2nd Edition

www.LatheCity.com

Working Safely with Benchtop Systems Vol. 1

Metal Lathe Operations

By Uwe Burghaus

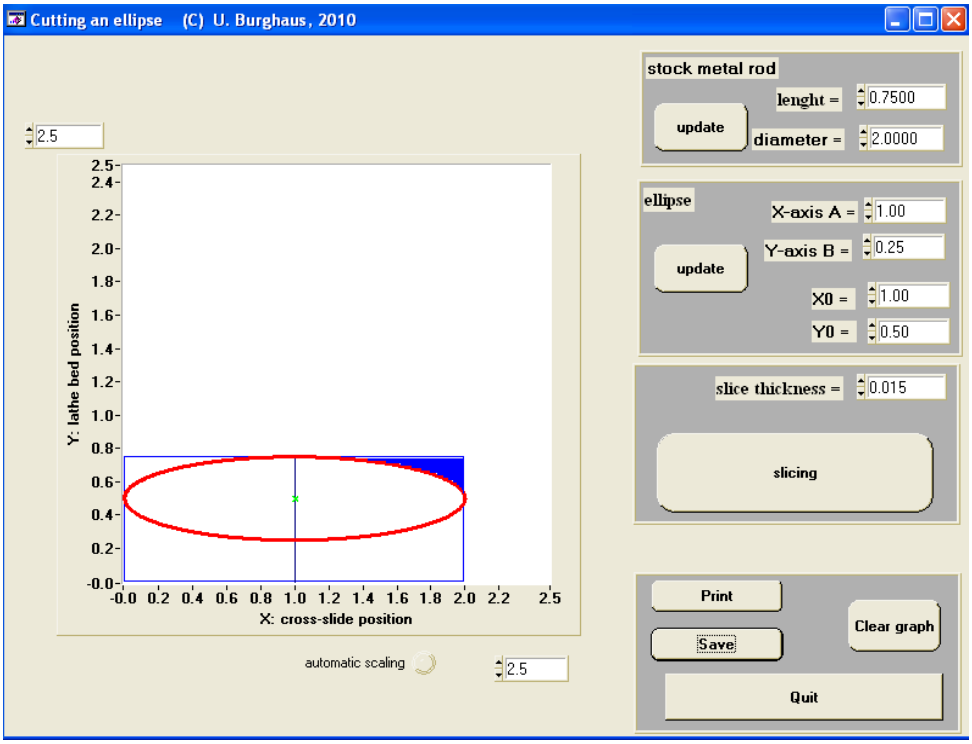
Featuring

Sherline & UNIMAT

www.LatheCity.com

Project example – artwork: earrings made out of aluminum, plastic, and brass.

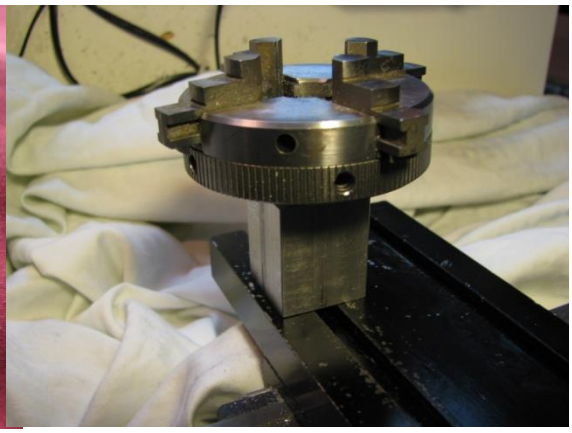
Project example – special shapes made easily: elliptical UFO shape.



"Poor man's" CNC lathe. Any shape can be approximated by slicing it. Thus, you can cut any shape on a mechanical lathe without any accessories. The basics of this operation are described in this book. Slicing tables are included. A CD can be purchased at our online shop which provides the software. Computer skills or a CNC system are not required.

Project example – engineering topics: how to cut a perfect Morse taper? Make your own accessories.

