Bearings and Live Center

Machining Lathe Live Center
A Practical Guide

Uwe Burghaus

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LatheCity
Safely Working with Benchtop Systems
Booklet 5 – Bearings and Live Center – Machining Lathe Live Center – A Practical Guide
Featuring Sherline / UNIMAT SL DB / UNIMAT 3 / Craftsman / China Import Lathes
ISBN-10: 0991153065
ISBN-13: 978-0-9911530-6-0
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Publisher and author: Uwe Burghaus, Fargo, ND, USA
Printed and written in the US.

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Safety notes

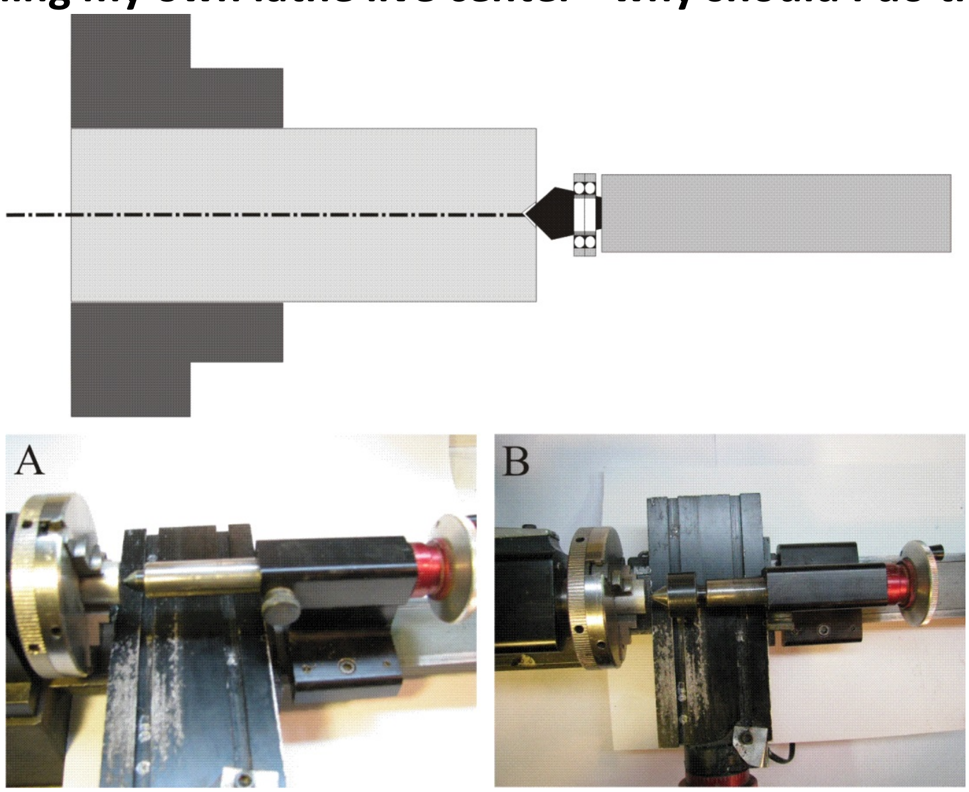
A separate safety booklet is included – read it. And/or go to www.LatheCity.com for a fee PDF download.

Regarding the use of live centers, I am aware of two concerns. The radial and axial load of bearings is specified by the manufacturer. Not all bearings can be used for heavy duty operations. When bearings break, the center can be jammed suddenly or the center pin can tilt and break out of the housing suddenly. The second concern may be imprecisely machines housings which result in large runouts. All of this can generate unstable and dangerous working conditions. The maximum RPM ratings of bearings and live times are usually far beyond spindle RMPs of small tabletop lathes. This is a little concern.

“Preface”

You hold a short and quick do-it-yourself guide in your fingers. The description is brief on purpose since it’s written for advanced hobby machinists. (Therefore, I did not number the images either.) Some sections are in “telegram” style rather than essay/tutorial style. I hope this serves the purpose: making a few of these by yourself (fast), getting ideas, finding suggestions, and saving money. Let’s get started (and as always read the safety notes and disclaimer).

