BULLETIN NO. 7-S

How to Make Bushings

for Automobiles, Buses and Trucks

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SOUTH BEND LATHE WORKS
993 E. MADISON ST. SOUTH BEND, INDIANA, U. S. A.

1938

Bulletin No. 7-S

How to Make Bushings

In the Motor Service Machine Shop

The practical methods for making bushings are illustrated and described in this bulletin. A modern Back-Geared Screw Cutting Lathe with a small assortment of chucks and tools is required for doing this work. See page 8 for a description and an illustration of the necessary equipment.

All sizes and all types of bushings can be made quickly and accurately in the lathe. It is more economical to make bushings as they are required than to go to the expense of carrying an assortment of finished bushings in stock.

Usually, when a replacement bushing is required, either the outside or the inside diameter of the bushing must be over-size or under-size and sometimes both the outside and the inside diameter are made to special dimensions. Some shops have found that even if a large stock of bushings is carried, the size needed in an emergency is seldom on hand. If a lathe is available, the necessary bushing can be made in a short time and there is no delay in getting out the job. However, if the special bushing must be ordered from the factory, there is not only an aggravating delay but also an added expense.

Bushings are often required for replacing bearings in automobiles, electric fans, generators, motors and machinery of all kinds. They are also required for drill jigs and manufacturing fixtures.

In addition to making bushings, the lathe may be used for turning, boring, facing, drilling, cutting right and left hand screw threads and general machine work of all kinds. Only a few minutes are required to set up the lathe for making bushings and when the work has been finished, the lathe may be quickly arranged for many other jobs.

South Bend Lathe Works

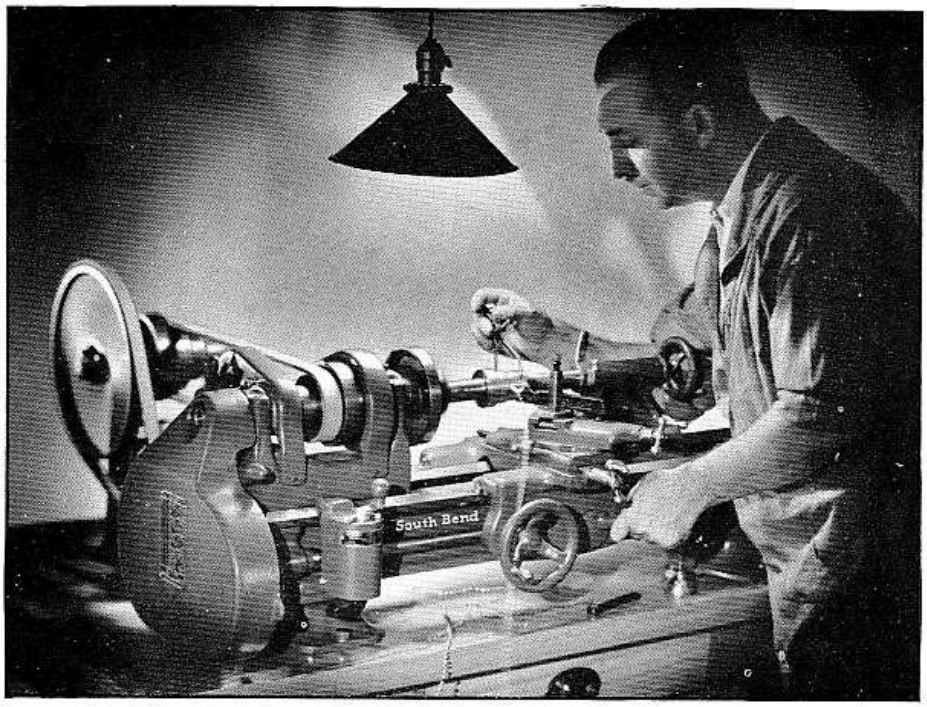


Fig. 1. Making a Replacement Bushing in the 9-inch "Workshop" South Bend Precision Lathe.

Making Bushings in the Lathe

Any size or type of back-geared screw cutting lathe may be used to make bushings. Most of the illustrations shown in this bulletin were made on a small bench lathe, but a large floor leg lathe could have been used just as well.

Bushings can be made of bronze, brass, babbitt, cast iron, fibre, bakelite, wood, steel or any other material required. When making replacement bushings, the first thing to do is to determine what kind of material was used for the original bushing. The replacement bushing should, of course, be made of the same material if it is available.

Each operation in the making of a bushing is clearly illustrated and described on the following pages. The methods outlined in this bulletin are used in the most modern shops and are practical, efficient and economical.

Additional information on grinding and setting lathe tool cutter bits, thread cutting, drilling, boring, reaming, etc., will be found in the book ,"How to Run a Lathe." See inside of back cover.

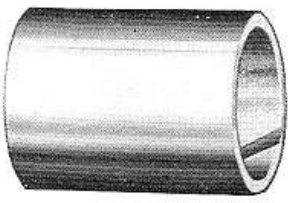


Fig. 2. Wrist Pin Bushing.

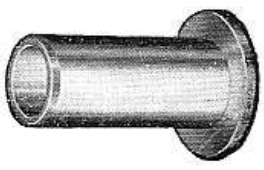


Fig. 3. King Pin Bushing.

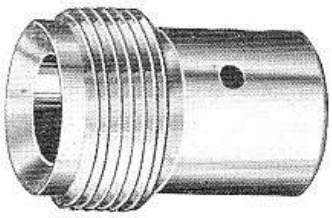


Fig. 4. Water Pump Bushing.

How to Make a Bushing in the Lathe

The operations in making a bushing are fundamentally the same regardless of the size or type of bushing. The illustrations below show the operations in their proper sequence.

