HOW TO RUN A LATHE

SOUTH BEND LATHE, INC.

PREFACE

ONE of the great needs of industry today is well trained workmen who are skillful with their hands and also trained to think about their work, diagnose troubles and suggest improvements. No man can hope to succeed in any line of work unless he is willing to study it and increase his own ability in it.

It is the purpose of this book to aid the beginner or apprentice in the machine shop and the student in the school shop to secure a better understanding of the fundamentals of the operation of a modern Screw Cutting Engine Lathe. In illustrating and describing the fundamental operations of modern lathe practice, we have made an effort to show only the best and most practical methods of machine shop practice in use in modern industries in the United States.

We are indebted to so many manufacturers, engineers, authors, educators, mechanics and friends for assistance in the preparation of this book that it would be impossible to give them individual mention here. However, we wish to express our appreciation for the cooperation that has made this work possible.

55th Edition of "How to Run a Lathe"

This 55th edition of the book "How to Run a Lathe" is printed in English. Other editions are printed in Spanish and Portuguese. The first edition, in English, was printed in 1907. Each succeeding edition has been revised and improved.

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How to Run a Lathe

REVISED EDITION 55

The Care and Operation of A Screw-Cutting Lathe

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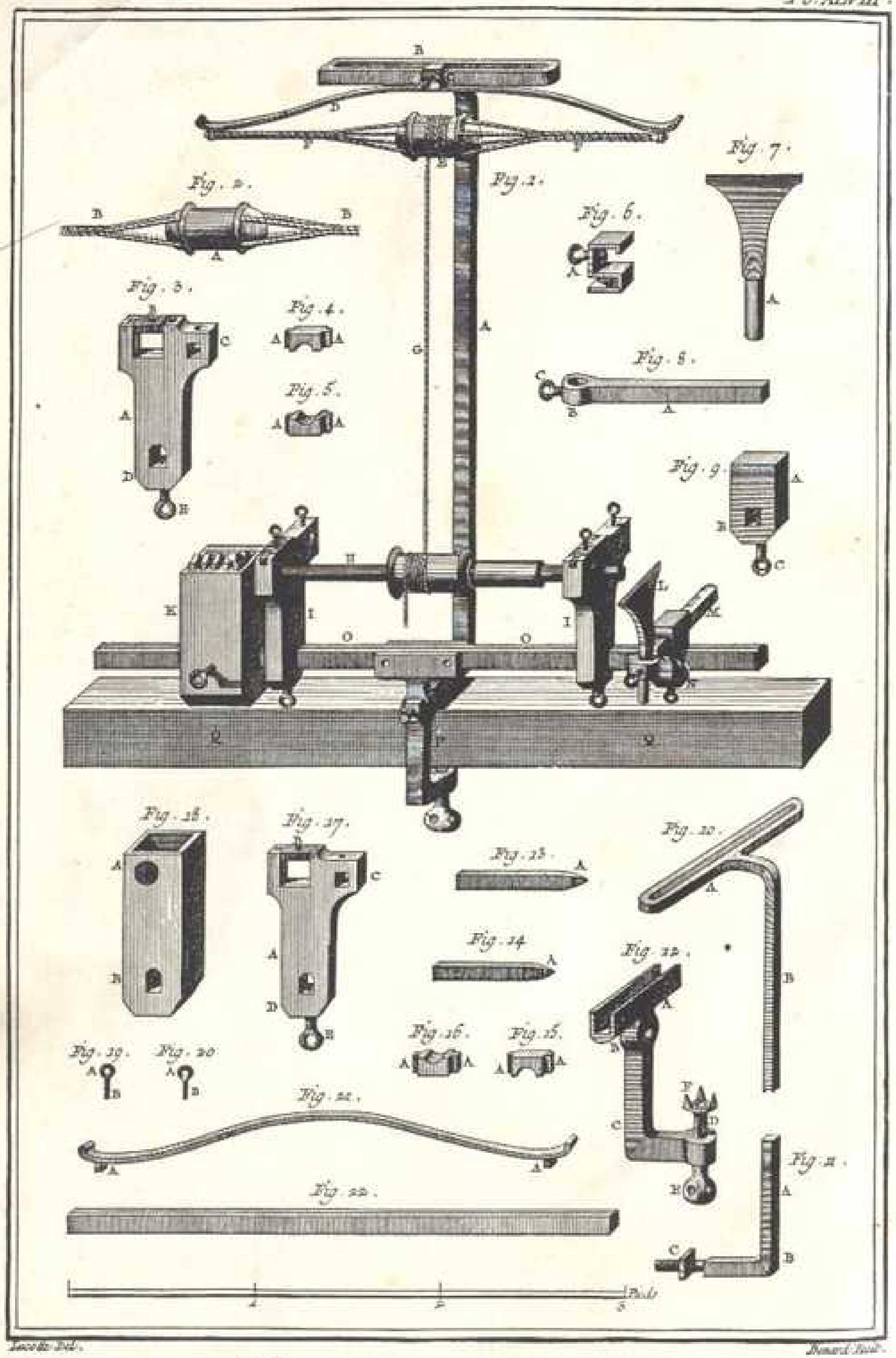