Machining my own lathe live center - why should I do that?



Typical setup for using centers. **A)** dead center, **B)** live center. Shown are shop photos and a Sherline lathe. The top image is an engineering type schematic, which is independent of the lathe type used. The dark grey areas symbolize the chuck; the light gray square is the work piece. On the right hand side is the schematic of a tailstock. The dashed-dotted line is the center line of the lathe/work pieces. (Sherline’s system is shown.)

Costs. Morse #2 live centers are really cheap. China mass produced, i.e., it's probably not worse to make one by yourself. However, if you have a lathe such as Sherline, UNIMAT, or Craftsman then purchasing a live center becomes a rather expensive enterprise. UNIMAT and Craftsman are vintage lathe brands; these are today only available on the secondhand market. Accessories are rather hard to find and usually these are expensive. Similarly, if you need a Morse #4 live center or a specialty size then costs are going up. Therefore, making these by yourself again becomes financially attractive. Now, hobby type bearings are in small quantities available at OK costs. You can purchase as little as a single one or just 10 for $30. Therefore, you would indeed save significantly making live center by yourself.

Curiosity. I often made tools not to save money or because I really needed the tool, but just to find out if I can actually do it. Curiosity, I guess. And, I do run a part time small business. New products once in a while keep the sales going.

What about you? Whatever your motivation is, apparently you have one otherwise you did not purchase this book. Shoot us an e-mail and let us know why this topic was interesting to you. We are at sales@lathecity.com

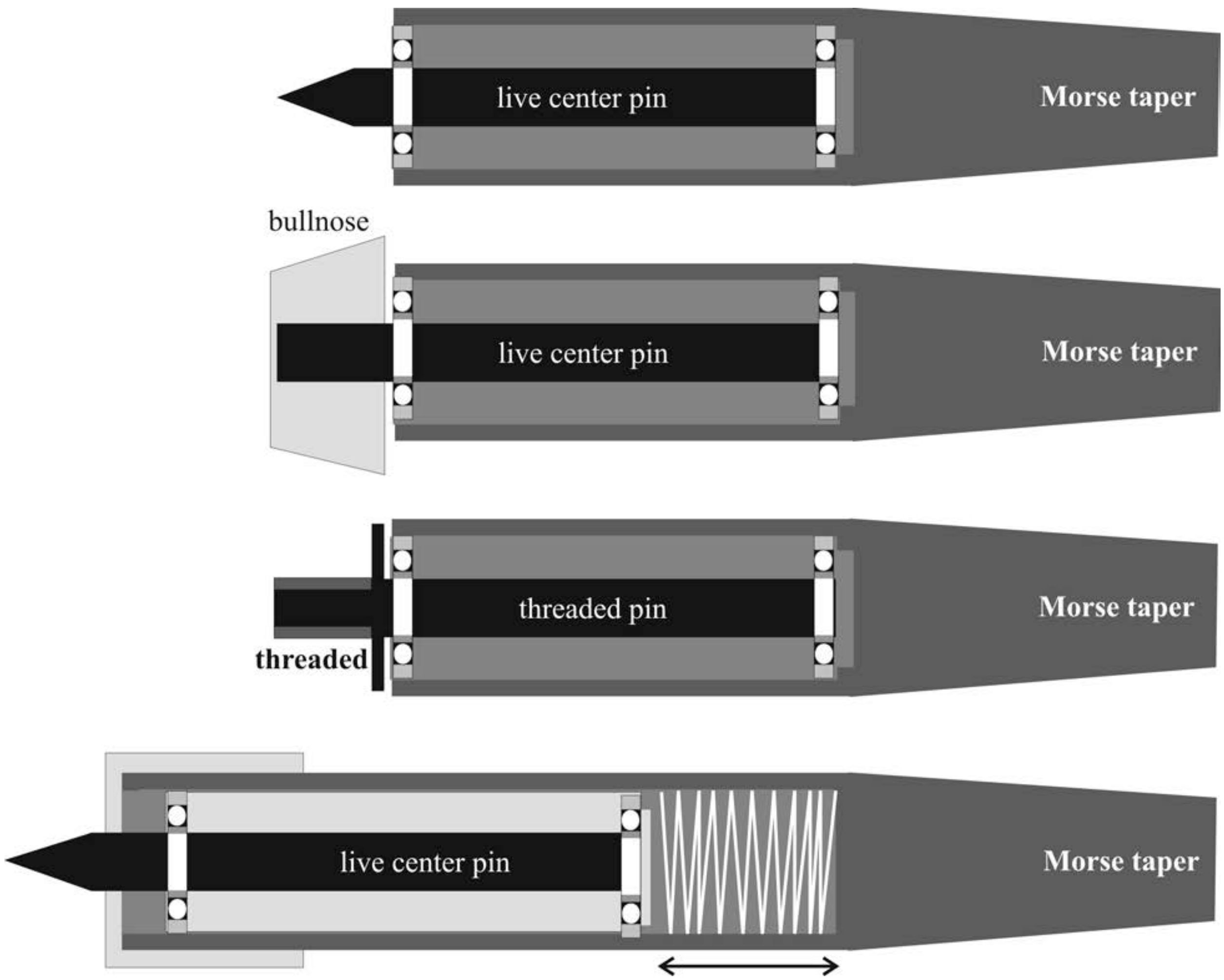
Collection of lathe centers for different lathes and of different styles. Drawings will be described later for making some of these. To the left live centers; right dead centers. Most of these are self-made or came together with the lathe. One is from Sherline, some came with a SIEG lathe.