Truing Up Work in the Lathe Chuck

Select a piece of stock of the same material as the bushing to be replaced, about one-eighth inch larger in diameter and one-eighth inch longer than the original bushing. Mount the stock in a lathe chuck. If an independent chuck is used, chalk the "high spot" as shown in illustration and adjust the jaws so the stock will run true. See "How to Run a Lathe."

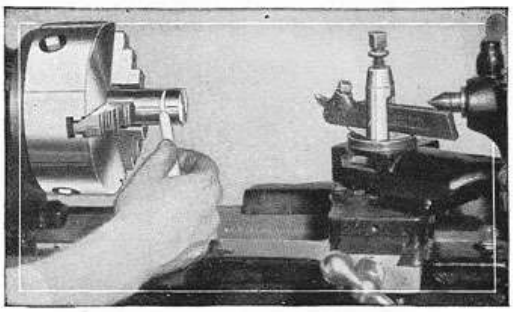


Fig. 5. Truing Up Rough Stock in Lathe Chuck.

Facing the End of the Work

Face the end of the work smooth, being careful to adjust the cutting edge of the tool so that it is exactly on center, otherwise a small projection will be left in the center of the stock which will cause the center drill to run off center.

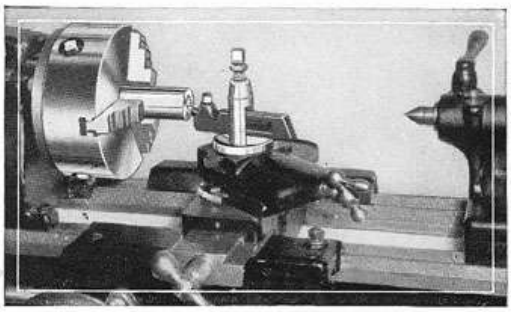


Fig. 6. Facing End of Bushing.

Centering the Work

Mount a drill chuck in the tailstock spindle of the lathe and center drill the end of the stock using a combination center drill and countersink. The work is center drilled to start the large drill and to prevent it from running off center. Feed the center drill into the revolving stock by turning the tailstock hand-wheel, very carefully at first.

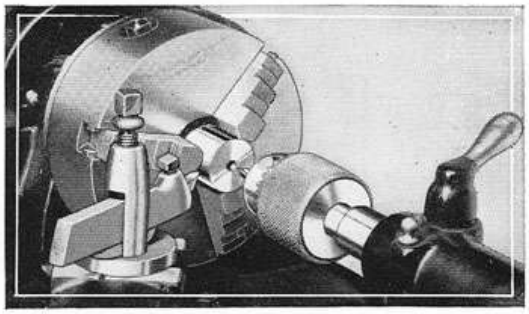


Fig. 7. Centering Bushing to Start Drill Straight.

Drilling the Hole

Place a drill in the drill chuck and drill through work allowing at least one-sixteenth inch on the inside diameter of the hole for boring and reaming. Withdraw drill from work frequently to remove the chips which accumulate. If drilling a large hole, run lathe at slow speed with back gears in mesh and feed drill into the work slowly. If making a steel bushing, use oil on the drill point.

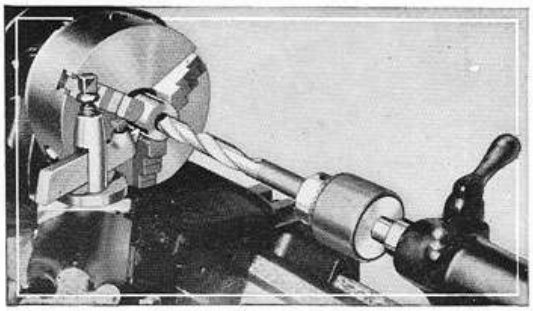


Fig. 8. Drilling Hole Through Bushing.

Boring the Hole

Mount a boring tool in the tool post of the lathe and rough bore the hole to within .010 inch of the finished diameter. If a reamer of the correct size is available the hole may be finished by reaming. However, if a reamer is not available the hole can be finished almost as well by careful boring.

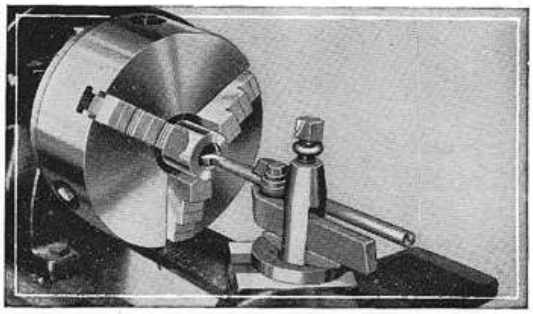


Fig. 9. Boring the Hole in the Bushing.

Reaming the Hole

Ream the hole to size using a slow spindle speed. If a reamer is not available, finish bore the hole to fit the shaft. Feed in about ¼ inch, then stop the lathe and test the diameter of the hole with the shaft. If the shaft enters the hole too freely or is too tight the tool should be adjusted so that the proper diameter will be obtained.

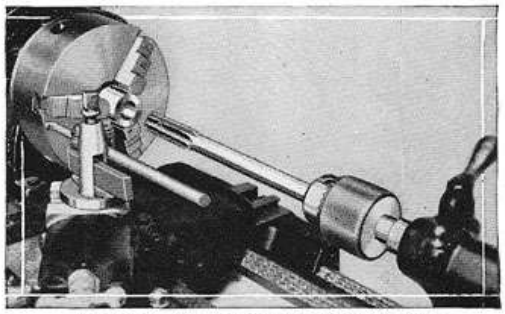


Fig. 10. Reaming the Hole to Size.

Facing the Ends

Remove the work from the chuck and press it on a mandrel. Be sure to oil the mandrel well so that the bushing can be easily removed. Place between centers and face both ends, taking a smooth finishing cut and making the bushing exactly the same length as the old bushing.