Project example – engineering topics: inexpensive chucks for center drills.



Project example – engineering topics: inexpensive lathe chuck to T-slot table adapter.

LatheCity
Safely Working with Benchtop Systems I
Volume 1 - Metal Lathe Operations
2nd Edition, 2013

ISBN-10: 0991153006
ISBN-13: 978-0-9911530-0-8

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Disclaimer

The book has been written carefully and all projects and procedures have been tested thoroughly. However, as always, the author, publisher, and/or LatheCity cannot guarantee that the procedures are perfect and without any mistakes. In addition, it is impossible to predict and prevent all the potential problems someone might possibly run into when working with a lathe. Using a motor tool can be dangerous and the proper use is the responsibility of the one using the tool. Neither the author, publisher, and/or LatheCity shall be liable for any damage arising therefrom. If you are not perfectly comfortable with working with motor 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 that results in harming yourself or damaging the tools you use. Don't use half broken or damaged tools, perhaps purchased inexpensively at a secondhand store or who knows where. This would be overwhelming to handle in the beginning. Thoughtful work will be your responsibility. Again: Neither the author, publisher, nor LatheCity shall be liable for damage arising therefrom.

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. In fact, the author holds a Ph.D. 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 mini benchtop lathe for hobby type work.

This book features, in particular, the Sherline lathe and accessories. However, none of the statements or procedures may coincide with Sherline Inc.'s opinion or interests. Similar concerns are true with regard to the UNIMAT lathe and accessories.

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.

Web addresses are given without any warranty or guarantee: web sites may be infected by a computer virus and/or may not provide the best service. Neither the author nor publisher nor LatheCity shall be liable for damage arising therefrom.

Computer codes are provided without any warranty or guarantee of correctness. They are intended for private and non-commercial use only.

You will perform all operations herein described at your own risk, in any regard. Neither the author nor publisher nor LatheCity shall be liable for any damage arising therefrom.

Notes for the 2nd edition of Vol. 1

About 100 copies of the 1st edition of this book were legally sold so far within about two years. That's rather significant for a special interest book offered by a self-publisher, I would say. Why I print and sell this myself? Well, I did publish other books through "established" publishers and have never seen a penny coming out of it. LatheCity is my hobby, but it's also a small business. I finance my hobby through LatheCity.

I became aware of small issues here and there in the first edition of the book, which I have now fixed in this second edition. Additionally, I changed the layout of the book; for example, pictograms are now used throughout the text.

As a big change, the 2nd edition was printed professionally and is offered as a paperback. The 1st edition used spiral binding and was just printed by myself on a LASER printer. It would have been great to offer the book printed in full color. The costs for that, unfortunately, are very significant. Almost no one would have purchased the book at that price, I guess. Thus, I've stayed with a gray scale print, but as a professionally printed paperback edition.

More importantly, perhaps, and considering the similarities of UNIMAT and Sherline lathes, it made sense to add sections specifically about UNIMAT lathes to the book. In other words, **both the Sherline and UNIMAT metal shops are now featured,** although the focus is still on the Sherline lathe. Therefore, numerous images were added and a number of pages. Also, **many images and text sections are independent of any model specifics.** I've added engineering type schematics for many machining operations. By making the text size manageable, I also shortened the Chapter about materials and manual CNC operations. Separate booklets "*Poor Man's CNC Lathe*" and "*Working with Exotic Materials*" are now available detailing these topics. Similarly, a booklet about thread cutting on a lathe is available from LatheCity. These are special topics mostly of interest to the more advanced hobbyist. I'm currently working on a text that will feature in particular a typical "China" benchtop lathe, which I plan to offer as a separate book. **However, basic lathe operations are identical on all metal lathes, small or large – whatever lathe you may have, this book should help you to get started fast and safely.** The 2nd volume of this series is for advanced hobby machinists who want to use specialized lathe accessories.

Pictograms used in this book

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

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

Engineering type notes. 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 are doing... right?