Why we need these? In most training metal shops instructors ask their students always to use a live or dead center for lathe work. Do so whenever possible. Guess why? It's much safer. It results in much sturdier machining conditions and higher precision. Work supported only in the chuck can be pulled off the chuck during the cutting (turning) operation and will fly off, which is dangerous. This can easily happen on a mini lathe with mini scroll chucks such as Sherline or UNIMAT. In addition, supporting the work piece at both ends will reduce problems related to bending of the work and misalignment of the work. Thus, the accuracy of the cutting process increases. The working conditions are much studier. This becomes more important the longer and wider the work piece is.

Lathe center varieties

The following list is formatted as a glossary for convenience and efficiency of using this guide.

Dead center A dead center is just a pin; i.e., a stationary tool. In order to fit in Sherline/Craftsman headstock/tailstock a Morse taper shape is cut in one end of this pin. For UNIMAT, a screw on pin can be used or just a rod with a tight fit to the spindles.



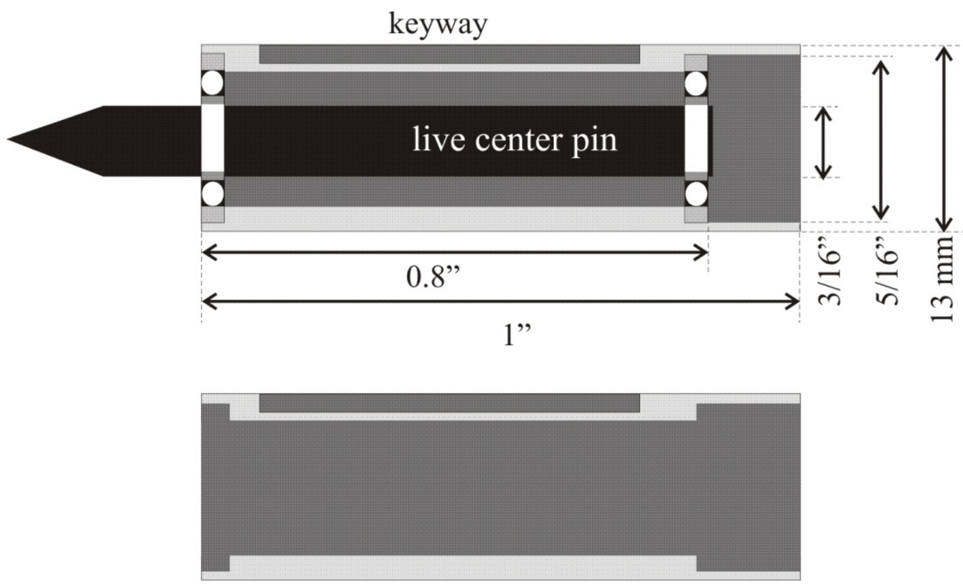
Schematics of lathe live centers: pin end, bullnose, revolving Jacobs chuck adapter, spring live center.

