3rd Edition

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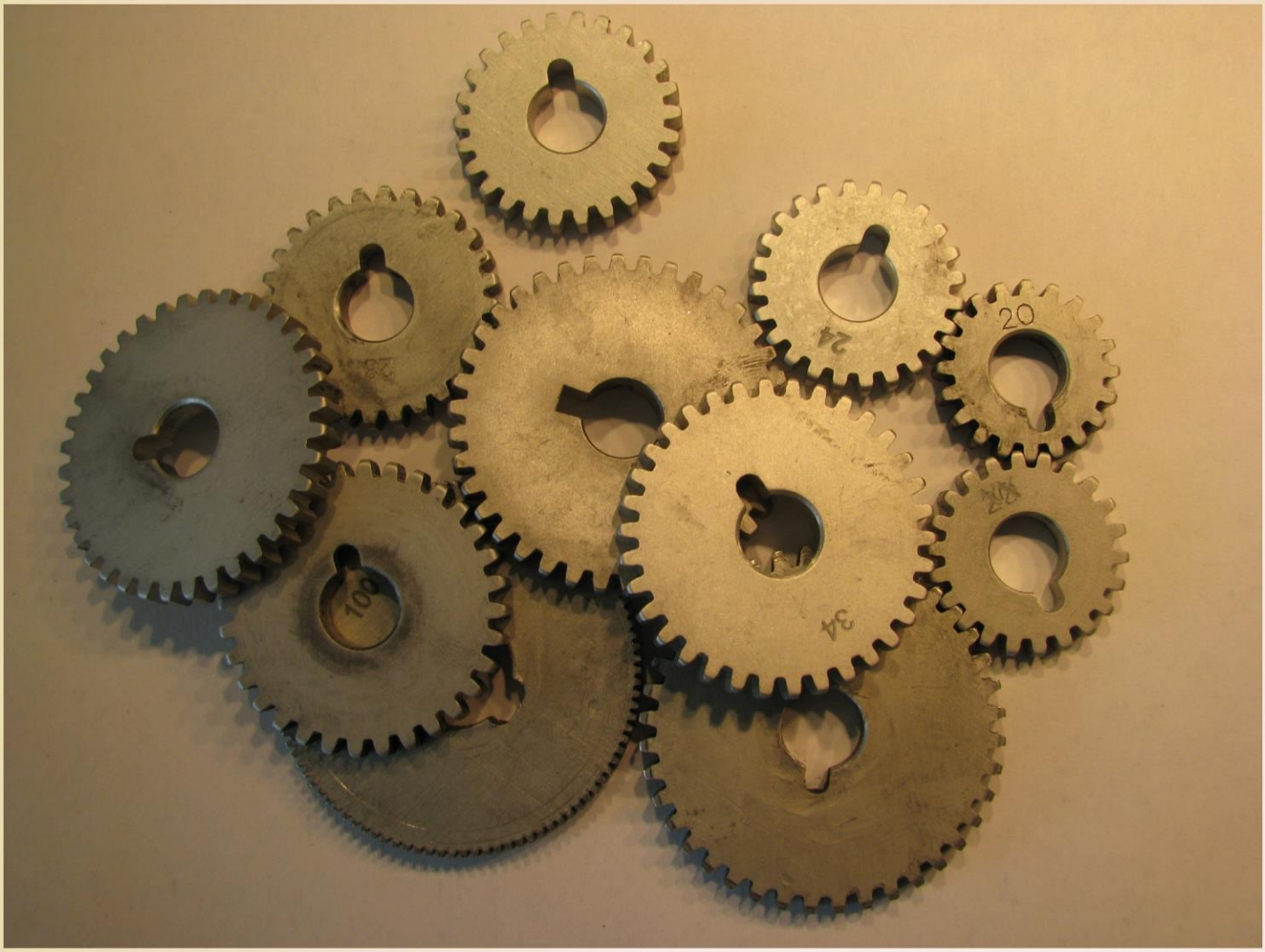
Thread Cutting On a Lathe