Tourneur, Tours d'Horlogers.

A small lathe built in France about 1770. From an old etching

Chapter I

HISTORY AND DEVELOPMENT OF THE SCREW CUTTING LATHE

The screw cutting engine lathe is the oldest and most important of machine tools and from it all other machine tools have been developed. It was the lathe that made possible the building of the steamboat, the locomotive, the electric motor, the automobile and all kinds of machinery used in industry. Without the lathe our great industrial progress of the last century would have been impossible.

Fig. 1. Early Tree Lathe

Early Screw Cutting Lathe

One of the earliest types of turning lathes was the tree lathe, shown in Fig. 1. A rope attached to a flexible branch overhead was passed around the work to revolve it. Later a strip of wood or "lath" was used to support the rope, and this is probably why the turning machine came to be known as a "lathe."

One of the earliest screw cutting lathes that we have record of was built in France about 1740. Fig. 2 shows this lathe as it was illustrated in a book published in 1741. A hand crank was attached direct to the headstock spindle. The spindle of this lathe was geared to the lead screw, but there was no provision for changing the gears for cutting various pitches of screw threads.

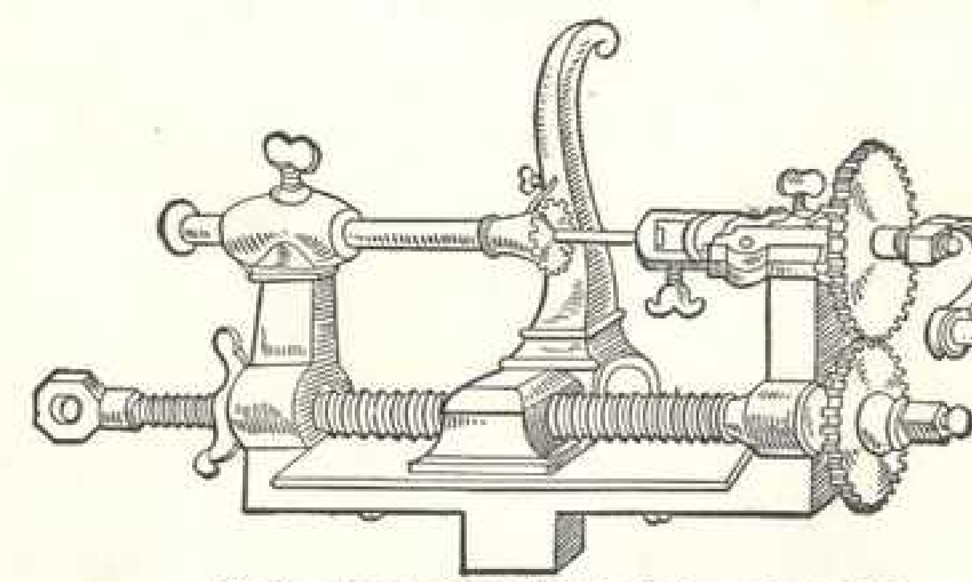


Fig. 2. French Screw Cutting Lathe, About 1740

(From Roe's ENGLISH AND AMERICAN TOOL BUILDERS; by permission of the publishers, McGraw-Hill Book Company, Inc.)