Specialty dead center We offer some "specialty" dead centers which are just Morse taper with interchangeable tool steel (I usually use A2 or W1), HSS (high speed steel) or solid carbide tips (sold as engraving tips, see e.g. McMaster-Carr). If you have broken HSS endmills … here you go, machine a taper in these and stick them in a Morse blank (machinable end Morse taper). That makes an excellent and cheap dead center. Most HSS can be cut with standard carbide inserts, not a big deal or see the LatheCity book "*Machining Exotic Materials*" for some help with that. We do offer machinable end Morse blanks and also tools for actually cutting machine taper.

taper length of 1.5”. A bolt is screwed into the small diameter end and acts as a knock-out bar for the taper.

Besides the size of the tool, the next decision is, as always, what bearings to use? Given the max O.D. of ¾”, I used rather small ball bearings 3/16” x 5/16” x 1/8”. Two of these hold the 3/16” tool steel pin of the live center and were pressed in a short cartridge made from O.D. 13 mm tool steel I had floating around.

Instead of a cap as shown in the schematics, I did cut a keyway in the cartridge and used a setscrew in the housing. That prevents that the cartridge pops out and stays stationary. The length of the keyway depends on the spring you use similar to the exact position of the set screw. The movement is not very large for these centers. One may want to pre-press/pre-load the spring somewhat.



Cartridge of the spring center.

The spring is a quite stiff compression spring with O.D. 11/32” or so and 1.5” length when expanded. I got a set of various springs in a hardware store, i.e., it’s some kind of cheapo spring. You may need a washer/spacer between the cartridge and spring. Or, close up the end of the cartridge.

I used tool steel for the cartridge simply because of the small diameter tolerance of tool steel rounds. One wants to have a tight sliding fit of the cartridge in the housing. The surface finish of tool steel also is excellent – but, still add a drop of oil to the cartridge. And, I had a 13 mm reamer in the shop. That size also is used for some UNIMAT spindles I made before.

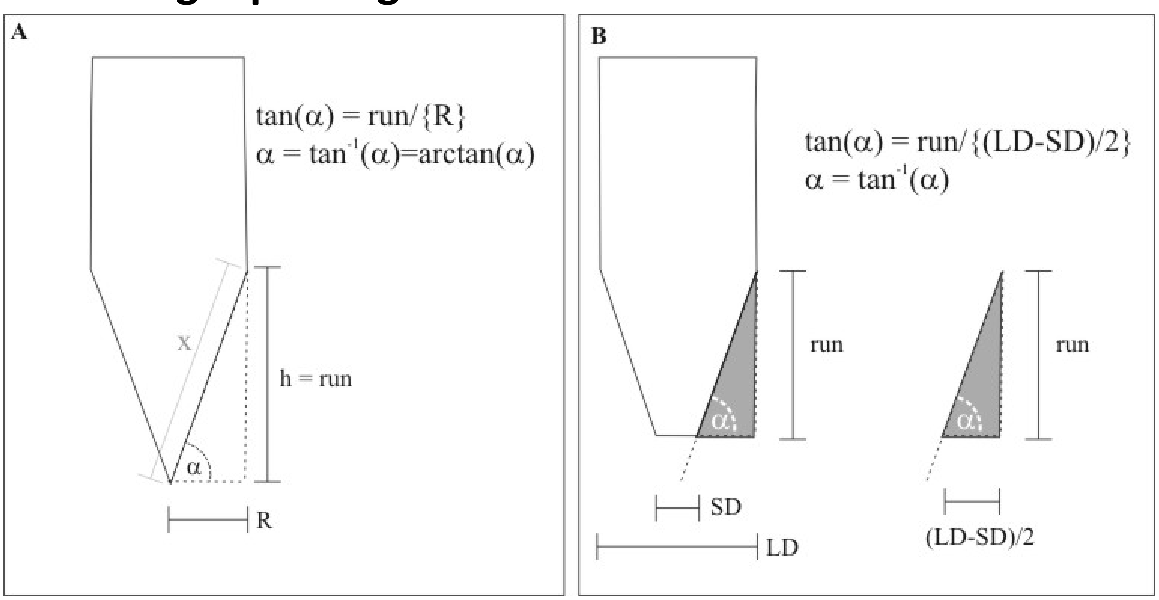
First, I did press the front bearing on the live center pin by pressing on the inner race. Next, press front bearing in cartridge housing by pressing on outer race. Next, press back bearing into housing by pressing on outer race. Next, press back end bearing on pin and housing by applying force to the inner and outer race. You need simple fixtures for that, as discussed above. One cannot use set screws to mount bearings for a cartridge spindle unless you make the piece huge.

