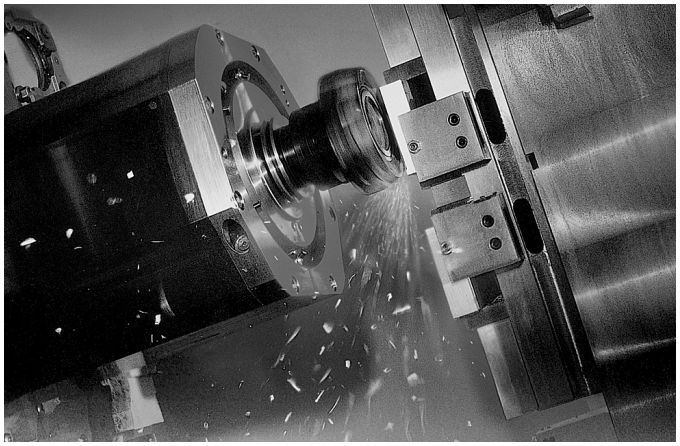


Chapter 13

The Lathe

LEARNING OBJECTIVES

After studying this chapter, students will be able to:

- Describe how a lathe operates.
- Identify the various parts of a lathe.
- Safely set up and operate a lathe using various work-holding devices.
- Sharpen lathe cutting tools.

INSTRUCTIONAL MATERIALS

Text: pages 201–240
Test Your Knowledge Questions, pages 239–240
Workbook: pages 69–76
Instructor's Resource: pages 171–190
Guide for Lesson Planning
Research and Development Ideas
Reproducible Masters:
13-1 Lathe Operation
13-2 Lathe Measurement
13-3 Parts of a Lathe
13-4 High-Speed Steel Cutting Tools (*nomenclature and shapes*)
13-5 Sharpening HSS Cutter Bits
13-6 Using the Cutter Bit Gage
13-7 Calculating Cutting Speeds
13-8 Cutting Speed and Feed Problems
13-9 A, Checking Center Alignment
13-9 B, Checking Center Alignment
13-10 Facing in a Chuck
13-11 Test Your Knowledge Questions
Color Transparencies (Binder/CD only)

GUIDE FOR LESSON PLANNING

Because this chapter is rather extensive, it should be divided into several segments. Teach the segments that best suit your program.

Part I—Parts of the Lathe

Have students read and study pages 201–211. Review the assignment using Reproducible Masters 13-1, 13-2, and 13-3 as overhead transparencies and/or handouts. Discuss the following:

- How a lathe operates.
- How lathe size is determined.
- Major parts of the lathe.
- Preparing a lathe for operation.
- Cleaning a lathe.
- Lathe safety.
- Emphasize the importance of lubricating and checking over a lathe before operating.

Part II—Cutting Tools and Tool Holders

A selection of cutting tools and tool holders should be available for the class to examine.

Have students read and study pages 211–219. Review the assignment using Reproducible Masters 13-4, 13-5, and 13-6 as overhead transparencies and/or handouts. Discuss the following:

- High-speed steel (HSS) cutting tools and how they are shaped for different types of turning.

- How to sharpen high-speed steel cutting tools.
- Carbide-tipped cutting tools.
- Indexable insert cutting tools.
- How the shape of an insert determines its strength.
- The reason for a chip breaker on a single point tool.
- The nine basic categories of cutting tools.
- Emphasize how to handle sharpened cutting tools to prevent injury and premature dulling.

Part III—Cutting Speeds and Feeds

Have students read and study pages 220–222. Review the assignment using Reproducible Master 13-7 as an overhead transparency and/or handout. Discuss the following:

- The factors that effect cutting speeds and feeds.
- How to calculate cutting speeds and feeds. Use Reproducible Master 13-8 to provide practice in calculating cutting speeds and feeds.
- How lathe speed and carriage feed is set on the lathes in your shop/lab.
- Reason for making roughening and finishing cuts.
- How depth of cut is determined on lathes in your shop/lab.
- Demonstrate the difference between roughing cuts and finishing cuts. All students must wear approved eye protection during the demonstration.

Part IV—Work-Holding Attachments

Several lathes should be set up to show work mounted between centers, mounted in various types of chucks and collets, and bolted to a faceplate.

Have students read and study page 222. Discuss and demonstrate the various work holding attachments set up on the lathes. Explain the safety precautions that must be observed when mounting the attachments on the lathe and when they are being used.

Part V—Turning Between Centers

Have a lathe set up for turning between centers plus a selection of the equipment necessary for turning between centers.

Students should read and study pages 223–231. Review the assignment using Reproducible Masters 13-9 A and B as overhead transparencies and/or handouts. Demonstrate turning between centers. After the demonstration, discuss and encourage questions on the following:

- How to set up a lathe for turning between centers.
- Proper depth to drill center holes.
- How to check for center alignment.
- Selecting the proper size lathe dog.
- Proper way to mount work between centers. (Why a ball bearing center is preferred to a dead center.)
- Facing work mounted between centers.
- Facing to length.
- How to position the tool holder and cutting tool.
- Rough and finish turning.
- Turning to a shoulder.
- Grooving or necking operations.
- Emphasize the safety precautions that must be observed when turning between centers.

Part VI—Using Lathe Chucks

Set up lathes with the various types of chucks for demonstrations and student/trainee examination. Have students read and study pages 231–237.

Review the assignment using Reproducible Master 13-10 as an overhead transparency and/or handout. Demonstrate how the various types of chucks are used. Discuss the following:

- Advantages and disadvantages of the 3-jaw universal chuck.
- How to install jaws in the universal chuck.
- Advantages and disadvantages of the 4-jaw independent chuck.
- How to center work in an independent chuck.
- Using the Jacobs chuck in the tailstock and headstock.
- Advantages and disadvantages of the collet chuck.
- How to mount and remove chucks safely.
- Facing stock in a chuck. (How to tell whether the cutting tool is above or below center.)

