# MACHINE TOOL OPERATION

## INSTRUCTION SHEETS

BY

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*on Education and Special Training.*

Extract of Shaper section



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# PREFACE

There are certain things essential to machine-shop training, wherever or however gained. Some of these things may be gained by experience, and sometimes, perhaps too often, the experience is unnecessarily unpleasant. No doubt certain methods and processes are fixed in one's mind and body by practice, hence practice makes for speed and skill. Certainly the instructor must help his pupils and the foreman must help his apprentices get the necessary information and the properly directed practice. In any event, however, a reasonable amount of reading will make for quicker and better, and often easier, understanding of the elements of machine-shop work just the same as it does in any art or science.

These instruction sheets are designed primarily for school use, but many of them will be helpful to the apprentice in directing his study of what may be called "standard operations."

They are prepared to meet the needs of the beginner. If parts of them are easy, so much the better, if some parts are difficult, how much more difficult it would be to remember verbal instructions given an hour or a day before.

These sheets will help the student in machine work to focus immediately his attention upon the information suited to the job at hand as well as to direct the sequence of the operations. They are a help in continuous action for the boy in the shop. How many boys have quit work a quarter to a half hour, during the shop period and especially towards the end of the period because they "didn't know what to do next."

These sheets are a help in the feeling of progress on the part of the student. He feels that he has mastered certain

of the directions during his shop period or he feels at the end of a month that he has accomplished a number of real jobs.

They are of especial help to the slow or diffident pupil. Four out of every five boys who fail, do so because they have lost interest. They have lost heart because they "didn't know how" and the other fellows got ahead. They didn't know how because for some reason or other they didn't fully understand the instructions of demonstration or lecture and were too diffident or too proud to admit it. These instruction sheets are less likely to be misunderstood, or not understood, than verbal instructions.

These instruction sheets create familiarity with the text. A paragraph referred to will often lead into the next and the student will read it; or he will see an illustration that looks interesting and he will study it. They create a favorable familiarity—the student soon regards the book in the same way as he does his micrometer—as a help, as a tool, and not as something to be endured. Thus, the boy in the shop is being trained to obtain, absorb, and apply information from the printed page and from diagrams. This is valuable but not all. Incidentally he must reason. It may be more or less unconsciously on his part, but all the while he is busy studying and doing and thinking, he is being trained to use his hands and his head and that is what he is in the shop to do.

These instructions are for unit operations and should serve almost automatically to develop a knowledge of job analysis. As the student progresses he can analyze a given job and plan the operations involved. For example, a job is to make two spur gears.

Operation 1, Make the holes, Instruction Sheets D-4 or L-16 or L-17.

Operation 2, Face and turn, Instruction Sheet L-20.

Operation 3, Cut the teeth, Instruction Sheet M-11.

Operation 4, Plane the key seats, Instruction Sheet S-6.

These sheets have been prepared with several purposes in view—to provide a certain amount of instruction in themselves, to give definite page references to the text, and to furnish a plan of procedure in order to get acquainted with the machines and perform the given operations.

They have been used for several terms in the form of typewritten pages etc., and even so have been highly successful in making machine-shop work much more interesting and valuable for the student, and the teacher's work easier and more worth while. The boys like the sheets. They seem to enjoy looking up the references, doing the "written work" and finally getting a high mark on the "tests."

## SUGGESTIONS REGARDING THE USE OF THE INSTRUCTION SHEETS

Have in the tool room a reasonable number of books to check out the same as any tool. They will get soiled of course, but at that they will last as long as do the school books that are carried around. Have also a few clean books to loan to the boys who may wish to take an instruction sheet home.

The instruction sheets should be filed in a cabinet suitably partitioned and marked. The cabinet may be kept in the tool room or elsewhere, as desired.

In certain of the instruction sheets, answers to questions or problems are called for, and notebooks or composition paper should be provided. This written work serves, among other things, as proof that the student has looked up the references. It may or may not be corrected, as the teacher sees fit, but it should be checked and credit should be given.

At the end of most of the sheets is a list of questions that the student should be prepared to answer. When he is ready, give him a card with any four or five of these questions written on it, and paper on which he may write the answers. This serves as a test, and is invaluable. It is comprehensive and fair, the boys try for high marks, and the instructor's part is easily and quickly done.