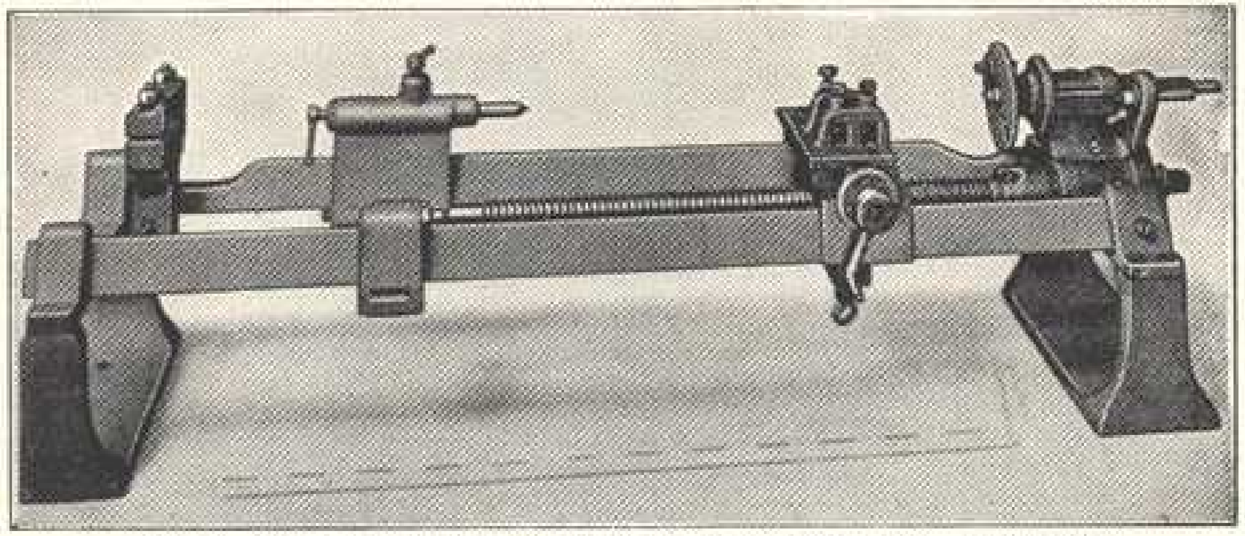


Fig. 3. Screw Cutting Lathe Made by Henry Maudslay, About 1797
(Courtesy Joseph Wickham Roe, Author of "English and American Tool Builders")

Henry Maudslay

Henry Maudslay, an Englishman, gave us the fundamental principles of the screw cutting engine lathe in a small lathe which he designed and built about 1797. On this lathe the gears used to connect the spindle with the lead screw could be changed, permitting the use of different gear ratios for cutting various pitches of screw threads.

Early American Lathes

Lathes were built in the United States between 1800 and 1830 with wood beds and iron ways. In 1836 Putnam of Fitchburg, Massachusetts built a small lathe with a lead screw. In 1850 iron bed lathes were made in New Haven, Connecticut, and in 1853 Freeland in New York City built a lathe, estimated 20 in. swing x 12 ft. bed, with iron bed and back geared head.