Procedures. At least in the beginning, I often give step-by-step descriptions of procedures. If you're looking for these, look for a large P.

Engineering type projects

Artwork type projects

Summaries

UNIMAT specific sections. The "UNIMAT" is a small lathe quite similar in design to a Sherline lathe.

Tips and tricks.

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 gets boring after a while.

Contents at a Glance

Contents

Part D: Boring and drilling

Part E: Working with longer stock

Part F: Left hand (LH) turning tools

Part G: Poor man's CNC system, or, how to cut fancier shapes (e.g. parabolas, circles, ellipses) with a manual lathe?

Part H: Full size systems

Part I: Next steps

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Project list

	page	level, time (min)	RH	LH	4-jaw chuck	drilling boring	grooving
Miniature tower (LatheCity)	88, 90	+, 10	x				
Experiment: surface finish	89	+, 10	x				
Working precisely	93, 94	++, 20	x				
Measure backlash	96	+, 5	x				
Measure runout	98	+, 5	x				
Experiment: tool chatter	99	++, 10	x				
Taper city	107, 113	++, 20	x				
Earrings	113, 116	++, 60	x				
Earrings	125	++, 10	x				x
Square city	129, 132- 134	+++, 15	x		x		
T nut	133	++, 20	x				
Drill stops	149	+, 5				x	
Spice dispenser	151	+++, 30	x			x	
Die holder	152	+++, 60	x			x	
Height gage	171	+++, 30	x	x		x	
Space needle	172, 173	+++, 30	x	x		x	
Parabola cuts	181	+++, 30	x			x	
Spherical cuts	186	+++, 30	x			x	
Elliptical cuts, UFO	190	+++, 30	x			X	
Cigar earrings	193	+++, 60	x			x	
Morse taper	194	++, 10	x			x	

The "++" indicates the difficulty level (from + simple to ++++ difficult), which is certainly a matter of taste and also depends on the tooling at hand. The time estimates might be somewhat optimistic and assume advanced machining skills. More projects are in our "Tabletop Milling" books since most engineering type projects requite both lathe and mill work.

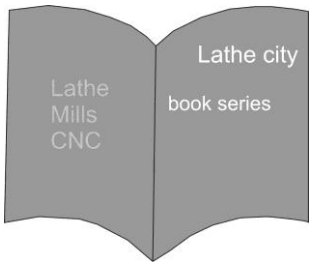
Part A: Introduction

Part A: Introduction

1. Why should you purchase this book?

You should purchase this book because it includes **detailed** descriptions of typical lathe procedures that assume nothing but your interest in metal work. Thus, it is perfectly o.k. if you've never touched a lathe before. In later Chapters, the explanations are detailed summaries rather than step-by-step descriptions, taking into account the skills you've gained in the meanwhile. **The objective is "getting you to work" efficiently and quickly, but safely.** I strongly emphasize safety issues throughout the book, but not with the intention of boring the reader to death. You would not like to lose an eye or finger when indulging your hobby. This would be more than stupid, right? Nevertheless, it is clear that metal work can be dangerous. You will perform all work at your own risk.

The descriptions are accompanied by numerous **figures** throughout the book, which are also useful for later reference. This means that if you already have some background knowledge of lathe work, then you can jump from one figure to the next, taking advantage of the figure captions. Or, if you forget later on how something worked – looking carefully at the figures might be good enough to bring back the knowledge – without rereading a lot. (I got feedback from a few readers of the 1st edition that some shop photos were too dark. That's always a problem: perfect lighting in a garage shop. I reshot some photos for this 2nd edition – I hope they're better now.)