The rest should be evident from the drawings. Obviously, this is a simple version. Commercial CNC spring centers have 5 bearing, specialty spring, and whatnot. As mentioned before, you (and I) will never really use this anyway. A few photos of my version are shown below.

Low budget hydraulic press

For the size of bearing hobbyists usually uses (O.D. < 1") a standard shop vise or screw based press is sufficient. I started to make spindles with larger bearings and machine accessories in small badges for my business. Therefore, a hydraulic press was handy. However, a press can be dangerous. People will rarely put their thumb in there, but even a short ¼" tool steel pin can easily bend and break. The fragments travel as bullets through the machine shop. Therefore, I added a safety screen at least to the front side of that mini two ton press (<$20). Situation awareness also here is important. I used a small hydraulic standard car jack. I don't provide any details of my design here: liability would be an issue. I would recommend: use a mallet or shop vise to press your bearings on a shaft. When using a hydraulic system, the risk will be yours.

Calculating taper angles



Usually 60° (included angle) taper are used for live center pins fitting to standard center drills. However, for a bullnose center this may not strictly be required and may not be the smartest anyway. I used typically a 20° taper angle with LD = 0.5" and SD = 3/16 which gives one a length of 0.42". There is an Excel taper calculator somewhere on Sherline's website.

For machining bullnose live center one would need to calculate the taper, or, for machining Morse taper into the live center's housing.

Example: Full length MT0 tan(α) = 2.0/[(0.3561-0.2520)/2] = 2.0/0.0521 = 38.3877 → 90°-α = 90° - 88.5078° = 1.49° (compare with tab below).

Example: Reduced length MT0 e.g. tan(α) = 0.8/[(0.3561-0.3145)/2] = 0.8/0.0208 = 38.46 → 1.49° . Non-standard length taper are common for small lathes.

Rewriting the equation above gives one $\alpha = 90^0 - \text{taper angle}; SD = LD - \frac{2*run}{\tan(\alpha)}$.

Example: MT2 short – 1.5" long; SD = 0.7-2*1.5/tan(88.5693) = 0.7-3/40.0390 = 0.7-0.074926 = 0.6251

Machining Morse taper

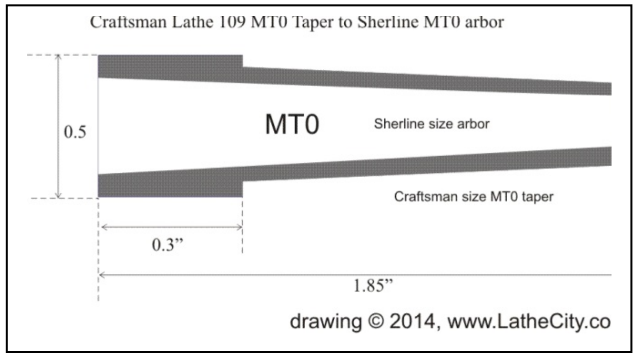
taper	Taper angle	90-alpha	Tan(alpha)	large end diameter	small end diameter	length
#0	1.4908	88.5092	38.4242	0.3561	0.2520	2.00
#0 short				*0.3561*	0.3093	*0.9*
#1	1.4287	88.5713	40.0951	0.4750	0.3690	2.13
#1 short				0.4750	0.4301	0.9
#2	1.4307	88.5693	40.0390	0.7000	0.5720	2.56
#2 short				0.7000	0.6251	1.50
#3	1.4377	88.5623	39.8440	0.9380	0.7780	3.19
#3 short	1.4377			0.9380	0.8627	1.5
#4	1.4876	88.5124	38.5069	1.2310	1.0200	4.06
#4 short				1.2310	1.1272	2.00