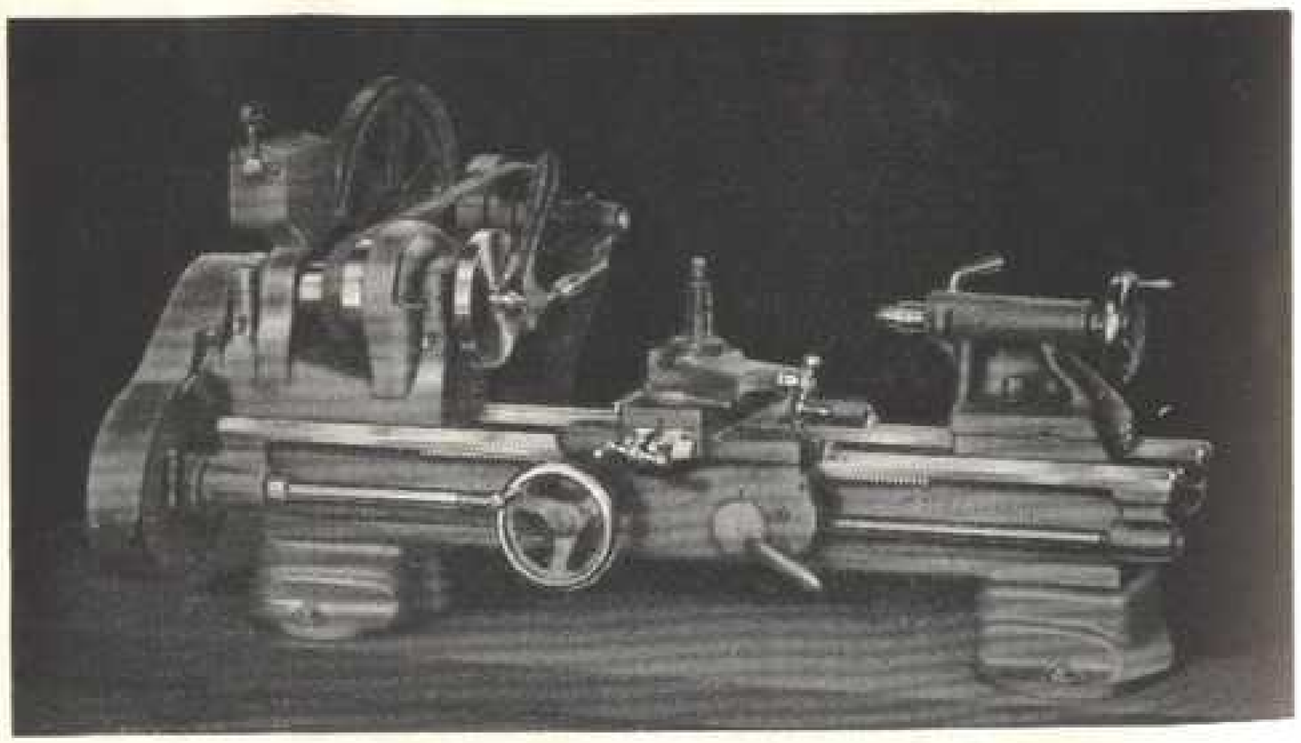


Fig. 4. A Modern Standard Change Gear Bench Lathe

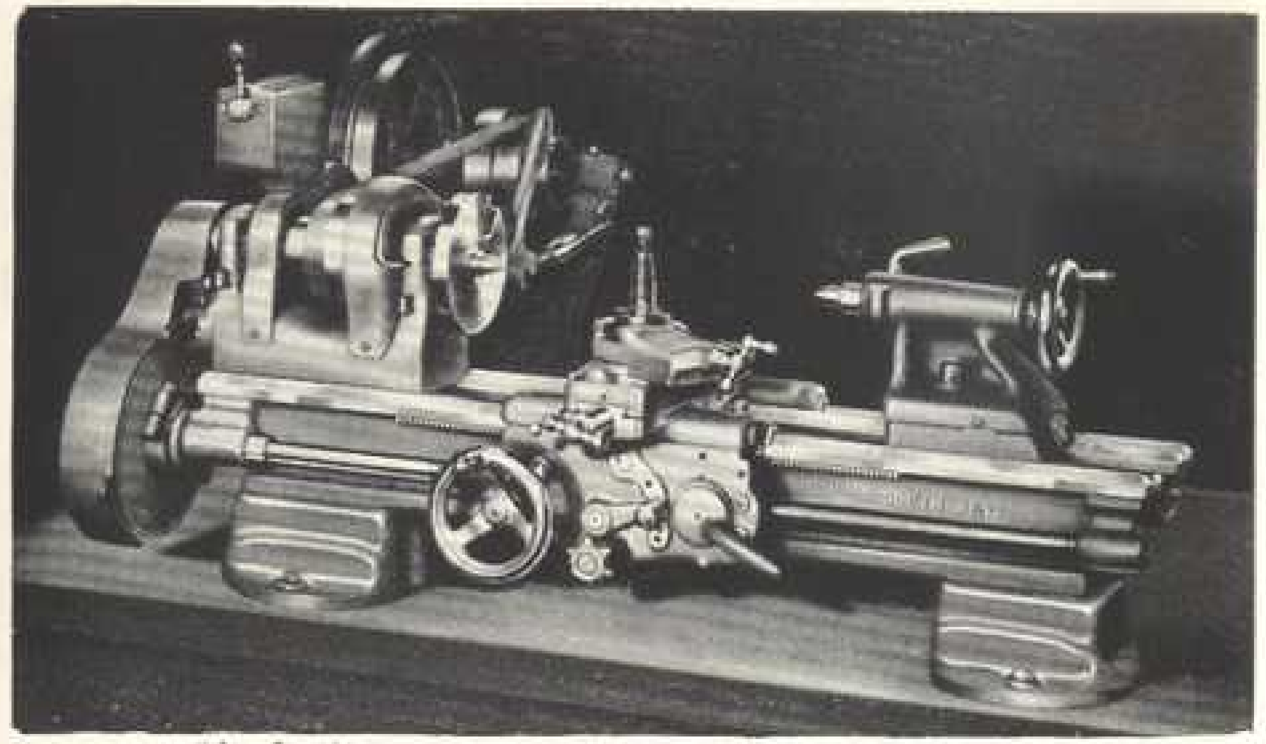


Fig. 5. A Standard Change Gear Bench Lathe with Power Longitudinal Feeds and Power Cross-feeds

The Modern Standard Change Gear Lathe

Modern bench lathes are shown in Figs. 4 and 5. These are known as standard change gear lathes because they have a set of independent change gears which are used to connect the headstock spindle with the lead screw for cutting various pitches of screw threads and for obtaining a series of power longitudinal turning feeds. The cross-feed for the lathe shown in Fig. 5 may also be operated by power through a friction clutch and series of gears in the apron.