Safely Working with Benchtop Machines - Booklet I

Sherline / UNIMAT / China lathes



U. Burghaus

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Featuring the Sherline / UNIMAT Lathes
Booklet 1 – Thread Cutting on a Lathe
3rd Edition

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USA

Disclaimer

The book has been written carefully and all projects and procedures have been tested thoroughly. However, as always, the author and publisher cannot guarantee that the procedures are perfect and without any mistakes. In addition, it is impossible to predict and prevent all the possible problems someone may possibly run into when working with a lathe. **Using a power tool can be dangerous and the proper use is the responsibility of the one who is using the tool. Neither the author nor publisher shall be liable for damage arising herefrom.** If you are not perfectly comfortable with working with power tools, then don't do it! In this case, take a metal working class rather than following a do-it-yourself outline. Or, find a different hobby. I cannot jump in if you make a mistake which results in harming yourself or damaging the tools you use. Don't use half broken or damaged tools, perhaps purchased for cheap at a secondhand store or who knows where. This would be overwhelming to handle in the beginning. Thoughtful work will be your responsibility.

The author makes no representations or warranties with respect to the accuracy or completeness of the contents.

The author is not a professional machinist or engineer. He is a hobby machinist as you probably are. In fact, the author holds a PhD in physics and teaches physical chemistry at a college. Therefore, no information provided herein represents professional advice or best practices in machining. All information is provided to help hobbyists and other non-professionals gain a better understanding of using a miniature benchtop (tabletop) lathe for hobby type work.

This book features in particular the Sherline and UNIMAT lathes and accessories. However, none of the statements or procedures may coincide with Sherline Inc.'s or Enco'S opinion or interests. In addition, some information about a typical "China import lathe" are included.

The author is not an employee of, or agent for any of the vendors referenced in the text and does not sell or represent any of the third party products discussed.

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Table of Contents

Generic list of pictograms used LatheCity books

→

Object of a given Chapter/brief introduction. Start of a project. The Chapter numbers are given in the content list.

Internet Movie

Internet addresses of potentially useful sites. However, web sites may be infected by computer viruses. Use them at your own risk.

STOP

Safety notes. It is not my intention to bother you, and this book is meant for adults with advanced machining skills, not for children. Therefore, whether you read the safety notes or not is your decision. However, don't blame me if you do not take the few minutes to do this and end up in the hospital. All procedures are performed at your own risk.

E

Engineering terms or topics are described here. You may skip these if you are only interested in the operation of the tool. Remember, though, that knowledge also always provides protection (safety). If you know what you're doing... right.

P_E P_A

Projects: engineering/artwork projects

L/M

Comparison of lathe and mill operations. Most of us started with lathe work, that is, these comparisons can help gaining a deeper understanding (even of lathe work).

Σ

Summary of the Chapters. See content list for Chapter numbers.

Tip: ....

Tips and tricks.

Example ….

Examples

The idea of using pictograms is to allow for fast browsing as well as making the book more appealing to read. Straight text is hard to digest and boring after a while.

Given here is a generic list of most all pictograms used in the LatheCity books. Not all of these may have been used in every book.

1. First things first – required safety notes – how to work safely?

Fig. 1.1: Safety glasses. Use versions with ANSI Z87 label. ASNI is short for American National Standards Institute. Chemistry goggles, as also shown here, are not recommended for metal work, since they may block the vision too much

Please note that **initially you may be at a higher risk** than folks doing this for living since you will be on your own. Typically hobbyists do not attend safety classes or safety briefings. Therefore, at least read the following.

When it comes to safety the "buddy system" is essential. Actually, nobody should work alone with motor tools. This is obviously difficult to organize for a hobbyist. Therefore, you are at a higher risk and have to manage that risk yourself.