The best way to study the instruction sheet depends, of course, on the particular sheet and on the type of student. The "Get Acquainted" sheets are a step-by-step procedure. In the others, many of the students prefer to read the sheet through to get a general idea, go through again and look up the references, next do the written work, then perform the operation, and finally take the test.

**Machine Shop Record Card**

Name: Bertrand Praschak

Operation: Getting ac. with the shaper

Instruction Sheet No. 5

Mach. No. ____ Job No. ____ No. pieces ____ Net pds. 4

Total pds. 6 from May 29 to May 31 Time out 2 periods

Reasons for time out: Memorial Day

| Instruction Sheet | RECORD | Practical Work |
|---|---|---|
| Written work ✓ ckd by H | | Accuracy etc. ____ ckd by ____ |
| Test 100 ckd by H | | Speed ____ ckd by ____ |

Record slips of some kind are very helpful in two ways: they provide a fair means of gaging the student's work at the end of the month, and provide also, if needed, a record of the work he has done. The slip illustrated, printed on a low-grade of paper, has proven very satisfactory as a record card for both instruction sheet and practical work. These slips may be numbered and clipped together, in order, until such time as the instructor calls for them.

H. D. B.

JERSEY CITY, N. J.
*August*, 1928

# BOOKS AND INSTRUCTION SHEETS

BY

HENRY D. BURGHARDT

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## MACHINE TOOL OPERATION

PART I

The Lathe, Benchwork and Work at the Forge

326 pages, 5½ × 8, 228 illustrations

PART II

Drilling Machine, Shaper and Planer, Milling and Grinding Machines, Gears

440 pages, 5½ × 8, 297 illustrations

## INSTRUCTION SHEETS FOR MACHINE TOOL OPERATION

PART I

Envelope containing 27 loose-leaf instruction sheets

PART II

Envelope containing 27 loose-leaf instruction sheets

PARTS I AND II

Bound together, in book form to match the texts.

McGRAW-HILL BOOK COMPANY, INC.
370 Seventh Avenue, New York

# LIST OF INSTRUCTION SHEETS

# MACHINE TOOL OPERATION

## PART I

By

HENRY D. BURGHARDT

### Small Tools

T-1. Using Measuring Tools—Scales, Calipers, Micrometers.
T-2. Using a Hack Saw.
T-3. Using a File.
T-4. Using a Tap and a Threading Die.

### Lathe

L-1. Getting Acquainted with the Lathe (No. 1).
L-2. Getting Acquainted with the Lathe (No. 2).
L-3. Centering Work in a Lathe.
L-4. Facing to Length—On Centers or in a Chuck.
L-5. Setting the Right Speed Feed and Chip.
L-6. Turning Straight (Roughing Cut).
L-7. Turning Straight (Finishing Cut).
L-8. Turning a Square Shoulder.

L-16. Chuck Work—Drilling and Machine Reaming.
L-17. Chuck Work—Boring and Hand Reaming.

L-20. Holding Work on a Mandrel.

L-25. Taper Turning; Off-set of Tail-stock Method.
L-26. Taper Turning with Taper Attachment.
L-27. Turning an Angle.

L-30. Getting Acquainted with Threads.
L-31. Gearing a Lathe for Cutting Threads.
L-32. Cutting a U. S. Standard Thread.
L-33. Measuring Threads by the Three-wire Method.
L-34. Cutting a Square Thread.
L-35. Cutting an Acme Thread.
L-36. Cutting an Inside Thread.

## Forge

F-1. Hardening and Tempering.
F-2. Making a Cold Chisel or a Screw-driver.

## Memorandum

Instruction sheets concerning the following jobs have not been prepared because it is believed that the information as given in the text on the pages indicated is sufficiently clear, direct and localized.

# MACHINE TOOL OPERATION

## Instruction Sheet S-1

## GETTING ACQUAINTED WITH THE SHAPER

References unless otherwise specified are to letters and numbers on the illustration of the shaper (Fig. 63, p. 68).

**1. Read Arts. 53, 54 and 55 beginning page 65 to get an introduction to the shaper and its value in machine shop work.**

**2. Move the table.**

Put the crank handle, furnished with the machine, on the squared end of the table feed screw (43) and move the table *G* to the far end of the cross-rail *E*.