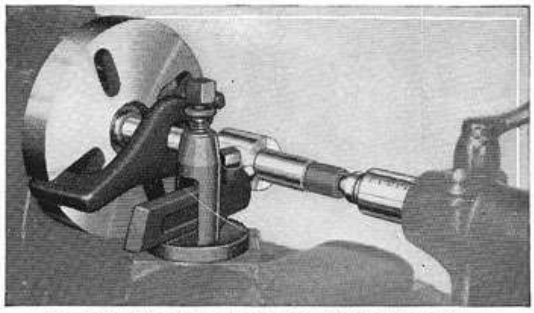


Fig. 11. Facing the Ends of the Bushing.

Turning the Diameters

Turn the outside diameter of the bushing to the correct size. In taking the finishing cuts turn only about ¼ inch on the end of the bushing, then test the diameter. If the diameter is incorrect adjust the cutting tool, take another trial cut and test again. Take the finishing cut across the entire length.

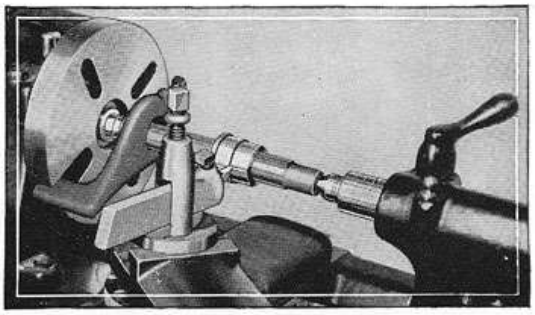


Fig. 12. Turning the Diameters of the Bushing.

Filing and Polishing

Use a fine mill file and file with the lathe running at a speed so that the work will make two or three revolutions for each stroke of the file. File just enough to make it smooth. If too much filing is done the work will be uneven and inaccurate. A very fine finish can be obtained by polishing with fine emery cloth and oil after filing.

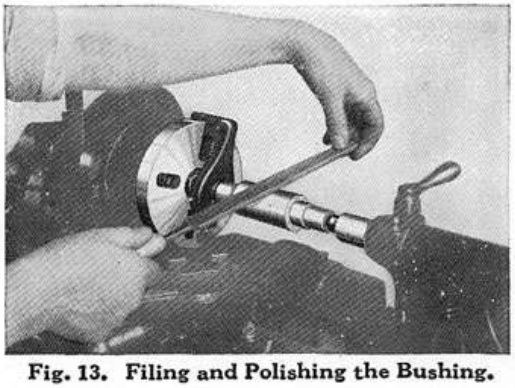


Fig. 13. Filing and Polishing the Bushing.

Making a Short Bushing Complete in the Chuck

Small short bushings are made from bar stock held in the chuck, as shown in Figure 14. The bar should extend far enough from the chuck so that the bushing may be machined complete and then cut off without changing the position of the stock in the chuck.

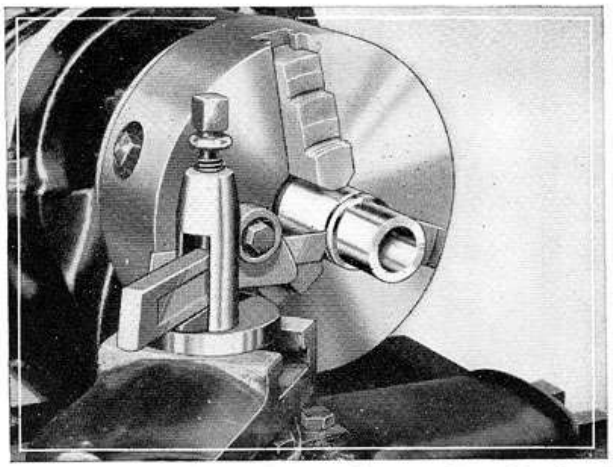


Fig. 14. Cutting Off a Bushing that Has Been Machined Complete Without Removing from the Chuck.

Most of the operations are exactly the same as those shown in the preceding illustrations except the turning of the outside diameter and cutting-off operation.

Turn the outside diameter of the bushing to the correct size, and complete all operations without removing the bushing from the chuck.

When the bushing is completed and the outside diameter filed and polished smooth, it may be cut off, using a cutting-off tool, as shown in above illustration. Set the cutting edge of the tool exactly on center and adjust the tool so that the bushing will be the correct length when cut off.

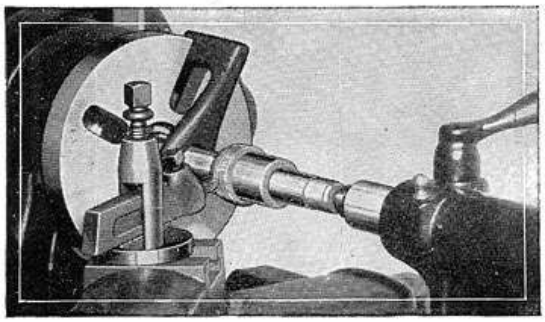


Fig. 15. Cutting a Screw Thread on a Bushing.
The 9-inch South Bend Lathe is equipped with change gears and lead screw for cutting all standard screw threads. See handbook "How to Run a Lathe" for information on thread cutting.

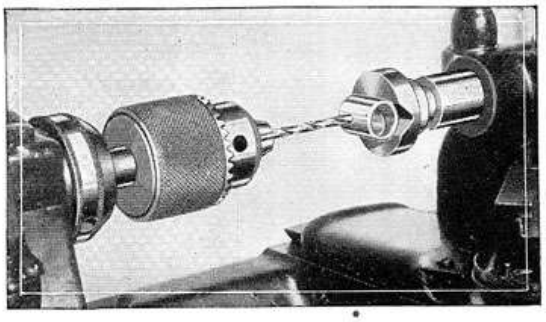


Fig. 16. Drilling an Oil Hole in a Bushing.
With the aid of a crotch center and a drill chuck the lathe can be used for all kinds of drilling. There are many bushing jobs requiring drilled oil holes, etc.