The end view of a standard change gear bench lathe, and the gearing for connecting the headstock spindle with the lead screw of the lathe are shown in Fig. 6. The gears may be arranged so that practically any pitch of screw thread may be cut. The change gears are also used for obtaining a wide range of power cross feeds and power longitudinal feeds for turning and facing operations.

The standard change gear type of lathe is popular in the small shop, as it is less expensive than the quick change gear type of lathe. It is also widely used in industrial plants for production operations where few changes of threads and feeds are necessary. For this class of work the standard change gear lathe has an advantage in that when set up with the correct feeds for an operation the adjustments are not as easily tampered with and changed as they are on the quick change gear lathe.

Fig. 6. End View of Standard Change Gear Lathe

Fig. 7. A Modern Quick Change Gear Box

Quick Change Gear Lathe

A quick change gear lathe is one in which the gearing between the spindle and lead screw is so arranged that changes for obtaining various pitches of screw threads may be made through a quick change gear box without having to change loose gears.

Fig. 7 shows a modern quick change gear box. The quick change gear mechanism is attached to the left end of the lathe and provides a series of 48 changes for cutting screw threads from 4 to 224 per inch, also a wide range of power feeds for turning, boring, and facing. See page 25.

The quick change gear type of lathe is popular in busy shops where frequent changes of threads and feeds must be made such as in tool and die work, general repair and maintenance, and for some production operations.

Quick Change Gear Box

The interior of the quick change gear box is shown in Fig. 8. The gears in this gear box are shifted by levers operated from the front of the lathe and replace the independent change gears used on the standard change gear type of lathe.