- Plain turning and turning a shoulder.
- How to safely perform parting operations.
- Emphasize the safety precautions that must be observed when turning work mounted in a chuck.

Briefly review the demonstrations. Provide students with the opportunity to ask questions.

Technical Terms

Review the terms introduced in the chapter. New terms can be assigned as a quiz, homework, or extra credit. The following list is also given at the beginning of the chapter.

compound rest
cross-slide
depth of cut
facing
headstock
indexable insert cutting tools
plain turning
single-point cutting tool
tailstock
tool post

Review Questions

Assign *Test Your Knowledge* questions. Copy and distribute Reproducible Master 13-11 or have students use the questions on pages 239–240 and write their answers on a separate sheet of paper.

Workbook Assignment

Assign Chapter 13 of the ***Machining Fundamentals Workbook.***

Research and Development

Discuss the following topics in class or have students complete projects on their own.

1. Make large scale wooden models of the basic cutting tool shapes. They should be cutaway models to permit the various clearance angles to be easily observed.
2. Prepare a comparison test using carbon steel, high-speed steel, and cemented carbide cutting tools. Make the tests on mild steel (annealed), tool steel (heat treated), and aluminum alloy. Employ the recommended cutting speeds and feeds. Make a graph that will show the times needed by the various cutting tools to perform an identical machining operation. Also indicate surface finish quality.
3. Develop and produce a series of posters on lathe safety.
4. Develop a research project to investigate the effects of cutting fluids upon the quality of the surface finish of turned work. Prepare a paper on your findings.
5. Show a film or video tape on the operation of a CNC lathe or turning center.

TEST YOUR KNOWLEDGE ANSWERS, Pages 239–240

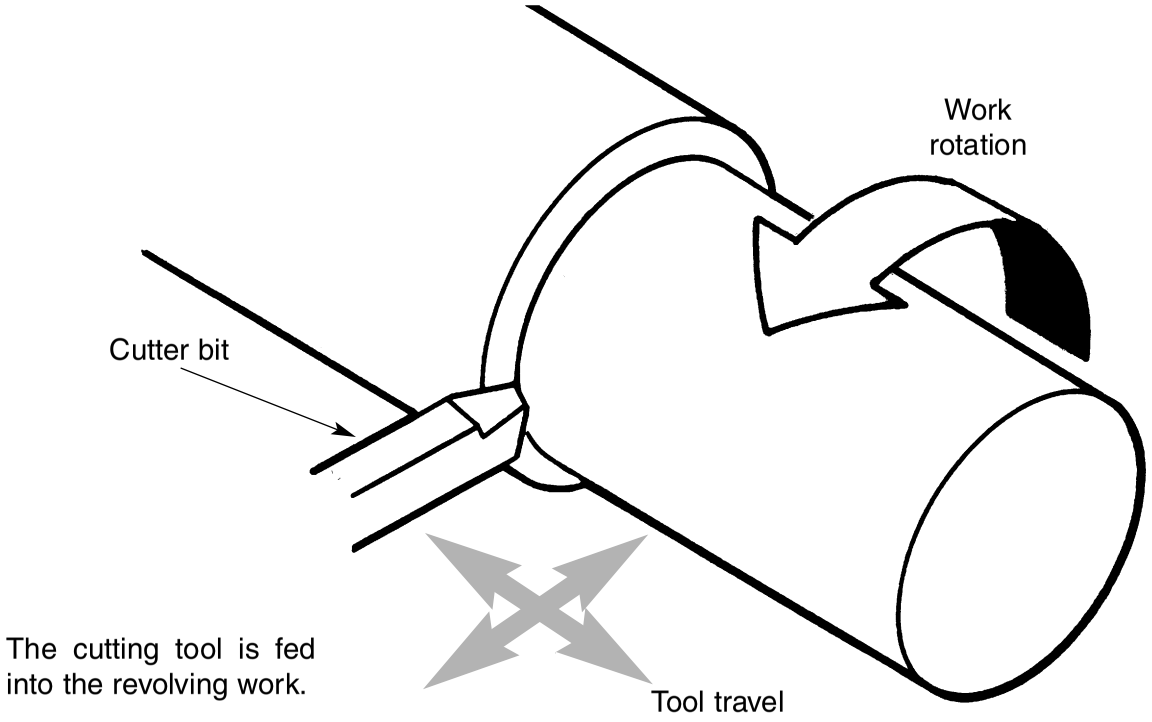
1. c. The work rotating against the cutting tool, which is controllable.
2. swing, length, bed
3. c. The length of the bed minus the space taken up by the headstock and the tailstock.
4. d. All of the above.
5. They provide precise alignment of headstock and tailstock and serve as rails to guide the carriage.
6. tool travel, spindle revolution
7. a. Fitted to the ways and slides along them.
   b. Permits transverse tool movement.
   c. Permits angular tool movement.
   d. Used to mount the cutting tool.
8. brush, your hands
9. b, c, d, and e.
10. high-speed steel (HSS)
11. carbide cutting
12. Cutting speed indicates the distance the work moves past the cutting tool, expressed in feet per minute (fpm) or meters per minute (mpm). Measuring is done on the circumference of the work.
13. Feed
14. A. 1600 rpm
    B. 200 rpm
15. 500 rpm
16. Between centers using a faceplate and dog, held in a chuck, held in a collet, and bolted to the faceplate.
17. Evaluate individually.
18. Checking centers visually by bringing their points together or by checking witness marks at base of tailstock.
19. Evaluate individually. Refer to Section 13.9.2.
20. Evaluate individually. Refer to Figure 13-76 in the text.

21. 3-jaw universal, 4-jaw independent, Jacobs, and draw-in collet. Evaluate descriptions individually. Refer to Sections 13.10.1 through 13.10.5.
22. one-third
23. To reduce chip width and prevent it from seizing (binding) in the groove.
24. Evaluate individually.