However, everyone can learn how to work safely with motor tools. Otherwise I would not offer this type of textbook. In one of the safety briefings I attended, the instructor, a professional machinist, outlined almost proudly how many accidents he had throughout his career ... well ... I still have all my fingers and would like to keep it that way. What about you? Therefore, READ the following general safety notes and hints about how to prepare yourself before switching on your lathe. **PLEASE, take this seriously it only takes 20 minutes.**

Specific safety notes for every procedure are part of every subChapter. Naturally the notes in the beginning are more extensive and become shorter towards the end of the book since I assume that you learn safe working practice along with the operation of your motor tools. (In addition, safety

concerns are often similar for different procedures.) This is one of the main goals and part of the title of this hobby machinist book series: "Safe working ..."

Working at a public university myself, I have to participate regularly in safety classes and I am at present (2011) in fact the safety liaison for our chemistry department. However, again I am a hobbyist myself when it comes to metal work. I still have all 10 fingers and two eyes, but there is no legal guarantee that the following notes are complete or even correct. **Read the disclaimer note above.**

- **Use safety glasses** (see Fig. 4.1). Chemistry goggles, which are also shown here, have the disadvantage that they may block your vision too much which again can generate a safety hazard. You need comfortable glasses and perfect vision. You need to look around. Glasses approved for metal would need to be closed all around the face (at the top, sides, and bottom) and in the U.S. they have the label **ANSI Z87** on them. Some versions additionally block UV light which was interesting to me, since I also work with glass pieces, using glue hardened by a UV lamp. In any case, a UV filter is better for our eyes, I believe.
- At most safety briefings you may come across the term "**situation awareness**", as a general strategy to reduce risks. Knocking over a leg of a storage rack when walking through a metal shop, which carries 500 pounds of steel, would not be it. Heavy footwear is unfortunately very uncommon except in an industrial setting. (We also don't want to overdo it in a hobby shop.)
- Let someone know that you are working in your garage and/or basement. Why? First, you are setting up "a buddy system" in doing so. Second, you are making sure that nobody disturbs you at a critical moment, startling you from behind.

- Have a working phone in reach. Check if your cell phone is working properly in your basement. Where is the closest hospital/emergency room? Emergency number in the U.S. is? Right, 911. At some locations the number may be different.

- ☐ **I did read the safety notes.**
- ☐ **I did understand them.**
- ☐ **I did read and accept the disclaimer statement.**

- Make your shop kid safe. Talk to your kids about the risks. Make sure that they do not sneak around a corner and surprise you when the lathe is running, etc. They often don't see the difference between "playing" and "safe working practices."
- Read the application notes and manuals that came with the tools and/or accessories before starting to use them. Learn the applications and limitations as well as the specific potential hazards of every tool.
- Don't use a tool for a purpose it was not designed for.
- Don't modify a tool yourself.
- Don't push a tool beyond the limits it was designed for. A mini metal lathe/mill is designed to work on small metal stock.
- Don't modify the electrical connections of your tools. Electrically ground all tools. If a tool is equipped a with three-prong plug, then it should be plugged into a three-hole receptacle. If an adapter is used to accommodate a two-prong receptacle, the adapter wire must be attached to a ground connection.
- Don't remove safety guards. Keep guards in working order. (I could tell you stories where a student did exactly that to "save time" and lost several fingers in the process. This is not a joke, but I will spare you the details. Fortunately, I was not involved in this accident, in this case, at a chemistry lab abroad ...) Don't remove safety guards. However, the little safety shields that sometimes come with a lathe provide only very limited protection. Use always goggles, in any case.
- Make it a habit of checking to see that keys and adjusting wrenches are removed from the chuck before turning on any machine. In the case of a

lathe, turn the spindle by hand before turning on the lathe making sure that it runs freely. Don't underestimate the power and torque generated even by a benchtop lathe. A key left behind in a chuck can easily fly off traveling at a significant speed for 10 ft (3 meters) or more. Full size lathes used to train students professionally are often equipped with **spring lock chuck keys (self-ejecting keys)**. These pop out of the chuck when not pushed down, i.e., it's impossible to leave them in the chuck unintentionally. Typically the chuck key would hit the instructor rather than the student running the lathe which may explain why this feature is eagerly installed in training metal shops. (Don't put your nose over the spindle anyhow.) In any case, just kidding I do like all instructors, safety first. Unfortunately, this type of system is typically not available for benchtop lathes, as far as I know.

