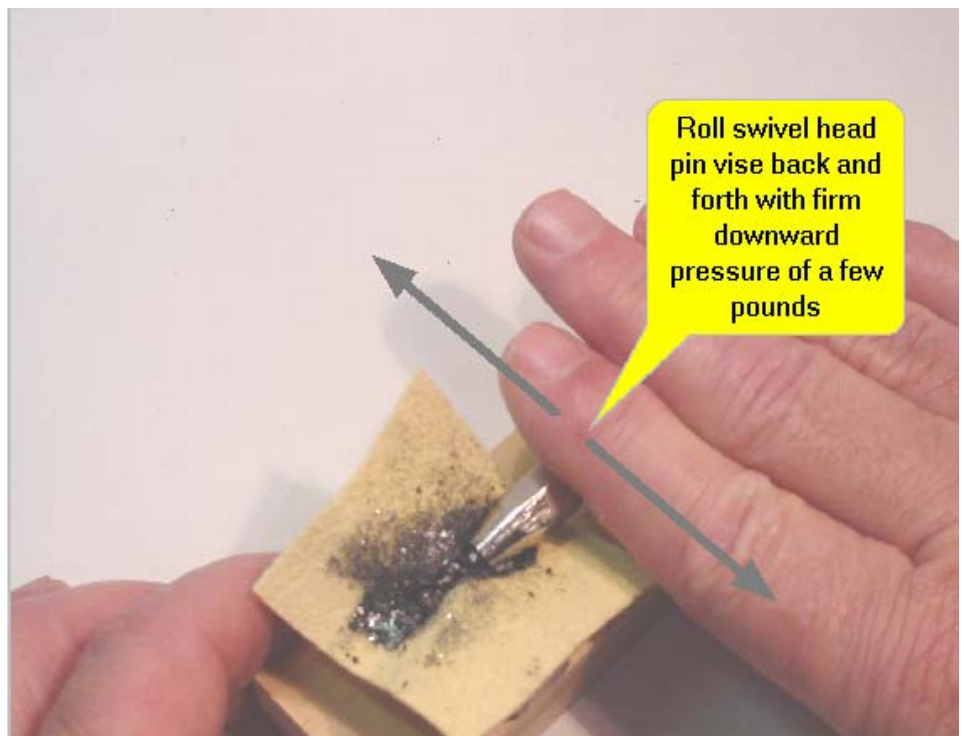


Figure 14 - Rub Super Z graphite on the axle.

- Axle lubrication is aimed at creating a monomolecular film of high purity graphite on the axle surface. Together with a similar film on the inside wheel bore, a very low coefficient of friction may be obtained. The axle polishing is very important because the metal surface must be very clean and oxide free to accept the Super Z graphite properly.
- As in the movie clip, when the axle is rotated on the Super Z graphite, press down firmly with the palm and fingers as the barrel of the pin vise is spun by moving the hand back and forth. Do this procedure for at least 30 seconds for each axle.
- Lubricate all four axles but do not get them wet later, even with alcohol. And do not touch the lubricated shafts. Set them aside in a safe place until installation into the wheel and body..
- ● For review, if you have a movie viewer, below you can see a short video clip of the axle lube steps we just went through.



[Click Left on Image to Play](#)

- This completes the **Lecture 16** on axle polishing and lubrication with graphite. For even less high speed friction, Super Z Oil may be applied after the Super Z Graphite procedure that was just finished. See [Lecture 13](#). There is a definite speed advantage if you start with nickel plated axles. These axles, normally blunt, can be sharpened on the end by grinding just like kit axles. Lecture 3 shows photos and details. The high quality nickel plated axles are available from Winderby.com.