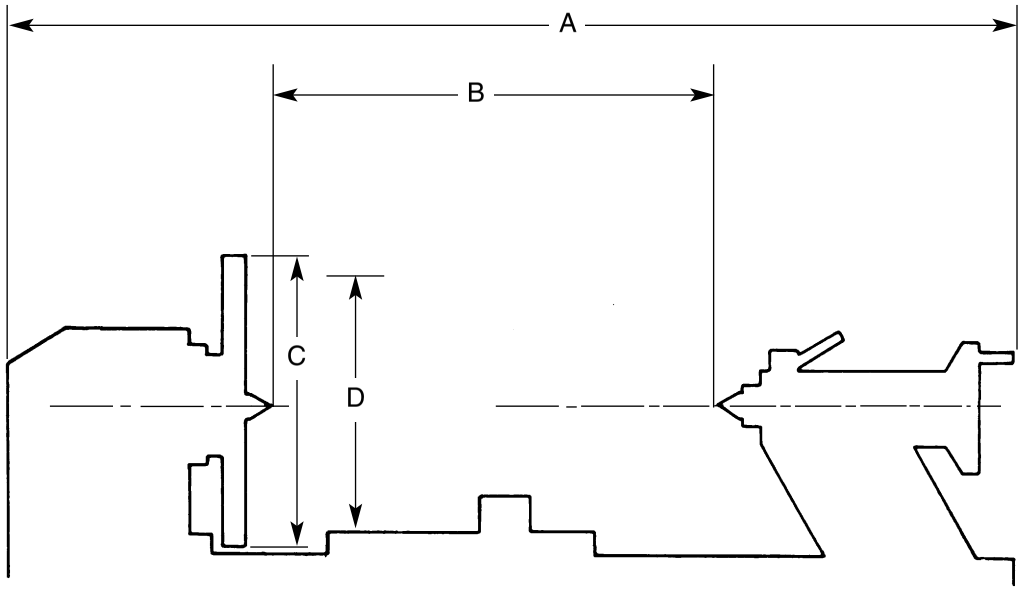
WORKBOOK ANSWERS, Pages 69–76

1. b. provides slower speeds with greater power
2. d. All of the above.
3. c. threaded spindle nose
4. d. All of the above.
5. index plate
6. lead screw
7. 2″ paintbrush
8. machine oil
9. b. to the left
10. d. It depends on the work being done.
11. e. None of the above.
12. Round nose tool
13. The irregular edge produced by grinding will crumble when used.
14. Chipbreakers
15. 685 rpm
16. 320 rpm
17. 84 rpm
18. 730 rpm
19. 186 rpm
20. a. 3-jaw universal
21. c. 4-jaw independent
22. b. Jacobs
23. collet; a separate collet is required for each different size or shape of stock
24. Using a dial indicator.
25. c. 4-jaw independent, 3-jaw universal
26. Be sure to remove the chuck key before turning on the machine.
27. c. bent-tail safety
28. b. bent-tail standard
29. a. clamp-type
30. combination drill
31. Eccentric diameters will result if the headstock center does not run true.
32. b. in either direction
33. That the cutter is slightly above center.
34. That the cutter is below center.
35. parting or cutoff
36. Long work should be center drilled and supported with a tailstock center.
37. A. Motor and gear train cover
    B. Carriage handwheel
    C. Thread and feed selector lever
    D. Quick-change gearbox
    E. Selector knob
    F. Lead screw direction lever
    G. Motor control lever
    H. Backgear handwheel
    I. Backgear control knob
    J. Headstock
    K. Variable speed control
    L. Spindle
    M. Carriage saddle
    N. Tool post
    O. Compound rest
    P. Dead center
    Q. Tailstock ram
    R. Ram lock
    S. Tailstock
    T. Tailstock lock lever
    U. Handwheel
    V. Cross-slide handwheel
    W. Rack
    X. Lead screw
    Y. Bed
    Z. Threading dial
    AA. Chip pan
    BB. Storage compartment door
    CC. Leveling screw
    DD. Tailstock pedestal
    EE. Clutch and brake handle
    FF. Half-nut lever
    GG. Power feed lever
    HH. Carriage apron
    II. Headstock pedestal
38. d. move faster or slower if the carriage is engaged to the lead screw
39. d. changes spindle speed
40. e. None of the above.
41. e. None of the above.
42. b. engages the half-nuts for threading
43. b. engages the clutch for automatic power feed
44. a. moves the entire unit right and left on the ways
45. c. automatic power cross-feed