- Cluttered work areas and benches are a safety hazard. This is indeed true.
- Do not use power tools in damp or wet locations. This can be an issue for garage or basement shops. Solve the problem if it exists at your location.
- Keep work area well illuminated. This is extremely important for safety issues and any proper work. Do you need new glasses?
- All visitors should be kept at a safe distance from the work area.
- Again make your workshop kid proof. Use padlocks, master switches, remove starter keys. This is of particular concern for hobby work, correct (?) I would in principle encourage you to awaken the interests of young adults for practical and creative work. Fortunately, perhaps in this case, many of them prefer to play dull computer games instead. However, teaching young adults to work with metal tools is particularly difficult and a major safety hazard for everyone involved in this process. At least don't do this in the very beginning. You must be very confident yourself, first. Make sure that they are old enough and have no access to the tools alone.

- Again, do not force tools or attachments to do a job for which they were not designed. Use the proper tool for the job.
- Avoid loose clothing, necklaces, gloves, or jewelry that could become caught in moving parts. We all know this, but taking care of it every day is another thing.
- By the same token, fluffy cloth appears to attract small cut off metal pieces like a magnet. They stick deep in the fabric and can scratch you fingers and skin.
- Wear protective head gear to keep long hair styles away from moving parts! If you would like to see a sad story in this regard, go to:

  Internet

  http://blog.makezine.com/archive/2011/04/yale-student-killed-in-lathe-accident.html
  http://www.nature.com/nature/journal/v472/n7343/full/472259a.html

  It takes milliseconds to pull you into the running chuck if something gets caught in the chuck. A benchtop system is safer in this regard than a full size system, I guess, but … (A lathe running at 1600 RPM makes 26 RPsec or ~40 milli seconds - 0.040 sec - for one revolution.)
- Use safety glasses i.e. goggles designed for metal work. Yes, this is on the list more than once.
- Use a face or dust mask if cutting operation is dusty.

Fig. 1.2: Full face shield with plastic foil that need to be peeled off

- When using a metal grinder you will generate sparks. Use a full face shield and goggles for these operations. Make sure not to have lots of cardboard boxes, gas containers for you snow blower / lawnmower, paint, solvents, etc. in your basement or garage hobby shop. The sparks generated by grinders or metal saws can ignite a fire. It may start to burn long after you left the shop … Full face shields often have a plastic foil on

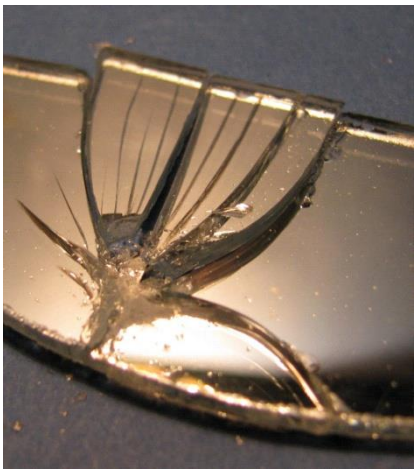
the shield which needs to be peeled off. Otherwise the shield may not be transparent (Fig. 4.2) – just a note in case you didn't realize. (I have seen students running around …)

- Use clamps or a vise to hold work. It is much safer than using your hand and frees both hands to operate the tool. This is more of an issue for the use of a drill press, milling machine, or saws than for a lathe, but it must be included here.
- Keep your proper footing and balance at all times. Wet floor? Cable? This is dangerous.
- Keep tools sharp and clean for best and safest performance. Follow instructions for lubrication and changing accessories.