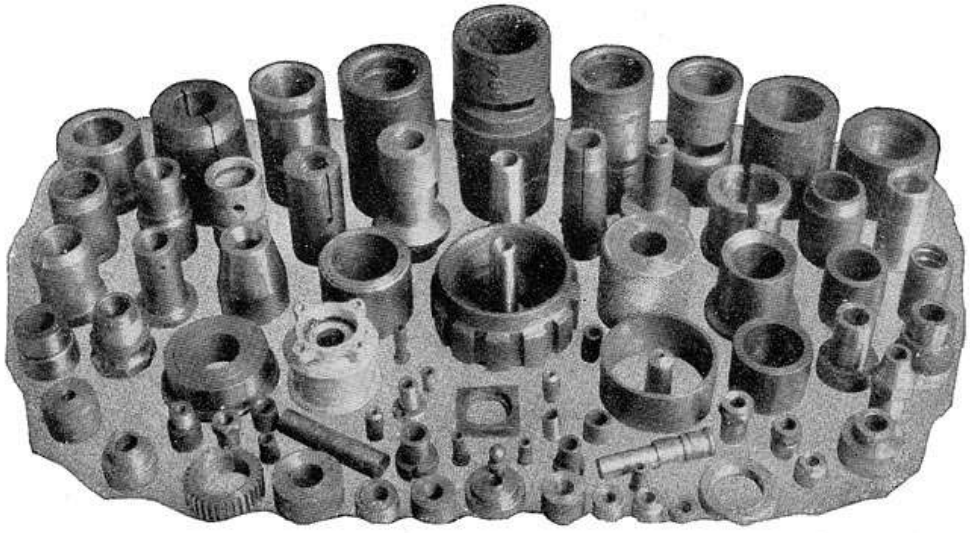


Fig. 17. Various Types of Bushings That Can Be Made in the Lathe.

How to Make Lathe Mandrels for Machining Bushings

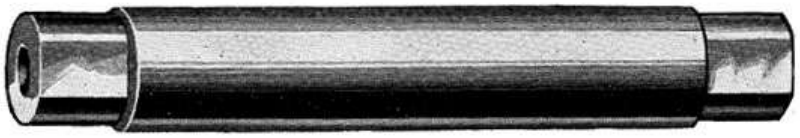


Fig. 18. Mandrel for machining work between centers in the lathe.

Any good grade of machine steel can be used for making lathe mandrels. Old automobile axles are excellent. If only a few bushings are to be made, the mandrel does not need to be hardened.

The tabulation below shows the dimensions recommended for standard lathe mandrels. A slight taper is required so that the mandrel can be pressed into the bushing tightly. The size of the mandrel is always stamped on the large end.

The center holes in the ends of the mandrel are very important. They should be large enough to provide a good bearing and they must be perfectly concentric with the outside diameter of the mandrel.

If a large quantity of bushings are to be made, it is advisable to case-harden the center holes or harden the entire mandrel. The outside diameter of the mandrel must be finished after hardening; otherwise it will not run true because the steel will warp during the hardening process.

Before mounting a bushing on the mandrel, always oil both the inside of the bushing and the mandrel.

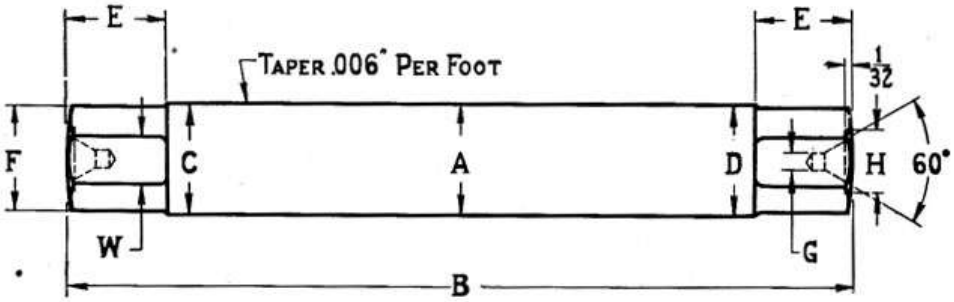


Fig. 19. See tabulation below for dimensions of mandrels.

All Dimensions Shown in Tabulation Below are in Inches

Nominal Diameter A	Total Length B	Small End C	Large End D	Undercut Length E	Undercut Diameter F	Center Drill G	Recess For Center H	Width Of Flat W
3/16	3 3/4	.1870	.1884	7/16	11/64	3/64	1/8	5/64
1/4	3 3/4	.2495	.2509	7/16	15/64	3/64	1/8	7/64
5/16	4	.3120	.3136	7/16	9/32	3/64	3/16	1/8
3/8	4 1/4	.3745	.3760	1/2	11/32	1/16	1/4	5/32
7/16	4 1/4	.4370	.4386	9/16	13/32	1/16	9/32	1/4
1/2	5	.4995	.5014	5/8	15/32	3/32	5/16	1/4
5/16	5 1/4	.5620	.5640	5/8	17/32	3/32	5/16	1/4
5/8	5 1/2	.6245	.6265	3/4	19/32	3/32	3/8	1/4
11/16	5 3/4	.6870	.6891	3/4	5/8	3/32	3/8	5/16
3/4	6	.7495	.7517	13/16	11/16	1/8	3/8	5/16
13/16	6 1/4	.8120	.8142	7/8	3/4	1/8	3/8	7/16
7/8	6 1/2	.8740	.8764	7/8	13/16	1/8	3/8	7/16
15/16	6 3/4	.9370	.9394	15/16	7/8	1/8	3/8	1/2
1	7	.9995	1.0020	15/16	15/16	5/32	1/2	1/2
1 1/16	7 1/4	1.0615	1.0641	1	1	5/32	1/2	1/2
1 1/8	7 1/2	1.1240	1.1267	1	1 1/16	5/32	1/2	1/2
1 3/16	7 3/4	1.1865	1.1889	1	1 1/8	5/32	1/2	1/2
1 1/4	8	1.2490	1.2520	1	1 3/16	3/16	5/8	1/2
1 5/16	8 1/4	1.3115	1.3144	1 1/4	1 1/4	3/16	5/8	1/2
1 3/8	8 1/2	1.3740	1.3760	1 1/4	1 5/16	3/16	5/8	5/8
1 7/16	8 3/4	1.4365	1.4396	1 1/4	1 3/8	7/32	5/8	5/8
1 1/2	9	1.4990	1.5022	1 1/4	1 7/16	7/32	5/8	5/8