Lathe Operation

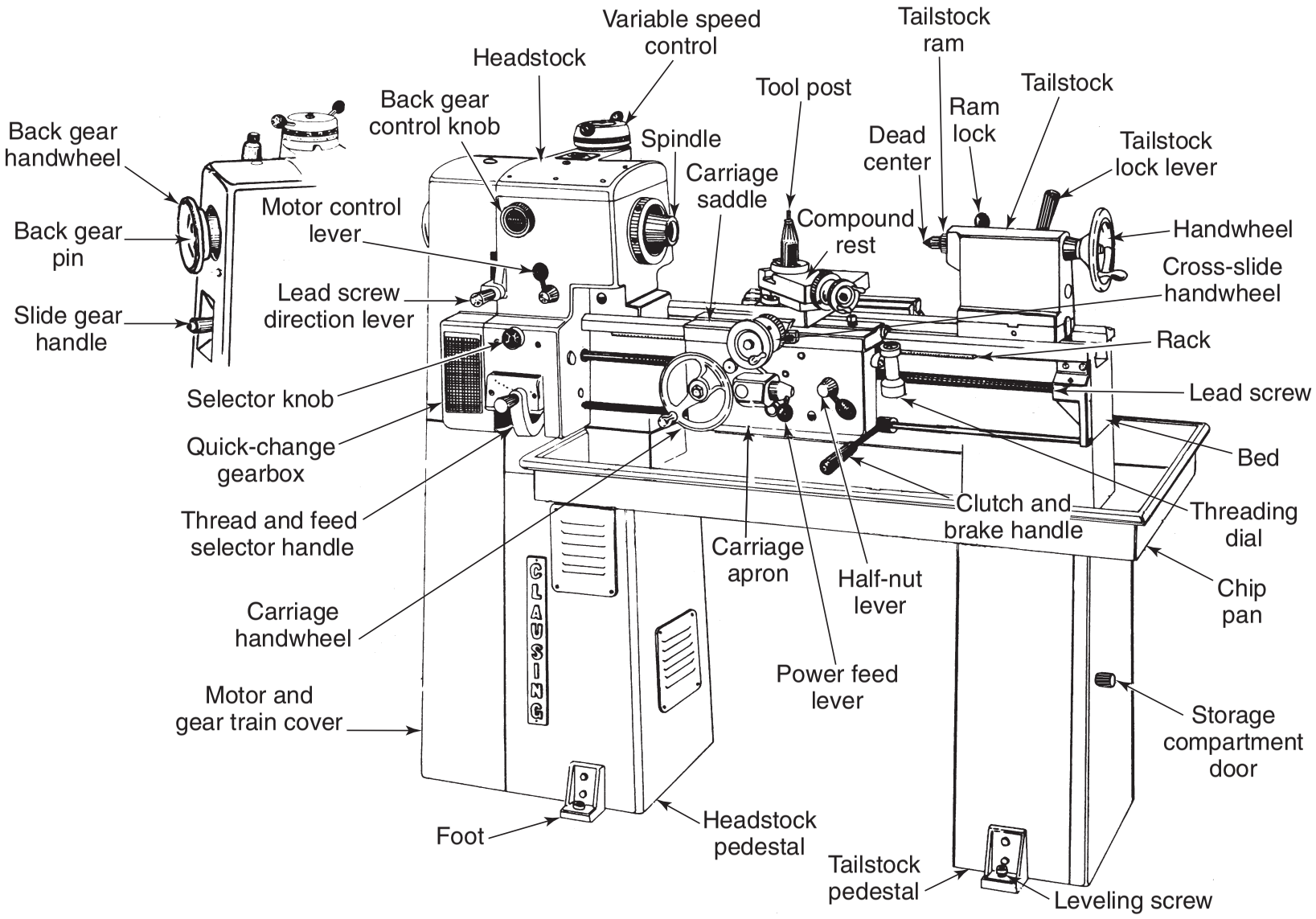


Lathe Measurement

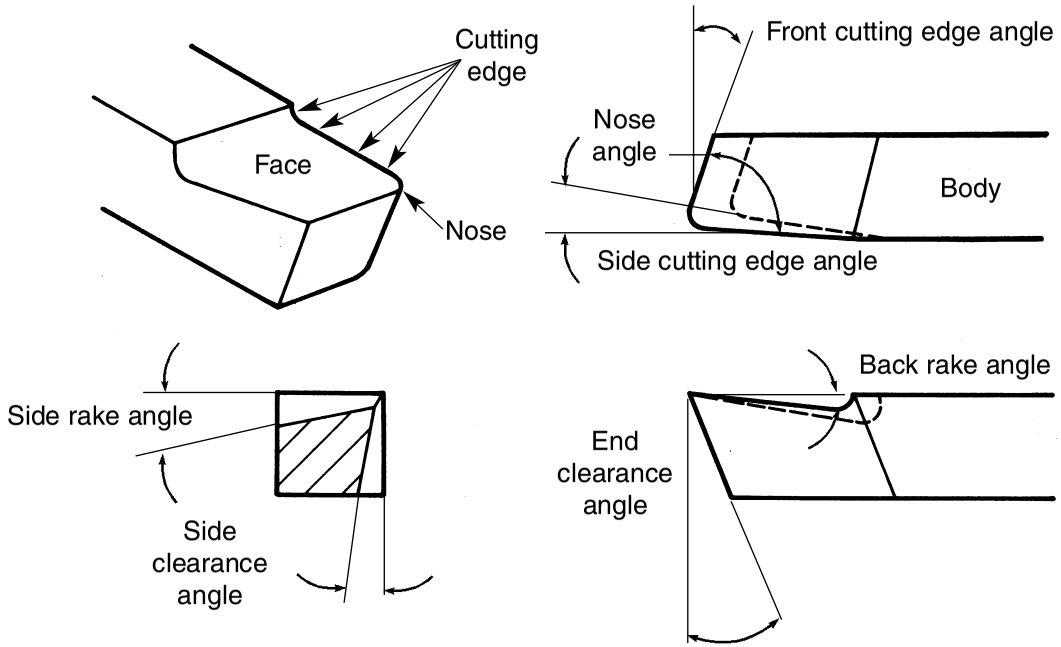


A—Length of bed. B—Distance between centers. C—Diameter of work that can be turned over the ways. D—Diameter of work that can be turned over the cross-slide.