This is a long list, but don't blame me if you did not read it and end up in a hospital – most likely on a weekend.

- Use only recommended accessories. Read the manual carefully and completely. Use of improper accessories may be hazardous.
- Unplug tool before servicing and when changing accessories such as blades, bits or cutters. Definitely.
- Make sure switch is "OFF" before plugging in a power cord. Double check.
- Again turn spindle by hand before switching the motor of the lathe on. This ensures that the work piece or chuck jaws will not hit the lathe bed, saddle or cross-slide, and also ensures that they clear the cutting tool.
- It is not recommended that the lathe/mill be used for grinding**.** The fine dust that results from the grinding operation is hard on bearings and other moving parts of your tool. For the same reason, if the lathe or any other precision tool is kept near an operating grinder, it should be kept covered when not in use. I do occasionally use a polishing sponge (safer than sandpaper) to polish pieces, but I don't overdo it.
- Make sure that all locking and driving attachments are tightened. However, also be careful not to over tighten these adjustments. They should be just tight enough. Over tightening may damage threads or warp parts, thereby reducing accuracy and effectiveness.

- Don't allow long stock pieces to stick out far in back of the spindle of the lathe. Long, thin stock that is unsupported and turned at high RPM can suddenly bend and loop around.
- **Wear proper safety glasses.** All folks working for a living in metal shops can unfortunately tell you stories such as this one: a piece of metal hit the backside of glasses (somehow) and the reflected piece hit the eye of the machinist. They had to pull the piece out of his eye in a hospital. This is not a joke. You need safety glasses specified for metal work, even if you wear optical glasses. You need glasses fully closed at the sides, the top, and bottom. Goggles that fit over optical glasses are often not very comfortable and restrict the vision. These are better than nothing, but you can purchase goggles with optical lenses. If you work every day in your shop, then invest the money to purchase really comfortable and safe glasses. Your eyes are worth the investment.



- This may sound as a talk to a teenage girl/boy, but ... you need proper eye protection before you switch on the lathe/mill for the first time. Safety glasses are perhaps the most important safety feature in a metal shop. Don't start without them with any work on a lathe/mill. Any home improvement store carries them.
- Don't work when you are tired. Rushing home, having a heavy dinner and a few beers, and then going down to the basement shop in your house … obviously not a good idea. Don't do it. Metal work requires your full attention, even if it is a hobby.
- You may realize that the fingers of the machinist are really close to the spindle when cutting certain shapes, in particular when you eventually polish pieces. The edges of the chuck are sharp and turn at perhaps 1800 RPM. It would cause very serious injuries when hitting the rotating chuck

with your fingertips. Sherline also offers a tool post for polishing (P/N 8976) which I did not, however, use myself. Polishing operations on the Sherline lathe are, by the way, not recommended by Sherline, mostly due to issues of metal dust which may end up in the motor controller box causing shorts. In addition, a dust mask is generally required for all sanding/polishing operations. Using a sanding sponge is somewhat safer than using sand paper for polishing since you can even touch the chuck with the sponge and the fingertips are still at an o.k. distance. Sanding sponges are available in any home improvement store.

- Mill cutters are not like lathe tools, they are indeed sharp. End mills are more like a knife or sharp saw blade. Thus, be careful. Recommended is typically not to touch mill cutters directly with your hands. Instead use a rag.
- Never leave a machine running while unattended.
- By the same token, if you experience a power failure switch off the machine (and/or set RPM to zero) since when power is restored machine may start up unintentionally. Considering the rather unstable power lines in the U.S. this does indeed happen.
- If you experience unexpected and/or unusual difficulties using the machine. Stop and get advice (call customer service etc.). Don't ignore difficulties, solve the problem.
- One last thing. Please be aware of that you will carry chips (small cut off metal pieces) with you all over your house. Don't ask how – chips stick to everything, somehow. Aluminum chips are rather soft and mostly "harmless", but steel chips are sharp as razor blades. Never clean up chips with your bare fingers, never.
- This kind of list can never be complete. Read the disclaimer statement.