**3. Oil the cross-rail bearing surfaces.**

(*a*) Cover the flat bearing surfaces, top, front, and back, of the exposed part of the cross-rail with machine oil, using your fingers to spread the oil.

(*b*) Run the table to the rear end of the cross-rail and oil the surfaces now exposed. Then run the table to about midway position.

**4. Raise and lower the table.**

(*a*) Be sure the thrust bearing at the base of the elevating screw (18) is seated, then loosen clamping screws (19) and table support (22) (if your shaper has a table support), and raise and lower the table (precaution—12, p. 99). (Information, (**Art. 61,** page 74.))

(*b*) On a piece of composition paper, state why the thrust bearing at the base of the elevating screw should be seated before the saddle-binding bolts are loosened.

References: "Machine Tool Operation," Part II—Burghardt.

## 5. Find the length of stroke for which the shaper is set.

By hand, pulling the belt if the shaper is belt driven, or if motor driven, turn hand wheel (32) and move the ram *C* to whichever *end* of the stroke the pointer (3) is over the number on the side of the ram. This number 2, 8, 10, or whatever it may be, indicates in inches the length of the stroke to which the shaper is now set. Start the machine and see if the length of the stroke tallies with the number of inches indicated.

## 6. Change the length of the stroke.

(*a*) Once more bringing the ram *C* to position at end of stroke, as directed above, loosen knob or nut (5) and putting crank handle on squared end of shaft (4) turn (4) and notice that the pointer (3) indicates a change in the length of the stroke. Set the stroke for 4 inches, tighten knob (5), and compare the length of the stroke with the length indicated. (Information, **Art. 56,** p. 67 and **Art. 57,** p. 70.)

(*b*) State on your paper the name of each part that moves when you turn the shaft to change the length of stroke as: shaft (4), bevel gear G, bevel gear H, etc.

## 7. Adjust the ram for any desired position of stroke (Art. 58, p. 71).

State the name of each part that moves when you change the position of the stroke.

## 8. Set the shaper for various speeds.

(*a*) Read **Art. 60,** page 72.

(*b*) Have the length of the stroke 4 inches or less, because over 4 inches may be too long for the faster speeds of the shaper.

(*c*) Set for the slowest speed by belt or by the speed-changing levers (30) (31) and (33). If this shaper has a speed box and levers are used, it may be necessary to move the hand wheel (32) a trifle in order to engage the gears. Do not change gears while the shaper is running by power.

(*d*) Start the machine by power (lever (29)) and note the speed. How many strokes per minute?

(*e*) Set for various other speeds. (Information, pages 72 to 74.)

**. Set the feed.**

(*a*) Have the work table *G* approximately middle position on cross-rail *E* and the shaper running fairly slow. Then move the pawl knob ((40) Fig. 63, and see also Fig. 68, p. 76), and "throw in the feed." Notice which way the table feeds, towards you or away from you.

(*b*) Now lift the pawl knob and turn it half around. Notice that this serves to "reverse the feed."

(*c*) From the information given in the text (pp. 76 to 78 and Figs. 68, 69, and 70) see if you are able to understand the feeding mechanism of your shaper.

(*d*) Answer questions 9 and 10, pages 80 and 81.

**. Loosen the clamping bolt (14) and swivel the apron (Information p. 79). Tighten in central position.**

Never strike the apron except with wood or babbitt.

**. Loosen the swivel head-plate clamping bolts (9) and swivel the head say 30 degrees, in either direction. (Information p. 79.) Tighten it exactly on zero.**

Written work: See instructions **5, 7, 8,** and **9** (*d*).
Be prepared to answer the questions on pages 75 and 76, mbered as follows and answered on the page indicated:

**2,** pp. 67 and 69.
**6,** p. 70.
**10,** Fig. 64 and p. 71.
**11,** p. 71.
**16,** p. 74.
**18,** p. 66.

so the question on pages 80 and 81:

**5,** p. 76.
**7,** p. 78.
**8,** p. 76.
**10,** p. 77.
**22,** p. 80.

ıd find the answers to **6, 9, 15, 16, 18,** and **19** by your own lculation or investigation.