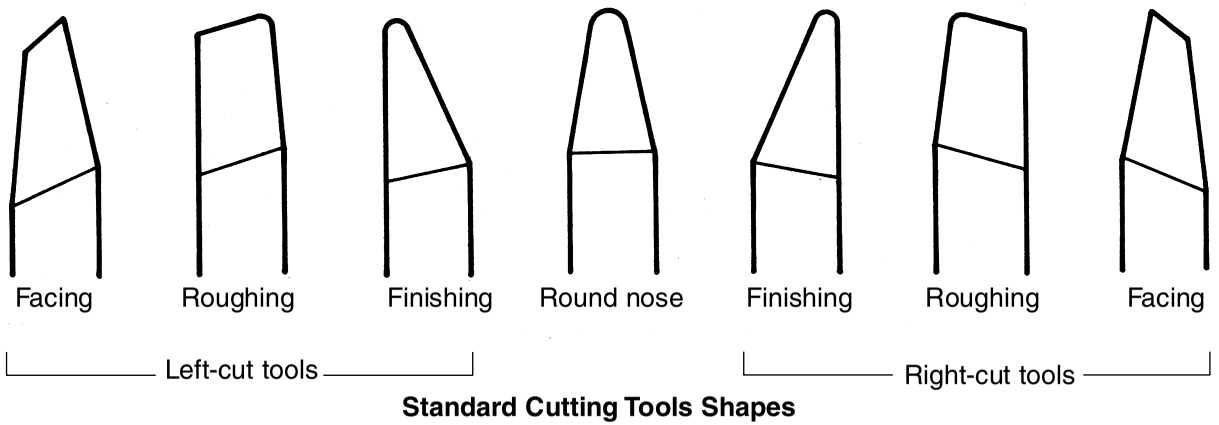
Parts of a Lathe



High-Speed Steel Cutting Tools

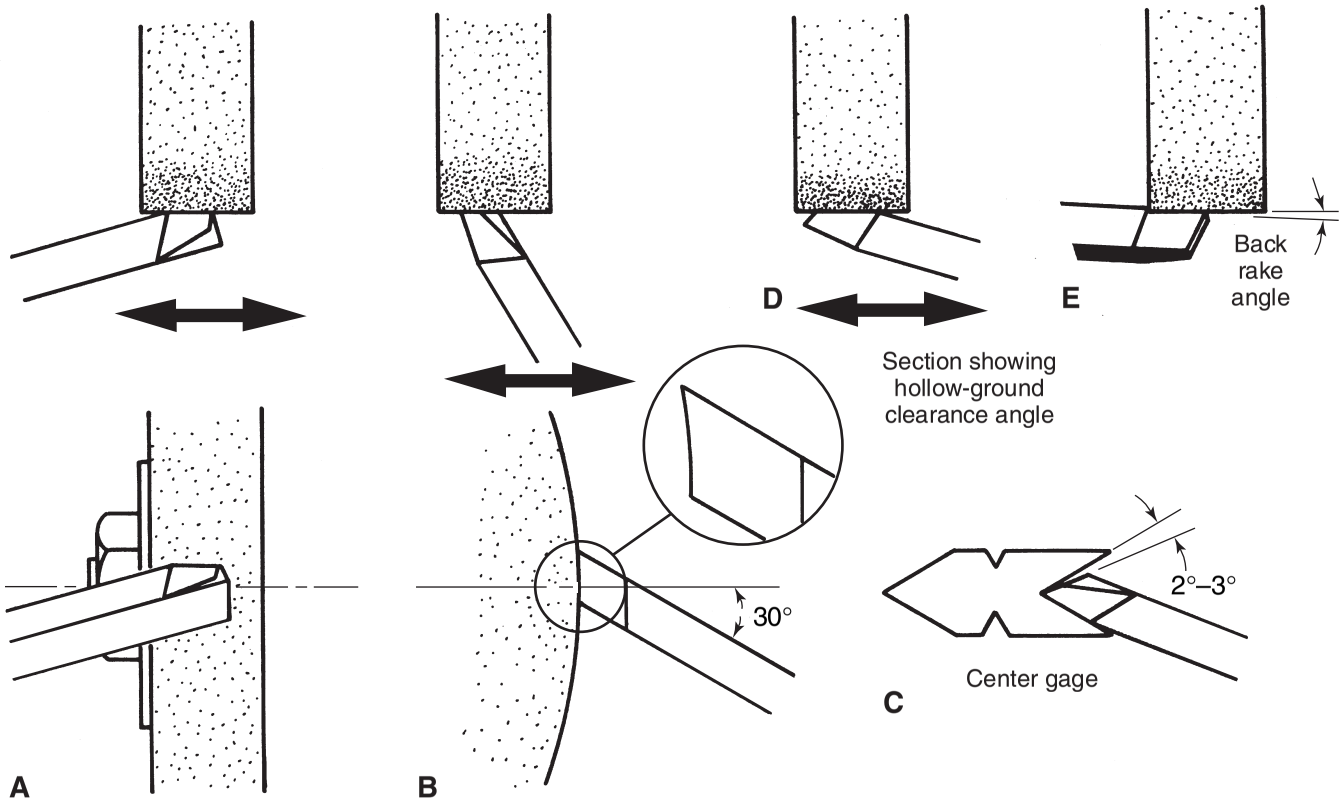


Cutter Bit Nomenclature

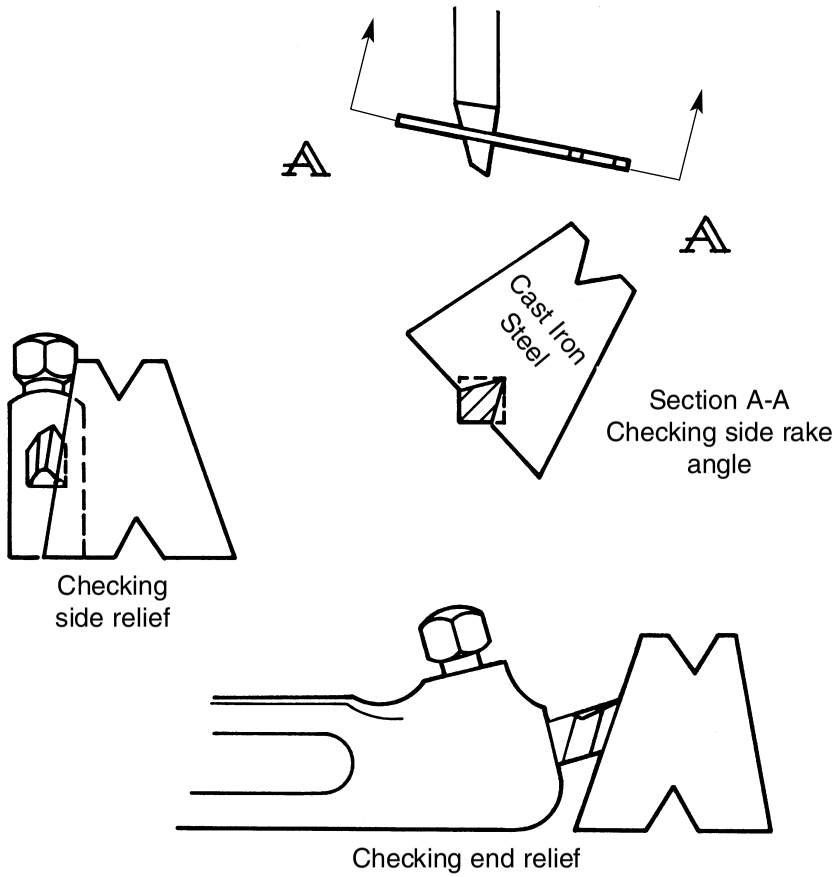


Standard Cutting Tools Shapes

Sharpening HSS Cutter Bits



Using the Cutter Bit



Bit gage being used to check accuracy after grinding cutter tip.

RAKE AND CLEARANCE ANGLE FOR LATHE TOOLS (High-Speed Steel)			
	Cast Iron	Low-Carbon Steel	High-Carbon Steel
Back Rake	6 – 8°	8 – 12°	4 – 6°
Side Rake	10 – 12°	14 – 18°	8 – 10°
Clearance *	6 – 9°	8 – 10°	6 – 8°
	Alloy Steels	Soft Brass	Aluminum
Back Rake	5 – 8°	0 – 2°	25 – 50°
Side Rake	10 – 15°	0 – 2°	10 – 20°
Clearance *	6 – 8°	10 – 15°	7 – 10°
	Copper		
Back Rake	10 – 12°		
Side Rake	20 – 25°		
Clearance *	6 – 8°		

* The end and side clearance angles are usually the same.

Calculating Cutting Speeds

- Cutting speeds (CS) are given in feet per minute (fpm), while the work speed is given in revolutions per minute (rpm). Thus, the peripheral speed of the work (CS) must be converted to rpm in order to determine the lathe speed required. The following formula can be used:

$$\text{rpm} = \frac{\text{CS} \times 4}{\text{D}}$$

rpm = revolutions per minute
CS = cutting speed of the particular metal being turned in feet per minute
D = diameter of the work in inches