The full length taper obey the ANSI definition.

At www.latheCity.com we sell machineable end Morse taper if that is a hurtle of making your own live center. We do also offer tools to cut these machine taper ($30-$100). Sherline and UNIMAT lathes have rotatable headstocks which makes it rather easy to cut Morse taper. Setting a compound slide is actually trickier. Some options are listed here.

- Copying angles from an existing Morse taper (see Vol. 1 of the LatheCity book series for details) e.g. using a dial indicator to set the angle of the compound slide, does not work too well and is quite tidies and time consuming.
- Slicing the shape (see Vol. 1 of the LatheCity book series) – this is for the novice perhaps the easiest way to machine a Morse taper; i.e., a CNC lathe is "simulated" using a manual lathe. It works, but is not very fast. In the meanwhile I use a CNC lathe to cut machine taper (see "Benchtop CNC lathes" another LatheCity book).
- Sherline lathe. Using an offset key that fits in the lathe headstock alignment slot set at the taper angle. We indeed offer this kind of tool for the Sherline lathe – go to our on-line store. However,

one is restricted to machining a few machine taper only, or several keys would be required. We offer one that is set in-between the taper angle of a Morse #0 and Morse #1 taper. That tool is very comfortable since no adjustments are required, but for every angle a different key is required. Arbors and taper also require different keys.



- Electronic protractors are in the meanwhile available for $50-$200. These could be used to set the angle of the headstock or a compound slide angle. The best I have seen (2014) were systems with 0.1° accuracy. In 2015, electronic protractors with 0.05° resolution became available for $50, or so. I did try one of these out. Well, the reading of these is jumping as hell and the reproducibility is an issue. Meaning, every time you use these to read the same angle setting you will get a different reading. By the way, the gyroscopes are very temperature sensitive (don't keep it in a cold basement) and need also to be calibrated. Nice toy, but probably not worse the investment. To calibrate the headstock angle you need to flip over the entire lathe …
- If you want to have something really fancy then mount the headstock of your lathe on a rotary table. The angle resolution would be very good and one can set any angle precisely. Small worm gear rotary tables cost probably about $100, but a different tool post would also be required etc…
- We cut machine taper in the meanwhile on a small CNC lathe. That kind of set up, however, start at about $2,000. Somewhat price for private projects.

How to measure machine taper

One cannot directly measure diameters precisely on a sloped surface. Therefore, I use a set of test arbors to measure (or test fit) machine tapers. The test sleeves are simply Morse arbors reamed in rounds cut to different length. One can see, feel, and measure the fit. Stick a feeler gauge in the end/front of the sleeve to measure the clearance. In the meanwhile I cut these on a CNC lathe. One can cut relative diameters very precisely even on a small CNC lathe. For example, assuming conservatively an accuracy of e.g. 0.0005", the taper angle variation over a length of 1.5" amounts to 0.01°. Critically also is the headstock – tailstock alignment.

Cutting tool steel

Spindles and live center pins are usually made from tool steel, at least. How to cut the stuff? As a hobbyist, one has the choice between chop saws, milter saw, band saw, rings saws, wire saw, etc. Commercial shops may also use water jet saws, CNC torches, or LASER cutting equipment. Besides torch cutting systems, which are not that expensive, all other options are out of reach for hobbyists, I would guess.