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# MACHINE TOOL OPERATION

## Instruction Sheet S-2

## PLANING A HORIZONTAL SURFACE AND A RECTANGULAR PIECE

1. **Be sure that the jaws of the shaper vise are clean, that is, free from chips and burrs (Art. 83, p. 97).**

2. **If, in the opinion of your instructor it is necessary, test the work seat (Arts. 79 and 80, p. 95) and the solid jaw (Art. 81, p. 96).**

3. **Measure the work and the height of the vise jaws.**

   Then obtain parallels (**Art. 76,** p. 94) of a size that will permit the work to be securely held and yet project a sufficient amount above the vise jaws (Fig. 95, p. 107).

4. **Read Art. 84, p. 98, "Hints on Shaper Work."**

5. **Write your own understanding of hints 9, 12, 16, and 17, and be able to explain any of the rest of them.**

6. **Tighten the work in the vise.**

   Use protecting pieces, and tap the work lightly with a babbitt hammer to seat it on the parallels (see 3, 4, and 9, p. 99).

7. **Read Art. 85, page 100, "The Horizontal Cut." Write on your paper the answers to the following questions:**

   (*a*) **How should the clapper block fit?**
   (*b*) **In what position should the tool be clamped? Why?**
   (*c*) **How is a strain caused in the tool head by running the slide down too far?**
   (*d*) **What is the objection to having the tool rub on cast-iron scale?**

References: "Machine Tool Operation," Part II—Burghardt.

**8. Select the tool (see pp. 82 to 86).**

**9. Fasten the tool in the tool post. Catch it fairly short in vertical position and clamp it tight.**

(*a*) The tool selected will probably be a left-hand tool bit in a lat tool holder, or a holder and tool similar to Fig. 75, page 86.
(*b*) Why is a left-hand tool used? (see **Art. 67,** p. 83).
(*c*) Why is it held in a vertical position? (see p. 101).

**10. Arrange the "length of the stroke" (p. 70) ¾ inch long than the work (reason, p. 100).**

**11. Arrange the "position of the stroke" (p. 71) ½ inch befo the beginning of the cut (reason, p. 100).**

**12. Inspect the clapper box to see that it moves freely an seats properly (see p. 101).**

**13. Calculate the number of strokes necessary to give th required cutting speed. (Table, p. 89; Rule 2, p. 90.)**

Then set the machine to the nearest speed available (**Art. 60,** p. 72

**14. Read Art. 70, page 88, "Depth of Cut and Amount Feed."**

**15. Now read Art. 62, page 76, and set the feed-adjustin knob to give the required amount of feed on the retur stroke.**

**16. Adjust the down-feed screw handle to give the desire depth of cut.**

Be sure the tool-head slide is not moved down much if any belo the head. Raise the table if necessary (p. 101).

**17. Have your instructor inspect your set-up, and with hi permission proceed to take the cut (see bottom of p. 101)**

State on your paper the reason for the statement contained in las two lines on page 101.

**18. Plane a similar cut on the next piece.**

When the surface is planed, stop the ram at the beginning of th stroke, and, without changing the down feed, run the work bacl

(cross-feed) to the beginning of the cut. Take out the work, put in the next piece, and take a similar cut on that.

. **When the first surface is planed on all of the pieces, then plane an adjacent surface ((2), Fig. 95, p. 107).**

. **After taking this cut test for squareness.**

. **When cut (2) is planed on all of the pieces, plane (3) and (4) (see p. 107).**

. **Square the ends (Art. 89, p. 107).**

(*a*) If necessary to take a vertical cut see **Art. 87,** page 103.
(*b*) The tool used for the vertical cut may be any one of several kinds: The lathe-turning tool holder and bit (right-hand, that is, side rake as for a turning tool bit) is satisfactory for the average small job if the tool holder is tipped somewhat. Or the shaper tool holder (Fig. 75, p. 86). Also forged tools (2) and (3), pages 84 and 85.

Written work: See instructions **5, 7, 9** (*b*) (*c*), and **17.**
Be prepared to answer the questions on page 91, numbered follows and answered on the page indicated.

**1,** p. 88.
**2,** p. 89.
**4,** p. 89.
**7,** p. 89.

so the questions on page 105:

**1,** p. 99.
**2,** pp. 94 and 99.
**4,** p. 94.
**10,** p. 98.
**12,** p. 101.
**13,** p. 101.
**14,** p. 102.
**17,** p. 101.
**20,** p. 100.