Safety notes can also be found on various web sites, a few links are given here:

http://www.mini-lathe.com/Mini_lathe/lathe_safety.htm
http://www.zeraware.com/
http://www.americanmachinetools.com/how_to_use_a_lathe.htm
http://www.fricknet.com/lp/safety_posters.php?gclid=CPTW6ZfFhaYCFQTNKgodFQoIpA

Internet

Safety products can also be purchased on-line, for example, perhaps look at:

http://www.envirosafetyproducts.com/product/magnifying_safety_glasses_magnifying_safety_glass

2. A bit "theory"

E

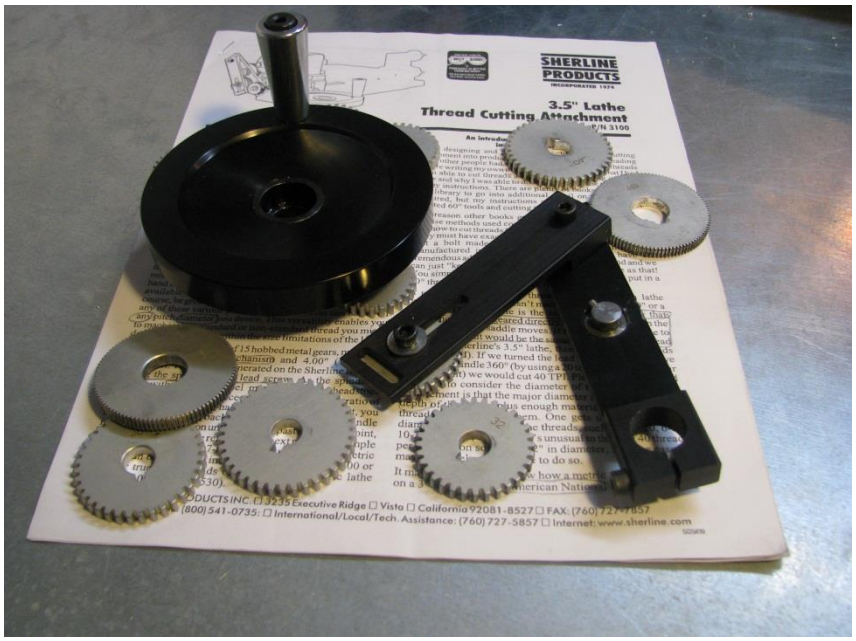


Fig. 2.1: Components of the gear-cutting accessory for the Sherline lathe from Sherline

Object: Cutting various thread types very precisely can be accomplished with a lathe. Unfortunately, on the Sherline system this is a purely manual procedure using a hand wheel. However, the description given in the following is fairly complete and includes outlines about left-hand threads and multiple-start threads. Also, using the accessory for making unusual thread types may be the main application. In addition, the system can provide a good introduction into typical thread-cutting procedures. Plan for a rainy weekend to try this out – it's a somewhat more demanding procedure than others. Trying to accomplish this in 20 min would only result in frustration. How to set up the tool and try it out are described in sections 3.1 and 3.2. The next few sections or chapters provide some "theory".

I am not aware of any safety concerns since this is a purely manual operation on the Sherline lathe using a hand wheel. However, on a full size system cutting threads can be dangerous, i.e., it is not too hard to jam the tool post into the rotating chuck.

STOP

2.1 Advantages of cutting threads on a lathe

For high-end applications — i.e., very precisely made work pieces or unusual sizes — cutting threads on a lathe has a number of advantages or may be the only way to do so:

Brief summary and glossary

ACME threads See chapter 2.6.