Chop saws are safer than band saws or table saws, I would say. Some band saws can be set up as chop saws. Chop saws are good general purpose tools. Standard carbide tipped blades cut the usual materials hobbyists use most often. If you work a lot with aluminum then get an Aluminum cutting blade for your chop saw. Larger diameter aluminum stock heats up badly when cut with a steel or stainless steel blade. Unless you have a really new blade and want to wear it out fast, **basically forget about cutting tool steel with a chop saw.**

Tough steels are better cut with band saws using in addition a coolant system if possible. However, band saws are trickier to use than chop saws. The type of blades used depends not only on the materials cut, but also on their diameter. The number of teeth in the saw blade has to fit with the diameter of the stock material you want to cut. Manufacturers provide various tables to select to correct blades.

Chop saws with abrasive blades became quite popular. By the way, I have been warned by a chop saw manufacturer/customer service not to mount an abrasive blade on their chop saw. Abrasive blades (best knows from Dremel cut off wheels) run apparently at greater RPM than Al/steel cutting saws and can indeed cut tough materials (such as tool steel). The saw blade and saw have to fit together; these systems are designed as a unit. Don’t improvise. I use an abrasive saw for cutting tool steel and a use a plastic quiz bottle as my coolant system. These blades are tougher than the mini Dremel blades. They don’t wire of that fast.

Technical drawings

For the drawings I did not use any formal standard, you noticed. ☺ However, the drawings together with photos of the items should make clear how the pieces look like. Consider it as shop drawings. Commercial CAD software is fairly expensive.

Caution again

Shown here are hobby type setups. The pieces shown here were made and tested, but: None of the drawings provided is based on engineering calculations or professional engineering tests. If you reproduce these tools or not is up to you and it is entirely at your own risk. In any case, recommended are small RPM and light loads. High end live center have usually numerous bearings, tapered bearing, and/or angular contact bearings to handle large loads. These designs are not shown here due to feasibility and cost concerns for a hobbyist.

Figure acknowledgement

Page 13, Bearings Reproduction of a painting that is in the public domain because of its age. Author Leonardo da Vinci downloaded from https://en.wikipedia.org/wiki/Bearing_(mechanical)

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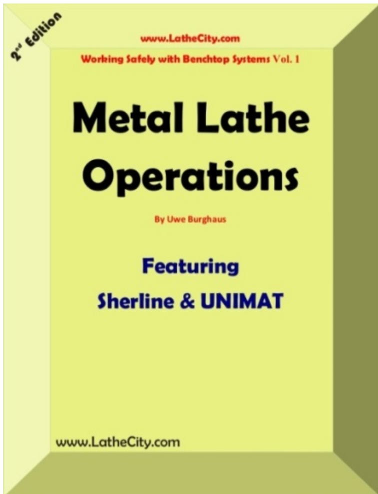