# MACHINE TOOL OPERATION

## Instruction Sheet S-3

## PLANING A VERTICAL OR AN ANGULAR CUT

A *vertical cut* is made in the shaper (or planer) by setting the head exactly on zero, arranging the apron so that the tool will clear the work on the return stroke, and feeding down.

An *angular cut* is made by *swivelling the head* of the machine, arranging the apron so that the tool will clear the work on the return stroke, and feeding down.

It should be understood that it is not always necessary to take an angular cut to produce an angular surface. An angular surface is one that is neither parallel nor square to a given base or other surface. It may be machined in several ways:

(*a*) The work may be supported on a tapered parallel (this is often called a taper cut).

(*b*) A layout line indicating the position of the surface to be planed may be scribed on the work, and the work held in the vise with this line horizontal (for either taper or angle).

(*c*) The work may be held in degree parallels (Fig. 85, p. 94).

(*d*) The vise may be swivelled to an angular setting (**Art. 73,** p. 91).

(*e*) Some shapers are provided with a universal table (illustrated in Fig. 81, page 92 and described at top of page 75).

(*f*) The head of the shaper may be swivelled as shown in Fig. 78, page 92, and Fig. 94, page 105.

References: "Machine Tool Operation," Part II—Burghardt.

Excepting a down cut on a piece held in a vise which ha been swivelled to a given angle (as in (*d*) above) all of the firs five methods suggested require only the regular horizontal cu The last method (*f*) involves the angular setting of the swiv head and is very properly called "an angular cut."

This instruction sheet is primarily for the purpose of callin your attention to the set-up of the shaper (or planer) for th down cut for producing either a vertical cut (*a* Fig. 94, 105) or an angular cut *b* or *c*, same figure.

**1. Read Art. 87, page 103. "Vertical and Angular Cuts."**

**2. Be able to explain Fig. 93, page 104.**

**3. Memorize the rule for setting the apron.**

**4. Answer in writing, questions 17, 18, 20, 21, 22 and 23, o page 106.**

Refer to pages 100 and 101 for answers to 17, 18, and 20.

**5. Set the work in the machine.**

(*a*) Cleaned.
(*b*) Rigidly and securely held.
(*c*) Arranged so that the cut you are to make may be complete without change.

**6. Set the head.**

(*a*) If you are to make a vertical cut set the head on zero.
(*b*) If you are to make an angular cut, set the head to the complemen of the angle (90 degrees minus the angle).

**7. Set over the apron (rule, page 104).**

**8. Select the tool.**

There are several kinds of tools that may be used for down cutting The lathe-turning tool holder and bit is satisfactory for the averag job. Or the shaper tool holder (Fig. 75, p. 86). Also the forge tools (2), (3) and (7), pages 84 and 85.

**. Run the tool head slide up, and set the tool.**

The position of the tool head slide, that is, the distance it is raised, is important, and the position of the tool, the distance it projects and the angle to which it is set must be considered. These settings depend upon the distance from the top to the bottom of the cut you are to make and both should be as rigid as the cut will permit. Read the last two paragraphs on page 104.

**. Set the stroke for length and position.**

**. Adjust the height of the table if necessary.**

(*a*) If the table is too high the ram may not clear the work.
(*b*) If the table is too low, either the tool will have to project too much or the slide will be fed too far down.

**2. Set the speed.**

**3. When planing your first vertical or angular job, have your instructor inspect the set-up.**

(*a*) Setting of work.
(*b*) Setting of head.
(*c*) Swivel of apron.
(*d*) Kind of tool selected.
(*e*) Setting of tool.
(*f*) Vertical position of tool head slide for start of cut.
(*g*) Height of table.
(*h*) Speed.

**4. Proceed to take the roughing cut.**

If more than one roughing cut is needed, run the tool up to the eginning and move the table (hand cross-feed) as much as you desire or the next cut.

**5. Test the surface after the roughing cut.**

(*a*) Use a square, or a protractor, or a special gage, depending on the job.
(*b*) Do not wait until the finishing cut is made before learning that the head is not set exactly right.