Finishing Hardened Bushings

Hole Should be Ground

Hardened bushings should always be finished by grinding because the hardening process will warp the steel. An electric grinder with internal grinding spindle is used for grinding the inside diameter. The lathe spindle is arranged to revolve at a moderate speed and the grinding wheel passed back and forth through the bushing. When grinding bushings in the lathe, always cover the V-ways and other bearing surfaces of the lathe with a cloth to prevent the emery dust from damaging the bearings.

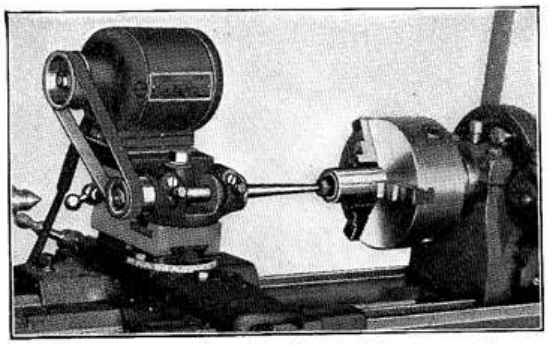


Fig. 20. Grinding the Inside Diameter of a Hardened Steel Bushing.

Lapping Hole to Size

If an Electric Grinding Attachment is not available, or if the hole in the bushing is so small that the grinding wheel will not enter, the hole must be lapped with emery dust and oil.

Fig. 21 shows the lathe set up for lapping the hole in the bushing. The lap may be made of cast iron or it may consist of a split steel rod around which fine emery cloth is wrapped. The lathe spindle is arranged to revolve at a moderate speed while the bushing is passed back and forth over the lap.

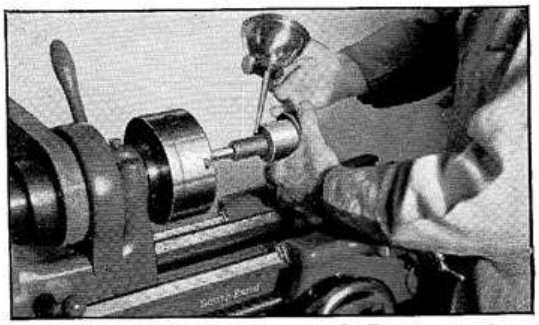


Fig. 21. Finishing the Inside Diameter of a Hardened Steel Bushing by Lapping.

Grinding Outside Diameter

Before grinding the outside diameter of the bushing, the hole should be finished to the required size, either by grinding or lapping, as described above. An electric grinding attachment, mounted on the tool rest of the lathe, is used for grinding.

During the grinding process, the V-ways of the lathe bed should be well protected by a cloth to prevent the emery dust from damaging them. It is also advisable to cover the headstock spindle bearings and other bearings to prevent flying particles of emery from working into them.

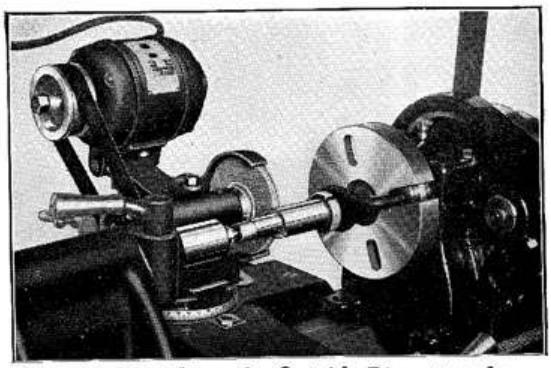


Fig. 22. Finishing the Outside Diameter of a Hardened Steel Bushing by Grinding.

Recommended Spindle Speeds for Turning Bushings in the Lathe

The chart at the right shows the recommended spindle speeds for turning various kinds of metals. The spindle speeds listed in column two should be used for machining cast iron bushings and column four gives the spindle speeds recommended for turning bronze bushings.

This chart is based on average working conditions. Finishing cuts may sometimes be taken at slightly higher speeds, and slower speeds may produce better results on heavy roughing cuts.

When rough turning, use a coarse feed and take as many cuts as are required to reduce the work nearly to the finished size. When finish turning, use a very fine feed and remove .005″ to .007″ or less from the diameter in one cut.

Diameter of Work Inches	Revolutions per Minute			
	Cast Iron 60 F.P.M.	Mild Steel 90 F.P.M.	Brass 150 F.P.M.	Bronze 90 F.P.M.
1	229	344	573	344
1½	153	229	382	229
2	115	172	287	172
2½	92	138	229	138
3	76	115	191	115
3½	65	98	164	98
4	57	86	143	86
5	46	69	115	69

F.P.M. = Feet per minute at tool point.

Press Fits and Running Fits

For Bushings, Bearings, Shafts, Etc.