This is an introductory text. However, I do not stop at the simplest possible operations. **Included are nearly all operations you can accomplish on a benchtop metal lathe** (without sophisticated accessories). The first book described work that can be done with a typical Sherline or UNIMAT starter lathe package. The first book included descriptions of the most basic lathe accessories such as the rear parting (cut-off) tool (Sherline) and the 4-jaw independent chuck (UNIMAT's standard chuck is a 4-jaw chuck). Most of the other accessories for the Sherline lathe, however, are detailed in volume 2. In addition, engineering topics (materials properties, cutting materials, rake angle, chip ratio, machinability index, etc.) are included in the 2nd volume, since they are not too important in the very beginning. We also have a booklet about machining exotic materials, which includes materials (and nanoscience) sections. (I am actually a physical chemist.) In addition, the LatheCity book series also includes books about "*Tabletop Milling*," thread cutting, and (lathe/mill) artwork projects. Booklets are also available that specialize in a single topic. If you are interested in making a small business out of your hobby metal work, guess what? That's what I did, and I made another book (product) out of it: a 7-step-guide about how to set up an E-commerce small business. Now, that's enough advertisement!

I struggled quite a while about what **writing style** would be the best. As you can already read here, I do use a more or less informal and personal style that appears to me to be the best in a respectful "learning environment" with adults. I hope that I have not over done it in this regard. I got feedback: that's OK. Some notes about what I do myself, besides hobby metal work, can be found at the end of the book, if this is of any interest.

My own background. I started to write the first edition of this book while learning how to use a metal lathe myself. Thus, this might guarantee that the text is detailed enough for beginners. You can also be certain that I mostly ran into the same problems that you might. **Solutions are provided here.** Later on, I took metal working classes that also used full size systems. I learned how to use CAD software, etc. I presently have a range of full to shop size tools in my "hobby" shop, which has developed into a small part-time business: www.LatheCity.com . However, this **book is written by a hobbyist for hobbyists**. I am NOT a professional machinist; I don't have a degree in Engineering or machining. Actually, in my real job, I am a physicist and university physical chemistry teacher. Read the disclaimer.

This book features the Sherline and UNIMAT lathes. However, apart from differences in the tool posts and cross-slide designs, lathe operations are basically identical on any lathe, independent of the particular model you might want to use. The systems differ in regard to size and available accessories. Some comments on other lathe systems (including "full" size lathes) are also included throughout the book. However, Sherline may offer the most complete mini-lathe system that is smartly designed. UNIMAT is only available on the secondhand market, but it is cheap – at least the older SL DB 200 lathes are. More details about this later on.

I hope that this has convinced you to purchase this textbook. That would allow me to acquire a few more cool tools for my own "hobby" garage machine shop... just kidding (?).

By the way, the layout of all LatheCity books is in color; all photos and images are in full color. Due to the rather small number of books we sell, most LatheCity books, however, are still printed in black-and-white. If you are desperate and want a color version then contact us. We would just print it on a color LASER printer.

2. Does it make sense to learn practical procedures with a textbook?

I have been told that guys working in metal shops don't like to read much. Similarly, an English professor might enjoy reading, but typically not about metal work. Well, I do know personally exceptions to these "rules" that identify these statements as an unfair misconception – in both cases. In addition, I have also seen that females, not just males, work naturally in metal machine shops: a good trend. However, in any case, it is plausible that explaining rather complex manual operations can generate texts of significant length. Videos can be found on the internet or DVDs can be purchased, but often they are designed to sell a product rather than to explain how a given motor tool, such as a metal lathe, really works. Metal work is something students learn best from a foreman/woman in a metal shop. True – perhaps, but this is not how a hobby machinist typically develops his/her skills. (If you have the chance to take metal working classes: do it, for sure, as I did at some point.) In any case, the Machinist and English college teacher are two extreme examples. Therefore, ***I believe that a textbook, together with other media such as videos and good images, can provide a good start for operations on a metal lathe.*** Many books with titles like *Hobby Machinist, Benchtop Tools,* and *Complete Course about Metal Work on the Lathe* already exist. True again and I have read a number of these books. However, I was not perfectly satisfied with most of them. Statements such as "metal work is not like drawing-by-the numbers" and "some common sense and thinking is required" can often be found in technical notes and manuals. It is true, certainly, that thinking always helps, but this might also be an excuse not to write down procedures clearly enough. I hope that I've done a better job here.