Left handed screws See chapter 3.4. These can be cut basically in the same way as right handed screws. The gear train determines the handyness of the threads rather than the thread cutting operation on its own.

Half nut, split nut Devise to synchronize the cross-slide and lead screw of a larger lathe. Fig. 4.4

Threading die holder Mounting fixture for dies, see Fig. 4.10, which can replace a thread hand cutting machine.

Threading tap holder Just use a Jacobs chuck, see Fig. 6.1., special fixtures are not really required.

Runout Miss-alignment of e.g. the thread axis and work piece axis. See Fig. 6.9

Dial indicator Mechanical DRO, so to say. Can be used to measure e.g. the runout. See Fig. 6.9

DRO Digital readout. Gives the position of the lathe cutter.

Tapping machine Fig. 2.9, hand tapping machine.

Boring square holes See Vol. 1.

Clutch Engagement mechanism used on some thread cutting machines. Prevents to build up too large torque while cutting threads (safety clutch, friction clutch). See chapter 6.6.

Bench block Fig. 6.2

Threading leader Template for thread cutting, see Fig. 5.2

Threading to a shoulder No special thick is here required, but cut the thread from the shoulder, i.e., start at the shoulder, see chapter 4.5.

Metric threads The gear train determines if a metric or English thread is cut. See chapter 3.5.

Double lead screws Double start screws would be the correct term. A screw can have only one lead.

Double start screws Chapter 3.8. Two helixes are cut in a bolt.

Change gears The gears of the gear train. On a small lathe one has to change these gears a lot in order to change the TPI machined. I guess that's where the term is coming from.

Threading dial Fig. 4.5, used to synchronize the lathe chuck and cross-slide.

Tapered threads Chapter 3.9, threads cut in a taper. Can be done by turning between centers and off-setting the tailstock.

Lead The linear or axial distance a nut moves in one revolution of a screw.

29° That magic angle, right, see Fig. 3.12.

Pitch One over TPI. Example 20 TPI threads have a pitch of 1/20=0.05"

¼-20 ¼ is the nominal diameter, 20 are the TPI

M8-1.25 8 mm is the nominal diameter, 1.25 mm is the pitch. For metric screws the pitch is given rather than threads per mm.

TPI Thread per inch, or turns (of a nut) per inch.

Gear train See chapter 2.4, assembly of gears.

Center gauge See Fig. 3.2. Used to square a thread cutter. You will never need it, save the money.

Thread cutting tools see Fig. 3.1.

HSS High speed steel, preferred material for low budget hobby type cutting tools. Better are carbide inserts.

HCS High carbon steel. Often misleadingly printed on cheapo tools. HSS, HCS all the same? Nope. HCS taps are good for cutting threads in drywall besides that use HSS tools.

Hand tapping machine See Fig. 2.9, helps to square threads and provides anough torque.

Wire gauges See Fig. 2.5, used to measure the depth of threads. Thread wire gauges.

Thread repair See chapter 4.5, no big trick, just readjust the cutter as good as possible with exsisting thread helix.

Thread gauge See Fig. 2.5, measures the pitch of threads.

UTS, UNC, UNEF See chapter 2.3, thread standards.

Major, minor radius See Fig. 2.3.

Buddy system: See chapter 1.

ANSI Z87 If you don't know what that is, PLEASE read chapter 1.

Thread repair dies Hex dies are often labeled as such which is basically bogus. A HSS hex die can be used to cut threads as any other die, assuming you have a die holder that does fit it and the die is compatible with a standard thread form (usually they are). Round dies can be better centered, however.

Acknowledgements and notes to the 1st Edition

Proofreading of this Booklet by Scribendi (Canada) is acknowledged.

I will continue to update and improve on the texts over time. These updates will be made available to our customers as a free newsletter – assuming that one of the textbooks was purchased from LatheCity. Go to the customer's corner and use the password provided with your purchase. We will not bother you with e-mails, but the updates can be downloaded from our website.