Standard tolerances for press fits and running fits, etc., are given in the tabulations below. The hole is usually made a standard size and the shaft made the required size for the desired type of fit. The figures shown in the tabulations below indicate the amount to increase or decrease the shaft diameter provided a standard hole size is maintained. The tolerance observed as standard for holes is usually + .000″ — .001″.

Since working conditions vary a great deal it may sometimes be advisable to increase or decrease the allowances shown in the tabulations. For example, the length of the bearing, the material used and the speed should all be taken into consideration when calculating the tolerance for a running fit.

Standard Tolerances for Press Fits

Light Press Fit

Diam. of Hole, in inches	Shaft Diam. Larger Than Hole, in inches
Up to ½	+.0004 to +.0006
½ to 1	+.0005 to +.0010
1 to 2	+.00075 to +.0020
2 to 3	+.0015 to +.0030
3 to 4	+.0020 to +.0040
4 to 5	+.0020 to +.0045
5 to 6	+.0030 to +.0050

Heavy Press Fit

Diam. of Hole, in inches	Shaft Diam. Larger Than Hole, in inches
Up to ½	+.005 to +.001
½ to 1	+.001 to +.003
1 to 2	+.002 to +.004
2 to 3	+.003 to +.006
3 to 4	+.005 to +.008
4 to 5	+.006 to +.010
5 to 6	+.008 to +.012

Standard Tolerances for Running Fits

Speeds up to 1000 R.P.M.

Diam. of Hole, in inches	Shaft Diam. Less Than Hole, in inches
Up to ½	—.0005 to —.0010
½ to 1	—.00075 to —.0015
1 to 2	—.0015 to —.0025
2 to 3	—.0020 to —.0025
3 to 4	—.0025 to —.0030
4 to 5	—.0030 to —.0035
5 to 6	—.0035 to —.0040

Speeds over 1000 R.P.M.

Diam. of Hole, in inches	Shaft Diam. Less Than Hole, in inches
Up to ½	—.0005 to —.0010
½ to 1	—.0010 to —.0020
1 to 2	—.0020 to —.0030
2 to 3	—.0025 to —.0035
3 to 4	—.0030 to —.0040
4 to 5	—.0035 to —.0045
5 to 6	—.0040 to —.0050

Standard Tolerances for Push Fits

Diam. of Hole, in inches	Shaft Diam. Less Than Hole, in inches
Up to ½	—.00025 to —.00075
½ to 1	—.0005 to —.0010
1 to 2	—.0005 to —.0015
2 to 3	—.0005 to —.0015
3 to 4	—.00075 to —.0020
4 to 5	—.00075 to —.0020
5 to 6	—.00075 to —.0020

Standard Tolerances for Sliding Fits

Diam. of Hole, in inches	Shaft Diam. Less Than Hole, in inches
Up to ½	—.005 to —.001
½ to 1	—.0075 to —.0015
1 to 2	—.0015 to —.0025
2 to 3	—.0020 to —.0030
3 to 4	—.0025 to —.0030
4 to 5	—.0025 to —.0035
5 to 6	—.0025 to —.0040

Equipment Required for Making Bushings

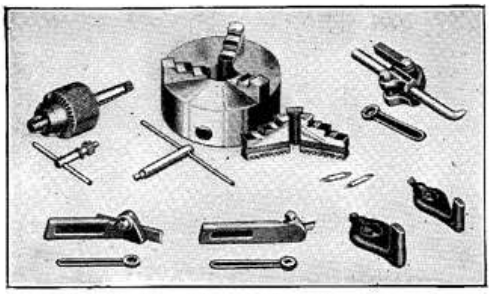


Fig. 23. Chuck and Tool Assortment for Making Bushings.

The illustration at the left shows a practical assortment of chucks and tools for making bushings in the lathe. This equipment consists of a 3-Jaw Universal Geared Scroll Chuck, a Drill Chuck, Boring Tool, Turning Tool, Cutting-Off Tool, and Lathe Dogs. In addition to these tools and accessories, the necessary drills, reamers, calipers, micrometers, etc. will be required.

Grinding Tools for Bushing Work

The round nose turning tool illustrated at the right may be used for practically all bushing turning.

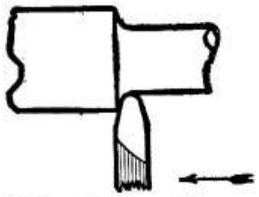


Fig. 24. Round Nose Turning Tool

The side tool illustrated in Fig. 25 is recommended for facing the ends of bushing, also for facing shoulders on bushings. For more complete information on grinding lathe tool cutter bits, see book, "How to Run a Lathe", illustrated on opposite page.

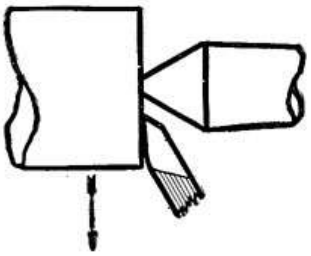


Fig. 25. Right Hand Side Tool

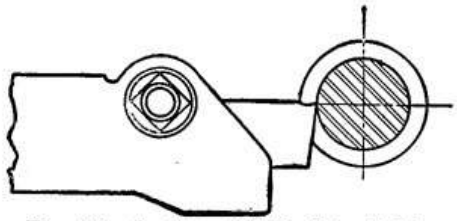


Fig. 26. Cutting Off Tool in Holder

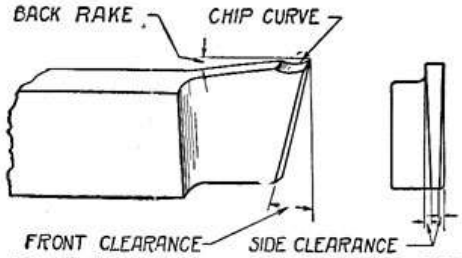


Fig. 27. Rake and Clearance for Cutting Off Tool

The cutting off tool is used for cutting off stock and for necking operations. In sharpening this tool, it is ground only on the front and top. Note that the cutting edge of the tool is on a center line with the work.