What about other textbooks? Well, I have a stack of books several feet high in my home office and you learn a little something from any book, but I did not add a list here on purpose. This is not because I want to promote my own book series, but because the best book for you depends very much on your interests, the tools you have available, and current knowledge you have.

This book here features, in particular, the Sherline/UNIMAT metal shop. It is ideal for beginners to have a text that is written especially for the tools at hand.

The only textbook I would recommend is a book that allows you to look up materials properties, turning speeds (how fast the lathe should rotate the metal piece), and things like that. Most machinists I know recommend *Machinery's Handbook*, published by Industrial Press. At present, the 28th edition is offered and it is available for about $60 in secondhand stores. A shorter guide version for under $15 is available too, which I haven't used myself, however. It would be good to get a reference book such as this one at some point – perhaps not in the very beginning, but at some point. In addition, also at some point, it will be hard to circumvent using CAD (Computer-aided design) software (unfortunately rather pricey). Perhaps try Pro/Engineer (Wildfire), which is somewhat less expensive and simpler to learn than other CAD programs. For a number of more formal reasons, CorelDraw has been used so far for the images in this textbook, including that commercial versions of CAD programs are very expensive. The objective of the technical drawings in this book is to make clear to anyone what the work piece looks like, rather than obeying any formal standards.

I did not add a reference section to this book. The few references included are given as part of the text. However, I would encourage you very much to take advantage of the internet. Therefore, lists of web sites are given throughout the book. If you won't like to type

these, go to the customer corner of my web site at www.LatheCity.com → look at the lower left corner → lock-in or try this link directly http://www.lathecity.com/CustomerCornerMain.php

Talk to the folks who do this for living; most of them will willingly share their knowledge and provide advice. Perhaps also try out the following links for clubs, other contacts, and journals devoted to hobby type metal work:

Tip:

www.metalworking.com

http://www.neme-s.org/images/links_to_other_metalworking_clubs.htm | Listing of metal-working clubs in the US

Internet

http://www.sherline.com/resource.htm | Sherline's web link site

http://www.livesteam.net/home | Steam engine model design journal

http://www.modelenginebuilder.com/ | Hobby Machinist journal

https://secure.villagepress.com/store | These folks publish journals from "Metal working" to "Dogs and Sporting"

https://secure.villagepress.com/contact/aboutus | Homepage

http://www.homeshopmachinist.net/home?noredirect=true | "Home Shop machinist," founded apparently in 1982

http://www.homeshopmachinist.net/noob/signup | You can get a free sample copy – try this link on your own risk

http://www.digitalmachinist.net/?noredirect=true | "Digital Machinist," CNC hobby journal founded in 2006

3. How is the book structured?

The book has a number of **parts** (A to I) in logical order. Thus, if you've never worked with a lathe before, then work your way through the book starting with the first Chapter in part A. To make the reading more enjoyable, each Chapter is broken up into many paragraphs using subhead lines and numerous figures. Later on, you may jump through the text, from headline to headline, using it for reference. In addition, **pictograms** are used throughout the book to label particular text sections; this also makes it easier to browse through the text later on.

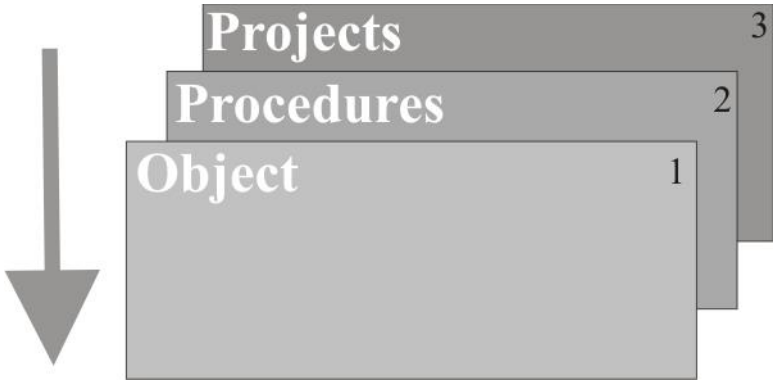


Fig. 3.1: Structure of the Chapters: **1)** What is the tool or operation doing? **2)** How do you use this tool? **3)** Examples/projects.