Suggested Cutting Speeds and Feeds Using High Speed Steel (HSS) Tools				
Material to be Cut	**Roughing Cut 0.01″–0.020″ 0.25 mm–0.50 mm feed**		**Finishing Cut 0.001″–0.010″ 0.025 mm–0.25 mm feed**	
	fpm	mpm	fpm	mpm
Cast iron	70	20	120	36
Steel				
Low carbon	130	40	160	56
Med carbon	90	27	100	30
High carbon	50	15	65	20
Tool steel (annealed)	50	15	65	20
Brass–yellow	160	56	220	67
Bronze	90	27	100	30
Aluminum*	600	183	1000	300

The speeds for rough turning are offered as a starting point. It should be all the machine and work will withstand. The finishing feed depends upon the finish quality desired.

*The speeds for turning aluminum will vary greatly according to the alloy being machined. The softer alloys can be turned at speeds upward of 1600 fpm (488 mpm) roughing to 3500 fpm (106 mpm) finishing. High

Cutting Speed and Feed Problems

Name: _____ Date: _____ Score: _____

- Using the formula for cutting speeds, solve the following problems. Show your work in the space provided. Round your answers off to the nearest 50 rpm.

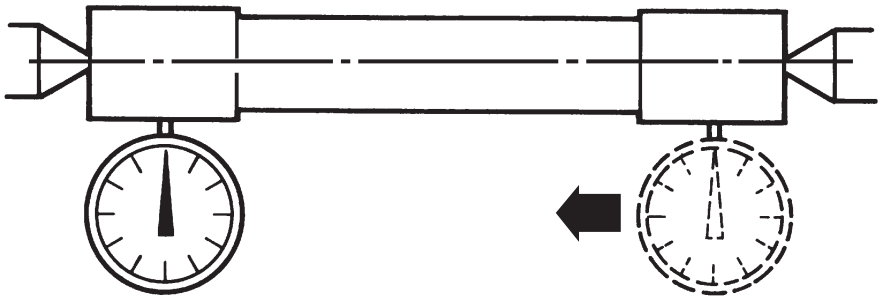
1. What spindle speed is required to finish turn 2.5″ diameter brass?

2. What spindle speed is required to finish turn 4″ diameter aluminum alloy?

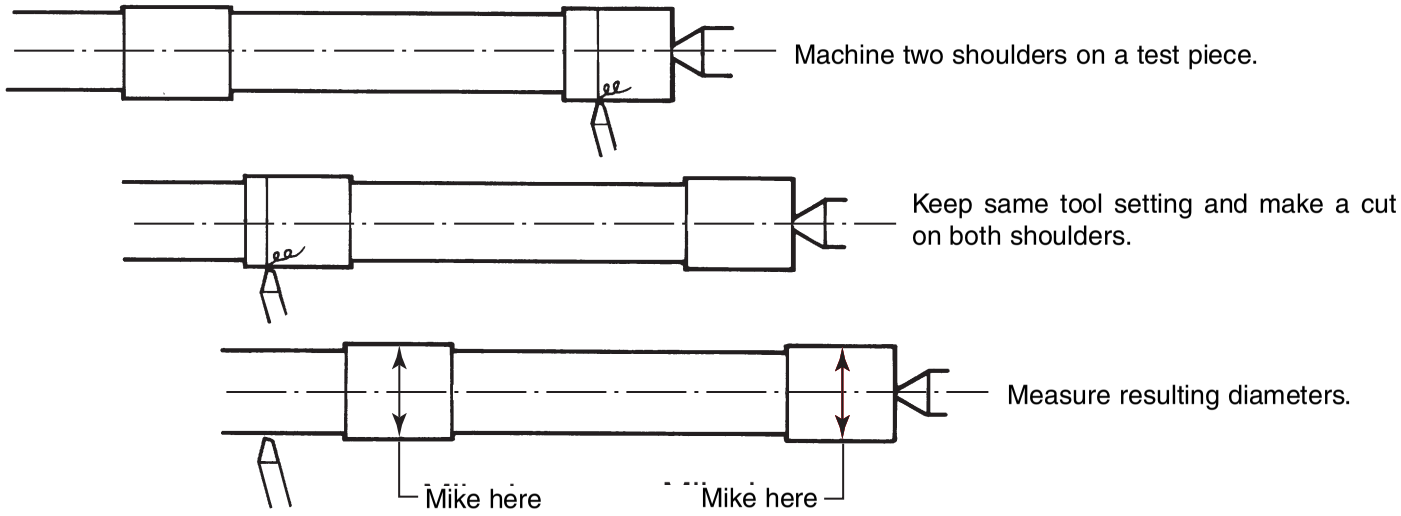
3. Determine the spindle speed required to finish turn 1.25″ diameter tool steel (annealed).