Bronze Bushing Stock

For the convenience of our customers we supply the best quality bronze bushing stock. Bars come either solid or with a cored hole, according to specifications given in the tabulation below at the right.

The market price of bronze varies from time to time, and the price quoted below is subject to change without notice.

The standard length for bronze bushing stock is 12 inches. An extra charge of 25 cents is made for sawing each piece, if shorter lengths are ordered.

Bronze Bushing Stock. Price per lb., f.o.b. South Bend, Ind.....$0.40

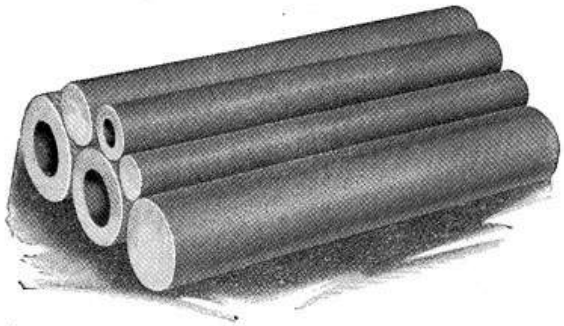


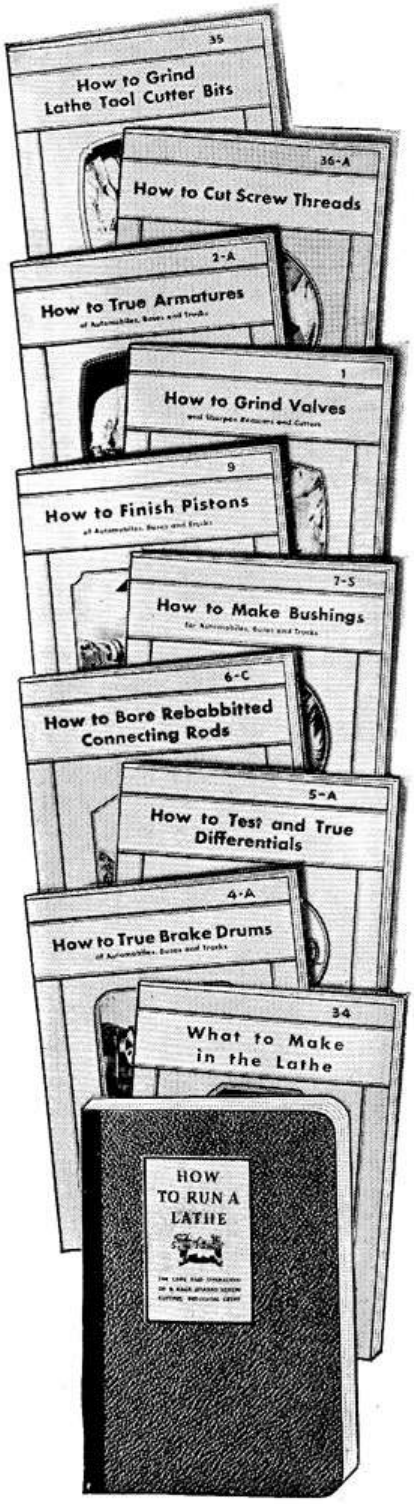
Fig. 28. Bronze Bushing Stock in 12-inch Bars.

Average Weight of Bronze Bushing Stock

Size Bar, Inches	1x12	1¼x12	1½x12	2x12	2½x12
Weight Solid, Pounds	3	4½	6¾	11¾	18¼
Size Cored Hole Inches	½	⅝	¾	1	1¼
Weight Cored, Pounds	2¼	3½	5	8¾	13¾

Valuable Books for the Mechanic

The bulletins listed below illustrate and describe how to handle general lathe work and seven major auto service jobs according to the latest shop practice that is followed in the most successful shops and plants in the United States. Thousands of mechanics are using these bulletins in their work. Order some of these for your mechanics—they may be helpful. Bulletins are 6″ x 9″ in size and contain from 8 to 128 pages each. When ordering specify the titles of the bulletins wanted and they will be mailed postpaid on receipt of price indicated. Coin or stamps of any country accepted.



"How to Grind Lathe Tool Cutter Bits" Bulletin No. 35. Explains in detail how to sharpen various types of cutter bits for lathe work. 16 pages, size 6"x9", 50 illustrations. Price postpaid 10c

"How to Cut Screw Threads" Bulletin No. 36-A. Explains various screw thread forms and how to cut screw threads in the lathe. 24 pages, size 6"x9", 65 iliustrations. Price postpaid 10c

"How to True Armature Commutators and Undercut Mica" Bulletin No. 2-A. (Automotive). Contains information on truing armature commutators and undercutting mica in the lathe. 12 pages, size 6"x9", 35 illustrations. Price postpaid 10c

"How to Grind Valves and Sharpen Reamers" Bulletin No. 1. (Automotive). Contains information on refacing automobile engine valves, sharpening valve seat reamers, cutters, etc. 12 pages, size 6"x9", 23 illustrations. Price postpaid 10c

"How to Finish Pistons" Bulletin No. 9. (Automotive) Contains detailed information on finishing semi-machined pistons in the lathe, reaming and honing wrist pin holes, etc. 12 pages, size 6"x9", 31 illustrations. Price postpaid 10c

"How to Make Bushings" Bulletin No. 7-S. Contains information on making bushings, lathe mandrels, press fits and running fits. 12 pages, size 6"x9", 28 illustrations. Price postpaid 10c