Most **Chapters** (1-57) are structured as shown in Fig. 3.1. Typically I explain first the **objects**; i.e., what is the purpose of a given tool or operation. Then, the **procedures** are described in detail. I always start here with the simplest and most basic operation that can be accomplished with a given lathe tool. In between, further notes are given, including troubleshooting, more safety notes if required, and more advanced operations.

You should at least browse over all of this (i.e., one subchapter) before starting to work with a new tool - just as a safety precaution. Reading one subchapter typically takes less than 30 minutes. Finally, each subchapter concludes with more or less small **projects** that take advantage of the new skills and/or tools. (Look for the pictograms *when looking for projects.*) Working on a single project can take 5-90 minutes.

I mostly describe how to use the tools safely, so that you can make whatever piece you like, rather than only going through extensive project descriptions. The projects are, at least initially, set up to make practice parts. The interests of hobbyists are simply too diverse to come up with meaningful general purpose projects. For example, I am interested in "useful" applications including furniture, household utensils, engineering type work, and tools rather than building model 711/3A of a steam engine or knickknacks. (You can find dozens of books about manufacturing models such as steam engines – which typically assume you already have advanced skills. If James Watt had known this in 1769 when he got his patent…) Anyway, small projects about making miniatures (LatheCity knickknacks) and making earrings are included in this book, as well as how to make a spinning top (gyroscope), household utensils, a self-ejecting chuck key (which actually comes in handy), a Morse taper (very handy), etc. Learn how the tools work and you can make anything you want, right? That's the strategy, but the first book already includes numerous small projects.

The book includes extensive safety hints, more than what you commonly find in other hobby machining books or texts for professionals. This was important and logical to me since hobbyists don't have (initially) the skills of a professional machinist and don't go to safety briefings and classes. **Thus, be aware that you may be at a higher risk than folks who do this for a living.** In particular, the first few weeks working with the lathe can be dangerous. You may quickly reach a level of confidence. This is good and it's my objective, but this phase of developing skills might result again in a high risk for accidents. If you are too confident, then you might become sloppy in "routine" operations.

If you are looking for a **really fast start** into machining, then read Chapters 12 & 20 and go from there. (This text Section is Chapter 3.)
If you need some help in purchasing your first lathe, then read Chapters 4, 5, and 54.

1" = 25.4 mm
1 mm = 0.0394"

http://mdmetric.com/tech/cvtcht.htm
http://industrial-enclosures.com/html/conversion-mm-inch.html
http://www.engineeringtoolbox.com/inches-mm-conversion-d_751.html

Sherline - one tick on the hand wheel s:
one-hundredth of a mm or 0.01 mm
one revolution 1 mm

4. Understanding machinist jargon – what is the maximum size of materials that can be worked on with the (Sherline) lathe?

Objective. Most of the information provided in the introductory Chapters might appear rather trivial, but not everybody starts at the same level. Advanced readers may quickly browse over the next text sections, jumping from one sub headline to the next since some details are included that might be new even for more experienced hobby machinists. Web addresses are provided just for convenience and can certainly easily be found using standard internet search engines. The lathe operations start in Section C.

Machinist jargon I explain here includes:

- Distance between centers
- Swing over bed/carrier
- Morse spindle
- Turning
- Work
- Dovetail
- Running true

If you want to purchase a lathe, then you need to read the specs. Therefore, it's important to know at least the most common terms or the guy (typically it is a guy) in the shop might "pull you over the table" – knowledge is always money … Yes, more experienced hobby machinists know all of this.

Purchasing stock/raw materials (aluminum, plastic, steel) is one of the first tasks. This raises the question: What size stock materials can be worked on with a given lathe?