**16. Take the finishing cut.**

For finishing tools, refer to Fig. 100, page 110, which shows too bits ground for corner or end, and suitable for steel or cast iron; also to Fig. 73, page 83, and to (7), Fig. 74, page 84.

Written work: See instruction **4** only: Quizzes **2 and 3**.

Be prepared to answer the following questions:

1. State four methods of planing an angle on a piece.
2. Give the rule for setting the apron for a vertical cut.
3. Explain the importance of the position of the tool head slide when starting a vertical or angular cut.
4. When should a vertical or angular cut be tested?



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# MACHINE TOOL OPERATION

## INSTRUCTION SHEET S-4

## PLANING A TONGUE OR A GROOVE

In nearly all cases where such operations as tongue and groove (Fig. 98, p. 109) or dovetails (Fig. 104, p. 112) are to be made a base surface is assumed to be planed. Also the surface where the tongue or groove or dovetail is to be cut is roughed to within $\frac{1}{32}$ inch. The other surfaces are usually planed square with the base surface at the same time, if they are ever to be planed. Assuming that these surfaces are already planed, you are ready for the tongue or groove, whichever your instructor prefers to have made first. The tongue is considered easier because there is more room for the tool.

**1. Read Art. 91, page 109.**

**2. Lay out the work.**

(*a*) Possibly a micrometer or a gage is to be used to measure the finished work, but even so the layout is useful when roughing.
(*b*) For information on laying out work, refer to Chap. XIII, Part I, beginning page 229.
(*c*) If practicable, make one job of laying out both tongue and groove.
(*d*) Make the layout on the end that will be in front when the work is in the shaper.

### PLANING THE TONGUE

**3. Set the work in the shaper.**

Have it clean, securely held, firmly seated, and the cut to be made free from obstruction such as clamps or vise jaws.

References: "Machine Tool Operation," Part II—BURGHARDT.

**4. Set the tool.**

(*a*) For roughing use a regular shaper tool, ground with a fairl small round nose.
(*b*) The tool will cut closer to the shoulder if it is tipped to brin the point towards the shoulder.
(*c*) Be very sure the tool is tight in the tool post.

**5. Set the machine for the length and position of the stroke and for the right speed.**

**6. Rough out the material between the right-hand layou lines.**

(*a*) Take fairly heavy cuts to remove the metal quickly.
(*b*) Start the tool at the edge and feed towards the center.
(*c*) Stop the power feed about $\frac{1}{8}$ inch from the vertical line and feed close to the line by hand.
(*d*) Finally cut to within about $\frac{1}{32}$ inch of both lines.

**7. Rough out the material between the left-hand lines.**

(*a*) Put in a tool of opposite rake and reset the tool holder.
(*b*) Proceed as in 6 (*a*), (*b*), (*c*) and (*d*) above.

**8. Select and set the finishing tool.**

NOTE: When a vertical surface over $\frac{1}{2}$ inch high is to be finished, it is usually necessary to set over the apron to allow the tool to clear the work on the return stroke. It is advisable to do this even when finishing a horizontal cut to a shoulder as in a tongue or groove. (See "Vertical and Angular cuts," Art. 87, p. 103 and also Instruction Sheet S-3.)

(*a*) For the smaller jobs, say a tongue not over $\frac{1}{2}$ inch high, of cast iron, the squaring tool illustrated in (5) Fig. 74, page 84, may be used for all surfaces (no set over of the apron needed).
(*b*) For steel work and for the larger jobs of cast iron the shoulder tools shown in Fig. 100, page 110, are best. (Set over the apron.)

**9. Finish one of the vertical surfaces.**

(*a*) Whichever tool is used, first cut away (with this tool and hand feed) most of the fillet left by the round-nosed tool when roughing.

(*b*) Then finish the vertical surface to the layout line, or to measure or gage, if advisable, and feed down practically to the horizontal line.

**). Finish the other vertical surface.**

(*a*) If the apron has been set over, reverse its position and reset the tool on the other side.
(*b*) If the squaring tool is used without setting over the apron, merely run it up, and over to the beginning of the other cut.
(*c*) Finish the other vertical surface to make the tongue the correct size, feeding down nearly to the horizontal line.