"How to Bore Rebabbitted Connecting Rods" Bulletin No. 6-C. (Automotive). Illustrates and describes the latest shop practice for boring, facing, and finishing rebabbitted connecting rods. 12 pages, size 6"x9", 25 illustrations. Price postpaid.....10c

"How to Test and True Differentials" Bulletin No. 5-A. (Automotive). Contains information on removing the old ring gear, testing and truing the ring gear seat, testing bearings of drive pinions, etc. 8 pages, size 6"x9", 20 illustrations. Price postpaid 10c

"How to True Brake Drums" Bulletin No. 4-A. (Automotive). Shows how to mount various types of brake drums in the lathe for truing the drum so that it will be concentric, round and true. 16 pages, size 6"x9", 40 illustrations. Price postpaid 10c

"What to Make in the Lathe" Bulletin No. 34. Illustrates and describes over 65 useful projects for the home and shop including tools, grinders, and other useful objects, also various models such as steam and gas engines, locomotives, airplanes, etc. 28 pages, size 6"x9", 75 illustrations. Price postpaid 10c

"How to Run a Lathe" (34th Edition). This is an authoritative and instructive manual on the care and operation of a back-geared, screw cutting lathe. It gives the fundamentals of lathe operation in detail with illustrations of various classes of work. Contains 128 pages, size 5¼"x8", and more than 350 illustrations.

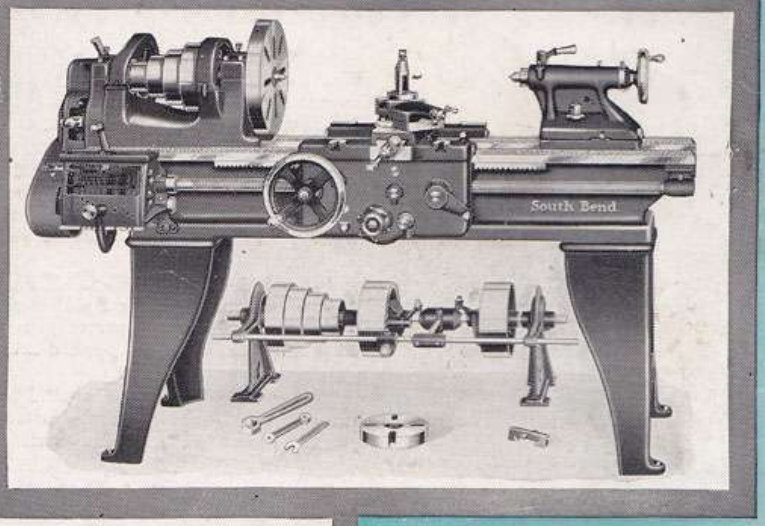
This book is used as a handy reference book by machinists and apprentices in industrial plants, railroad shops and machine shops, and is also used as a text book by students in educational institutions. It is considered the most popular text on lathe work in the world. More than a million and a half copies are in use.
Price postpaid 25c

"The Home Workshop" Handbook No. 11-Y. This is an interesting booklet on modelmakers' workshops, home workshops and various classes of homeshop work. Also contains tables and other useful information for the hobbyist. 28 pages, size 6"x9", 75 illustrations. Sent postpaid .....Free

At Left—No. 415-YA 9″ x 3′ New Model South Bend "Workshop" Adjustable Horizontal Motor Driven, Back-Geared Screw Cutting Precision Bench Lathe.

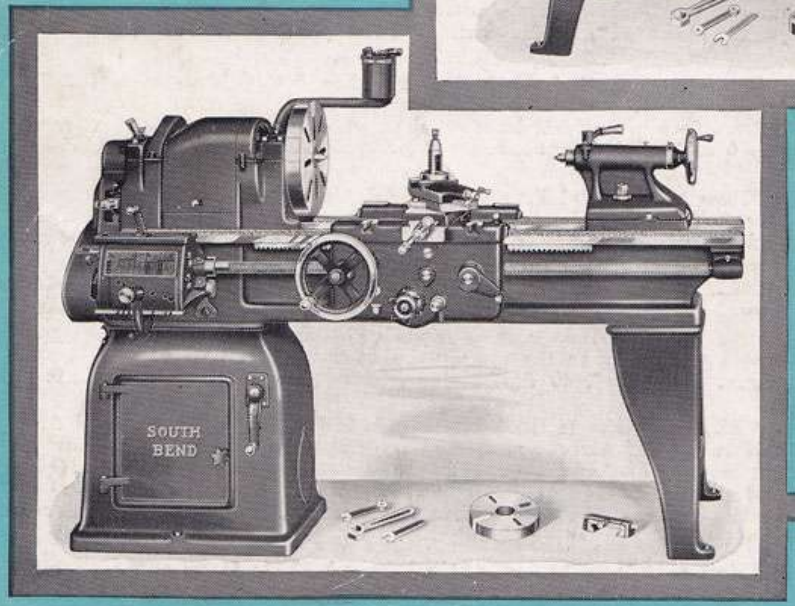
One of the finest small lathes we have ever built.

Prices of lathe, less motor drive, range from $85.00 up.



At Right—No. 17-C 16″x6′ New Model South Bend Overhead Countershaft Driven, Quick Change Gear, Back-Geared Screw Cutting Precision Lathe.

A popular type high quality precision lathe.



At Left—No. 117-C 16″ x 6′ New Model South Bend Underneath Belt Motor Driven, Quick Change Gear, Back-Geared Screw Cutting Precision Lathe.

A practical, efficient and popular motor driven lathe.

Below—The plant of the South Bend Lathe Works at South Bend, Indiana. This organization was founded in 1906 and has grown and developed to an enterprise occupying the buildings shown here, which have a floor space of 180,000 square feet and with a ground area of 4½ acres devoted exclusively to the manufacture of South Bend Back-Geared Screw Cutting Precision Lathes.

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