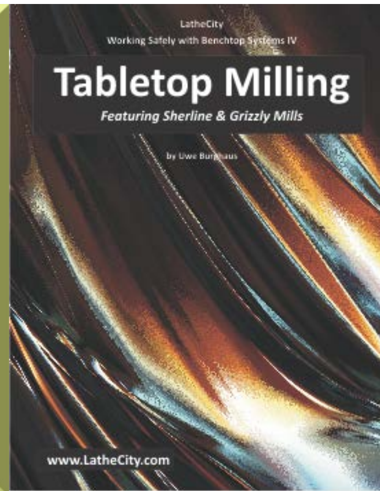

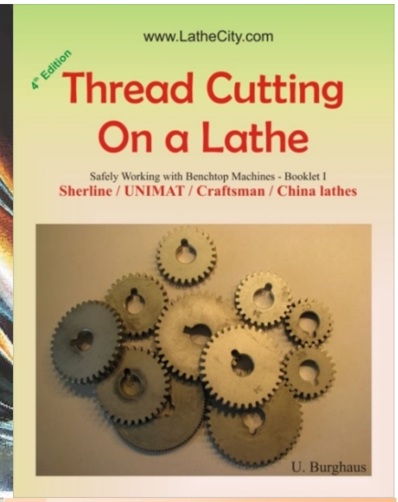

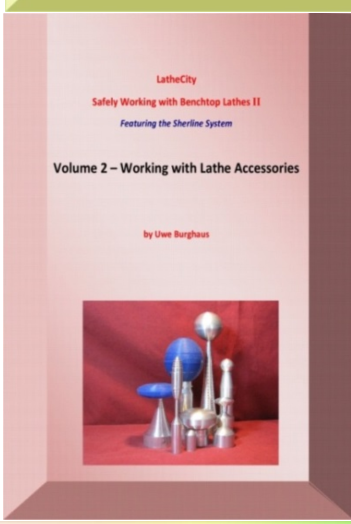

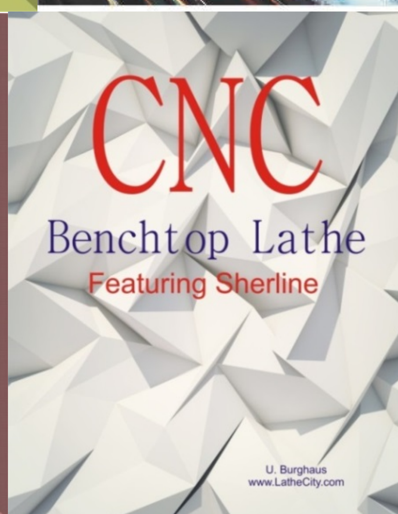

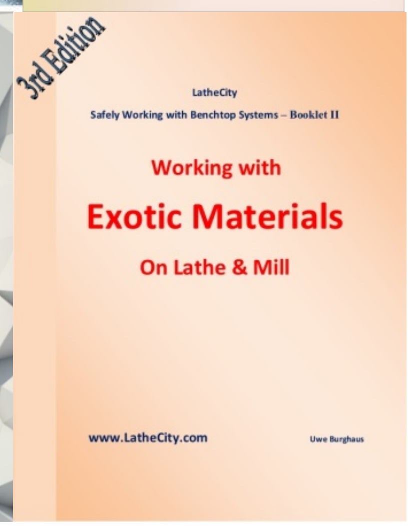

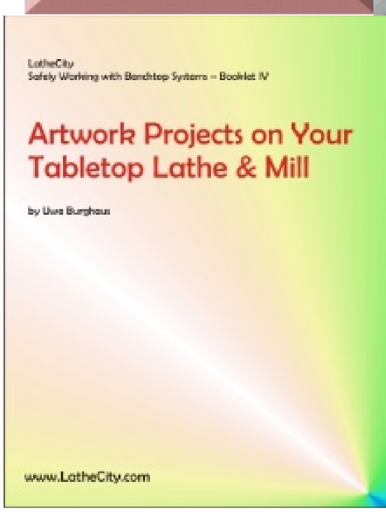

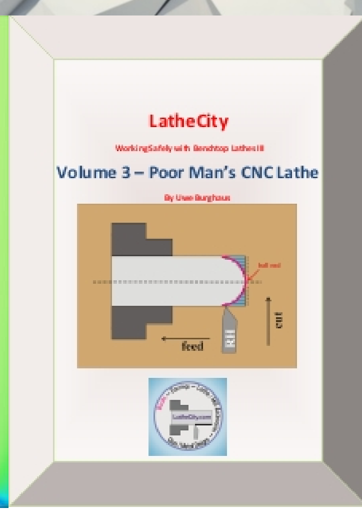

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You hold a practical guide about working with bearings in your hands. As an example illustrated is how to machine lathe live centers, but the knowhow offered here will also help one to machine spindles, model engines, toys, tools, etc. Featured are small and medium size machines such as Sherline, UNIMAT SL DB, UNIMAT 3, Craftsman, and China Import Lathes including new lathes and vintage models. Described are standard designs and standard sizes as well as specialty tools such as "spring live centers" and "revolving adapters" used on metal lathes. Numerous drawings and shop photos are included.

ISBN-10: 0991153065
ISBN-13: 978-0-9911530-6-0
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