4. Determine the spindle speed required to rough turn 2″ diameter cast iron.

Checking Center Alignment

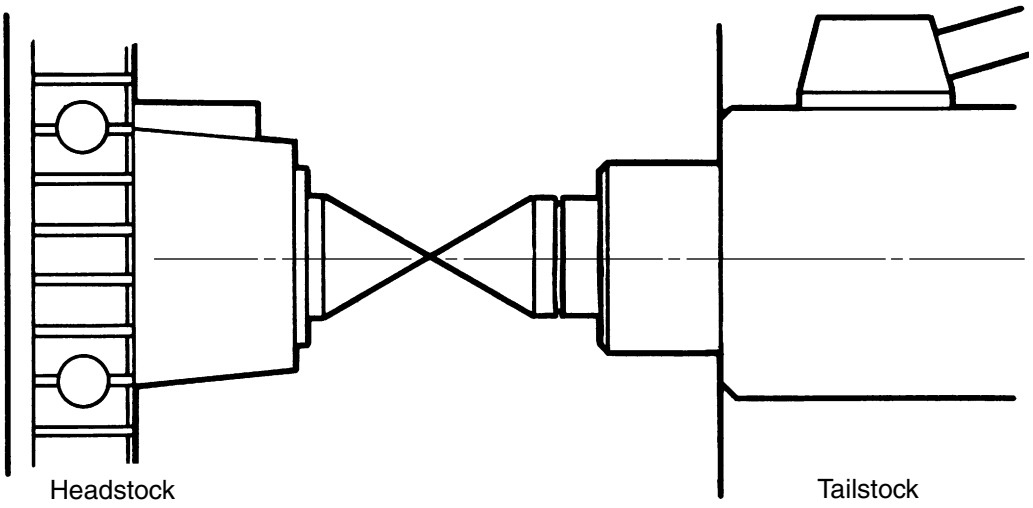


Using a Test Bar and Dial Indicator

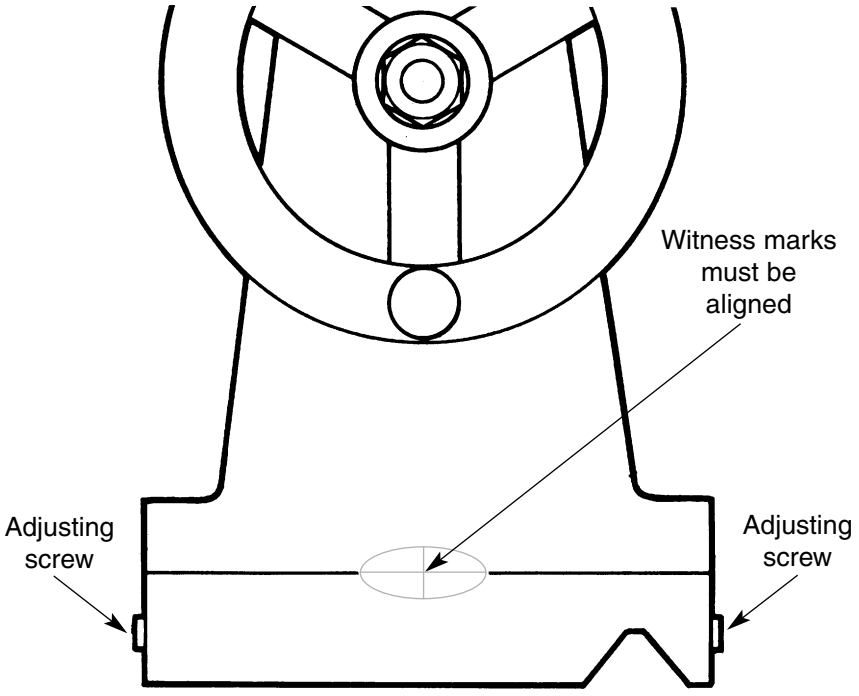


Using a Section of Scrap and a Micrometer

Checking Center Alignment

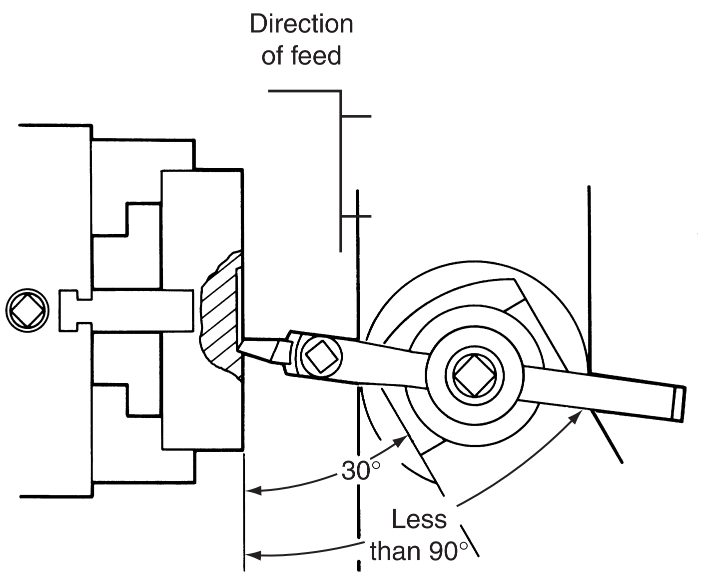


Checking Alignment by Bringing Points Together
(View is looking down on top of centers.)