**1. Finish the horizontal surfaces.**

(*a*) If the shoulder is under ½ inch high and a squaring tool is used, have the apron in normal (vertical) position and be sure the tool is ground and set square.
(*b*) If the shoulder tool is used, have the apron set over in the right direction and then set the tool square.
(*c*) If you are going to use the graduations on the down feed for gaging the vertical distance, first plane the top surface of the *tongue* (*b* Fig. 98, p. 109) to finish size then run the tool down the right distance and finish surface *a*, beginning at the edge and feeding towards the center.
(*d*) If you are going to use a size block (Fig. 99. p. 110) to gage the vertical distance, first plane surfaces *a* then set the tool by the size block and finish surface *b*.
(*e*) If a squaring tool is used both surfaces *a* may be finished with one setting of the tool.
(*f*) If shoulder tools are used, it will, of course, be necessary to reset the apron and change the tool to plane the second surface *a*. Set the tool to touch the finished surface and plane the other exactly in line with it.

## PLANING A GROOVE

Instructions for planing a groove are similar to above xcept the roughing cut. To rough out the groove proceed s follows:

With a parting tool or similar tool, cut slots *inside* of the ayout lines for the groove, one slot on each side nearly to the ottom of the groove. Then cut away the metal remaining etween the slots, possibly with the tool just used if only a

small amount is left. This will leave the groove rough out nearly to the layout lines.

When finishing the bottom of the groove with should tools, finish half or more on one side and the remainder wh the apron is reset and the tool changed.

No written work.

No test questions.



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# MACHINE TOOL OPERATION

## Instruction Sheet S-5

## PLANING A DOVETAIL

Refer to your drawing to note if other surfaces of the piece in which you are to make the dovetail are to be planed and, if so, plane them now. Finish the base surface for the reason that it is easier to lay out and work from a finished working surface or a base surface. Then plane the edges to within, say, $\frac{1}{32}$ inch of the finished size. It is best to leave about $\frac{1}{32}$ inch on both sides until after the dovetail is cut, then the sides of the base and slide may be easily finished in exact relation to the dovetail.

1. **Read Art. 96, page 112, and get an idea of cutting a dovetail.**

2. **Refer to your drawing or otherwise learn if a gib (footnote, p. 113) is to be used.**

3. **Read the first paragraph in Art. 97, page 113, and proceed to lay out the work.**

   (*a*) For information on laying out work refer to Chap. XIII, Part I, beginning page 229.
   (*b*) Make the layout on the end that will be in front when the work is in the shaper.

4. **Set the work in the shaper. Have it securely held, firmly seated, lines in sight, and the cut to be made free from obstructions, such as clamps and vise jaws.**

References: "Machine Tool Operation," Part II—Burghardt.

**5. Rough out the base (Fig. 104, p. 112) similar to operatio of roughing a tongue (Instruction Sheet S-4, direction 6 and 7).**

**6. Rough out the slide similar to operation of roughing groove (Instruction Sheet S-4).**

**7. Set the head to the complement of the angle of the dove tail (angle of dovetail is angle *a*, Fig. 105, p. 114).**

**8. Set the apron.**

NOTE: *Top* of apron in a direction *away* from surface to be cut.

**9. Set the roughing tool for the angular cut.**

(*a*) For roughing, use a regular shaper tool ground with a fairl small round nose (2) (Fig. 75, p. 86) (see also (7), pp. 84 and 85)
(*b*) Be sure the tool bit and the tool holder are tight.

**10. Set the machine for length and position of stroke, an right speed.**

**11. Rough to within $\frac{1}{32}$ or $\frac{1}{64}$ inch of the layout lines.**

(*a*) Use down feed for angular cuts, regular feed for horizonta surfaces.
(*b*) If power feed is used, throw out the power feed when withi $\frac{1}{16}$ inch of the corner.

**12. Set the finishing tool.**

Use any suitable tool holder and a tool bit ground similar to (7 (Fig. 74, pp. 84 and 85).

**13. Finish to within required limits of size (Art. 97, p. 113)**

**General notes:** (*a*) Whether it is better to rough both angle of the dovetail before either angle is finished, or rough an finish one angle before changing the tool, the swivel of head and the swivel of the apron, is a matter of judgment an depends a good deal on the size of the job.