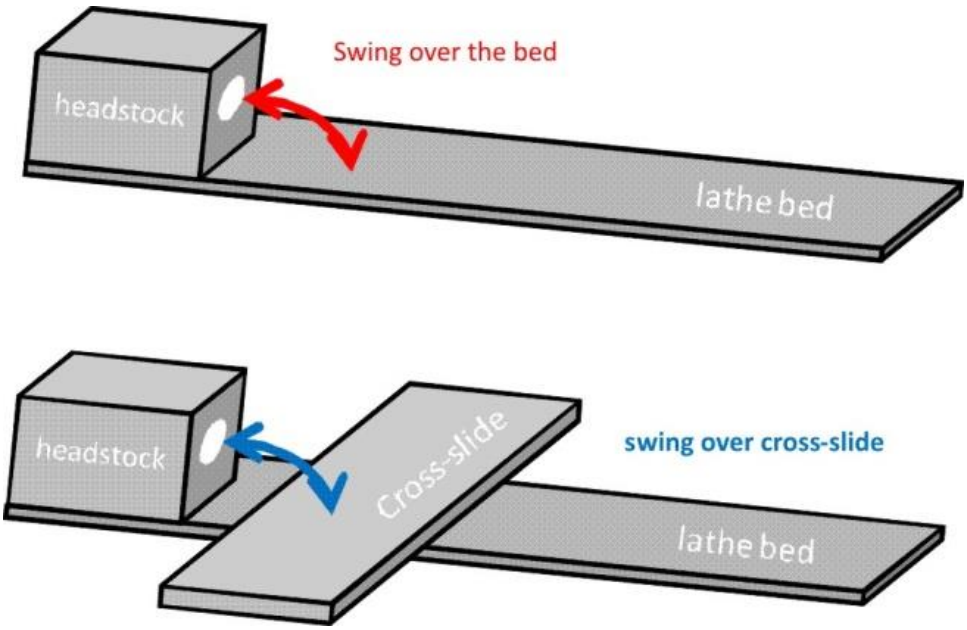


Fig. 4.1: For any lathe, the largest stock diameter that can be worked on is defined by the "swing over the cross-slide" (or carrier). On the left is the headstock with the lathe spindle. The long horizontal piece is called the lathe bed. The short perpendicular slide is the cross-slide, just in case the label doesn't show up perfectly in print.

Index

Uwe Burghaus, born in West Berlin, Germany, obtained his education in Physics and Physical Chemistry at the Free University of Berlin. He obtained a Ph.D. 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 of 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 including software tools and accessories: everything that's fun to make and might find customers. The strength of the business is custom designed pieces.

Acknowledgements (1st edition)

Proofreading of Vol. 1 by my wife Amy Erickson is gratefully acknowledged – we are still married. I hope that Amy caught most of the typos. I will continue to update and improve on the texts over time.

Last but not least, many thanks to the instructors of the metal working/engineering classes I took at North Dakota State University.

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

Acknowledgements (2nd edition)

Professional proofreading by Scribendi is acknowledged.

Detailed are typical lathe procedures assuming nothing but your interest in metal work. The book features the popular Sherline and UNIMAT metal shops, but it will be useful for projects with any tabletop metal lathe. The object is getting "you to work" efficiently, quickly, but safely. Project examples include various artwork projects, household utensils, and engineering type projects. However, the main philosophy is to describe clearly the lathe operations that one can machine whatever may be desirable. This is an introductory text with an endless number of photos and drawings. However, we do not stop at the simplest possible operations.

The author is not a professional machinist or engineer. In fact, the author holds a PhD in physics and teaches physical chemistry at a college. The author is a hobby machinist, as you probably are.

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Safely Working with Benchtop Systems I
Volume 1 – Metal Lathe Operations

$34.99
ISBN 978-0-9911530-0-8
53499>
9 780991 153008

ISBN-10: 0991153006
ISBN-13: 978-0-9911530-0-8