Writing a book about metal working typically does not improve the reputation of a scientist and chemistry college teacher (some prefer not to get dirty fingers...). Therefore, many thanks in advance to open-minded colleagues. However, in the UK, there is apparently a "tradition" to write your own book about "gardening" – the LatheCity books would be my version of this, I guess.

Acknowledgements and notes to the 2nd Edition

I added two chapters and a few more images. Because thread cutting on Sherline's system is not really practical, most home shop machinist think at some point about upgrading to a larger benchtop ("China type") lathe. Therefore, I added a chapter about thread cutting procedures on a lathe which actually allows for using the lathe motor for that purpose. In addition, a brief chapter about thread cutting on an UNIMAT is added. This may for most of us be a historic note. The add-on chapters were again proofread professionally by Scribendi (Canada). Also, the booklet was reformatted using pictograms and wider page margins.

Updated 3rd Edition

One usually adds something; it's hard to remove a chapter. The drawback, the costs increase, but the product price usually does not. Anyway, I did add a "Tips and Tricks" chapter and some more practical notes.

Other LatheCity books are available:

Vol. 1: Basic Lathe Operations [S]
Vol. 2: Working with Lathe Accessories [S]
Vol. 3: Poor Man's CNC Lathe [*]
Vol. 4: Tabletop Milling [S, G]

Booklet 1: Thread Cutting on a Lathe [S]
Booklet 2: Working with Exotic Materials on a Lathe and Mill [*]
Booklet 3: Summary of Basic Metal Lathe Operations [*]
Booklet 4: Artwork Projects on Benchtop Lathes and Mills [*]

Some project booklets/manuals are also available.

Volumes in preparation:
Vol. 5: Tabletop Lathes [*]
Vol. 6: The CNC Benchtop Lathe – an Introduction [S]

[S]: Featuring Sherline systems
[G]: Featuring Grizzly systems
[*]: Completely model independent

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Uwe Burghaus, born in West Berlin, Germany, obtained his education in Physics and Physical Chemistry at the Free University of Berlin.*) He obtained a PhD in 1995, after conducting his graduate studies in surface science at the Fritz-Haber Institute of the Max Planck Society in Berlin. After postdoctoral positions in Genoa (Italy) and Santa Barbara (USA), he went back to Germany to complete a habilitation/tenure in Physical Chemistry. Now at North Dakota State University, he started to establish a surface chemistry group in 2003 and obtained tenure in 2009. His group is currently focusing on studies about nanostructured catalysts.

His hobbies include machining furniture from metal and glass. He is not a professional machinist by training. However, his hobby developed into a small part-time business in 2012. LatheCity currently sells books about metal working, software tools, and accessories: everything that's fun to make and may find customers. The strength of the business is custom-designed tools.

**) It's (still) called "Free University", not because we don't need to pay tuition in Germany (education is indeed free!), but because it was located in the western part of Berlin (West Germany), as opposed to East Berlin the "Russian sector". The FU Berlin was founded with the help of the US after the end of the 2nd world war – Google the details, please. (I got a few funny e-mails and did add this explanation …) LatheCity books are unfortunately not for free, sorry – I also live in the US now … ☺*

Cutting threads on a metal lathe is described in detail, including curiosities such as cutting double start screws or left hand screws. The author focuses here on practical procedures and troubleshooting (tips & tricks) and shows how all of this can be done on a benchtop lathe. We have not seen this type of information presented as concisely as it is here anywhere else in a hobby type machining book. The descriptions focus on practical and doable procedures, but also include the engineering background.

In particular, details are provided for the thread cutting accessory of the popular Sherline metal lathe, giving a fair but critical and independent opinion about often pricy accessories. The author is a hobby machinist, as you probably are.

A short section describes thread cutting on an UNIMAT lathe, which is similar in design to Sherline. In addition, thread cutting on a larger benchtop lathe is discussed.

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