(*b*) Whether it may be advisable to rough one angle and then urn the piece end for end, and rough the other angle, will epend upon the job. It will save time if practicable.

(*c*) Unless the work is very accurate and square, and the ise in excellent condition, it is not considered good-practice o *finish* a dovetail by planing one angle and then turning end or end. As a rule, when one part of a dovetail is finished, he work should not be disturbed until the whole dovetail ut is done.

No written work.

No test questions.

# MACHINE TOOL OPERATION

## Instruction Sheet S-6

## CUTTING A KEYSEAT IN A PULLEY, CLUTCH, OR GEAR

The layout for a keyseat takes only a few moments and is usually done at the time the keyseat is made by merely scribing a radial line using the center square. If advisable, in addition, to lay out the full width of the keyseat, it may be done quickly in the shaper vise using a flat square and a scale. However, if several pieces are to be scribed the full width of the keyseat, it will be best to do the layout work before setting up the machine.

**1. Refer to Fig. 103, page 111, and select the keyseat tool as rigid (short and stocky) as convenient to use.**

(*a*) If the diameter of the work to be keyseated is fairly small, use a short bar *b* and let the tool post travel back and forth over the top of the work. That is, while the tool holder *h* is not caught especially short in the tool post, this lack of rigidity is more than made up for by the shorter bar. Such a set-up is illustrated in Fig. 79, page 92.

(*b*) If the diameter of the work is so large that the tool post cannot move back and forth over the blank, the bar will have to project far enough in front of the tool-post screw to go through the hole. In this case catch the tool short.

(*c*) Notice that the diameter of the bar in Fig. 103 is smaller than the diameter of the hole. This is because the tool bit projects and both the bar and projecting bit must go through the hole.

**2. Sharpen the tool bit.**

(*a*) The tool bit is quite small and you must be exceedingly careful to have it properly ground.

References: "Machine Tool Operation," Part II—Burghardt.

(*b*) The cutting edge must have clearance in order to cut and th sides must be backed off a little, otherwise the tool will ru Remember that only very little clearance is required.

(*c*) To avoid any tendency to have the top of the keyseat wider tha the bottom, the cutting edge of the tool should be the wide part, but only a trifle wider. Use a micrometer and be carefu

(*d*) Give it very little, if any, front rake and no side rake.

**3. Put the tool bit in the bar pointing directly up (see top page 112, also Fig. 103).**

**4. Set the length of stroke of the shaper about three quarte of an inch longer than the hole.**

**5. Have the position of the stroke back about as far as yo can (binder lever (1 Fig. 63) over the front end of th slot in the ram).**

**6. Set the tool in the tool post. Catch it as short as circum stances will permit (see 1 (*a*) and (*b*) this sheet).**

**7. Move the ram to the beginning of the forward stroke.**

Except that you may have to raise or lower the tool-head slide ( possibly the table) you are now ready to set the work so that the ho is about ½ inch in front of the tool.

**8. Get the shaper ready to hold the work.**

It frequently happens when holding work in the shaper vise, shown in Fig. 103, that the ram will not go back far enough. I such case you can do one of three things: (1) put one or more paralle as high as the vise jaw back of the work and clamp the work betwee the parallels and the movable vise jaw; (2) clamp the work in a mil ing-machine vise or a drill-press vise and then clamp the vise in th desired position in the shaper vise (Fig. 79, p. 92); (3) remove th shaper vise and clamp the work to an angle plate (**Art. 74,** p. 93

**9. Read Art. 93, p. 110, and also the directions beginnin top of page 112 and proceed to lay out the keyseat and se up the work.**

(*a*) Layout the keyseat, either one radial line or the whole width keyseat, as seems necessary.

(*b*) Set the work, radial line perpendicular.

(*c*) Be sure the tool bit is set correctly and tight. Also that the too holder is tight in the tool post.

(*d*) Take one stroke by hand (with the tool bit nearly touching the work) to make sure the length and position of stroke are right and that there is no interference.

0. **Move the ram to bring the tool bit to the front end of the hole and move the table to bring the layout exactly central with the tool bit.**

1. **Have the tool just touch the work, then loosen the feed-screw graduation collar and adjust it to zero.**

2. **When everything is all right start the shaper and feed carefully to required depth of keyseat.**

No written work.

No test questions.



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