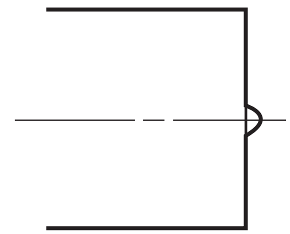


Checking Alignment by Checking Witness Lines on Base of Tailstock

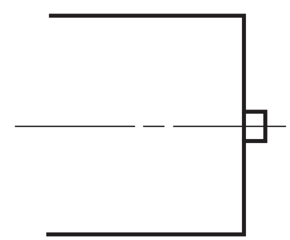
Facing in a Chuck



Correct tool and tool holder positions for facing.



Rounded nubbin left by cutter above center



Square-shoulder nubbin left by cutter below center

The Lathe

Name: _____ Date: _____ Score: _____

1. The lathe operates on the principle of: 1. _____
   a. The cutter revolving against the work.
   b. The cutting tool, being controllable, can be moved vertically across the work.
   c. The work rotating against the cutting tool, which is controllable.
   d. All of the above.
   e. None of the above.
2. The size of a lathe is determined by the _____ and the _____ of the _____. 2. _____
   _____
   _____
3. The largest piece that can be turned between centers is equal to: 3. _____
   a. The length of the bed minus the space taken up by the headstock.
   b. The length of the bed minus the space taken up by the tailstock.
   c. The length of the bed minus the space taken up by the headstock and the tailstock.
   d. All of the above.
   e. None of the above.
4. Into which of the following categories do the various parts of the lathe fall? 4. _____
   a. Driving the lathe.
   b. Holding and rotating the work.
   c. Holding, moving, and guiding the cutting tool.
   d. All of the above.
   e. None of the above.
5. Explain the purpose of ways on the lathe bed. _____
   _____
   _____
   _____
   _____
   _____
   _____
6. Power is transmitted to the carriage through the feed mechanism to the quick change gearbox which regulates the amount of _____ per _____. 6. _____
   _____

Name: _____

7. The carriage supports and controls the cutting tool. Describe each of the following parts:
   a. Saddle: _____
   _____
   _____
   b. Cross-slide: _____
   _____
   _____
   c. Compound rest: _____
   _____
   _____
   d. Tool post: _____
   _____
   _____

8. Accumulated metal chips and dirt are cleaned from the lathe with a _____, *never* with _____. 8. _____ _____

9. Which of the following actions are considered dangerous when operating a lathe? 9. _____
   a. Wearing eye protection.
   b. Wearing loose clothing and jewelry.
   c. Measuring with work rotating.
   d. Operating lathe with most guards in place.
   e. Using compressed air to clean machine.

10. In most lathe operations, you will be using a single-point cutting tool made of _____. 10. _____

11. Cutting speeds can be increased 300% to 400% by using _____ tools. 11. _____

12. What does cutting speed indicate? _____
    _____
    _____
    _____
    _____
    _____

13. _____ is used to indicate the distance that the cutter moves longitudinally in one revolution of the work. 13. _____

Name: _____

14. Calculate the cutting speeds for the following metals. The information furnished is sufficient to do so. 14. _____

    a. Formula: rpm $\frac{CS \times 4}{D}$
    b. CS = Cutting speed recommended for material being machined.
    c. D = Diameter of work in inches.

    Problem A: What is the spindle speed (rpm) required to finish-turn 2 1/2″ diameter aluminum alloy? A rate of 1000 fpm is the recommended speed for finish-turning the material.

    Problem B: What is the spindle speed (rpm) required to rough-turn 1″ diameter tool steel? The recommended rate for rough turning the material is 50 fpm.

15. Calculating the cutting speed for metric-size material requires a slightly different formula. 15. _____

    a. Formula: rpm = $\frac{CS \times 1000}{D \times 3}$
    b. CS = Cutting speed recommended for particular material being machined (steel, aluminum, etc.) in meters per minute (mpm).
    c. D = Diameter of work in millimeters (mm).

    Problem: What spindle speed is required to finish-turn 200 mm diameter aluminum alloy? Recommended cutting speed for the material is 300 mpm.

Name: _____

16. Most work is machined while supported by one of four methods. List them.

_____

_____

_____

_____

17. Sketch a correctly drilled center hole.

18. A tapered piece will result, when the work is turned between centers, if the centers are not aligned. Approximate alignment can be determined by two methods. What are they?

_____

_____

19. Describe one method for checking center alignment if close tolerance work is to be done between centers. _____

_____

_____

_____

_____

20. It is often necessary to turn to a shoulder or to a point where the diameters of the work change. One of four types of shoulders will be specified. Make a sketch of each. *Make your sketches on a separate piece of paper.*
    a. Square shoulder.
    b. Angular shoulder.
    c. Filleted shoulder.
    d. Undercut shoulder.

Name: _____

21. What are the four types of lathe chucks most commonly used? Describe the characteristics of each. _____

22. When using the parting tool, the spindle speed of the machine is about _____ the speed used for conventional turning. 22. _____

23. Why is a concave rake ground on top of the cutter when used for parting operations?

24. There are many safety precautions that must be observed when operating a lathe. List what *you* consider the five most important. _____