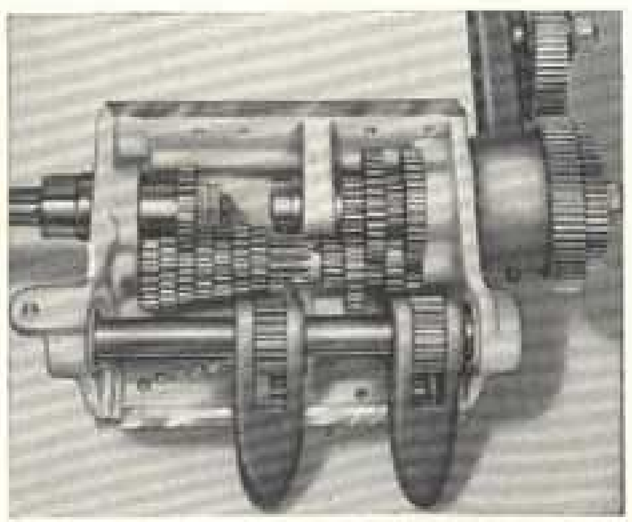
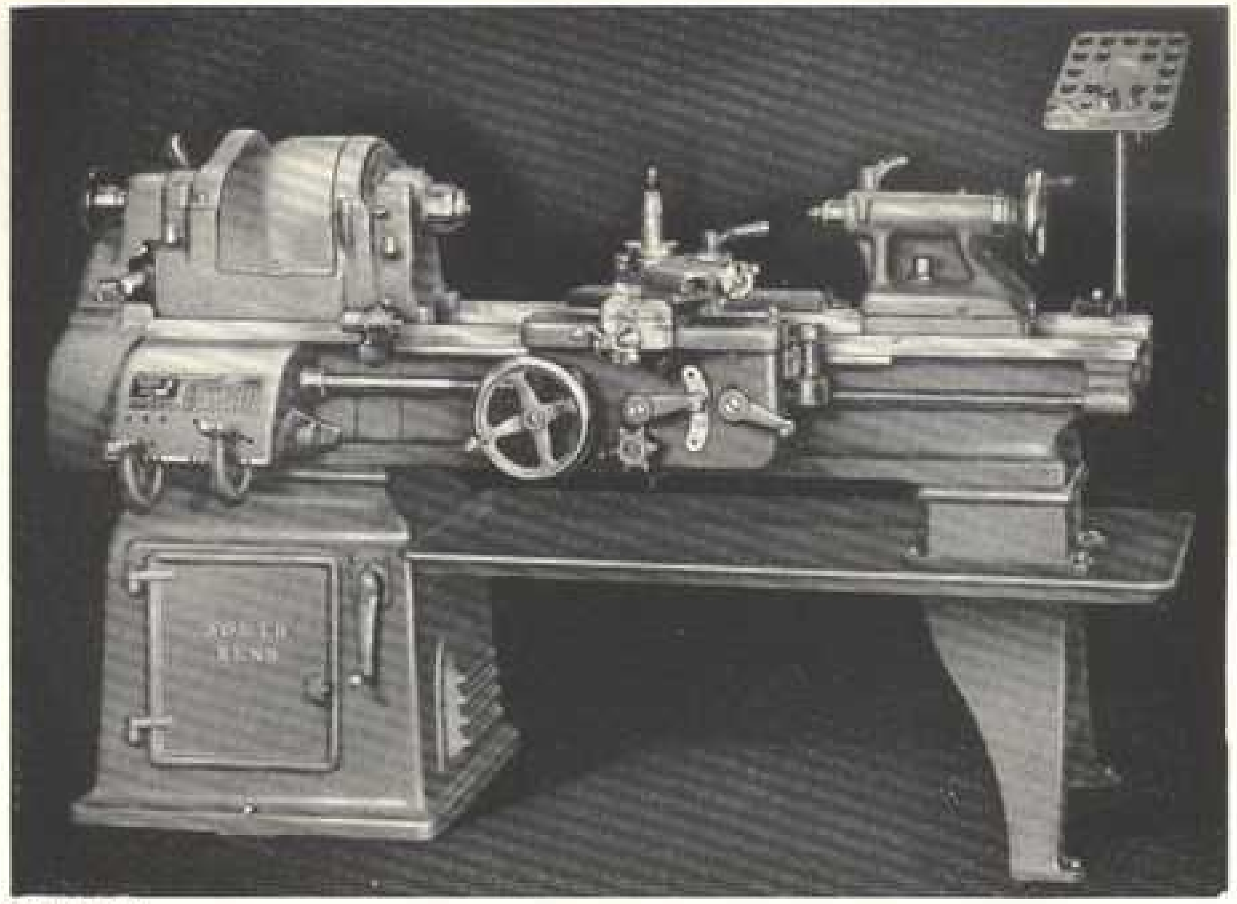


Fig. 8. Interior of Quick Change Gear Box



(Patented)

Fig. 9. A Modern Underneath Motor Driven Toolroom Lathe

Toolroom Lathe

The Toolroom Lathe is the most modern type of back-geared screw cutting lathe. It is supplied with underneath belt motor drive and quick change gear box, as shown in Fig. 9. Toolroom lathes are given special accuracy tests during the process of manufacture and are equipped with taper attachment, thread dial indicator, draw-in collet chuck attachment, collet rack, chip pan, and micrometer carriage stop. These attachments greatly increase the usefulness of the lathe.

The Toolroom Precision Lathe, as its name implies, is used in the toolrooms of industrial plants for making fine tools, test gauges and thread gauges, fixtures, jigs, etc., for making and testing the products manufactured.

A typical toolroom job, the making of a set of master thread gauges, is shown at right in Fig. 10. A threaded plug gauge for checking internal threads is being finished in the lathe and the round object in the lower left-hand corner is the threaded ring gauge for checking external threads.

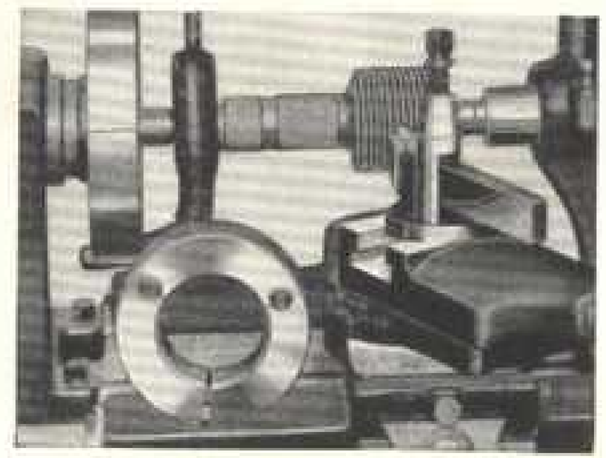
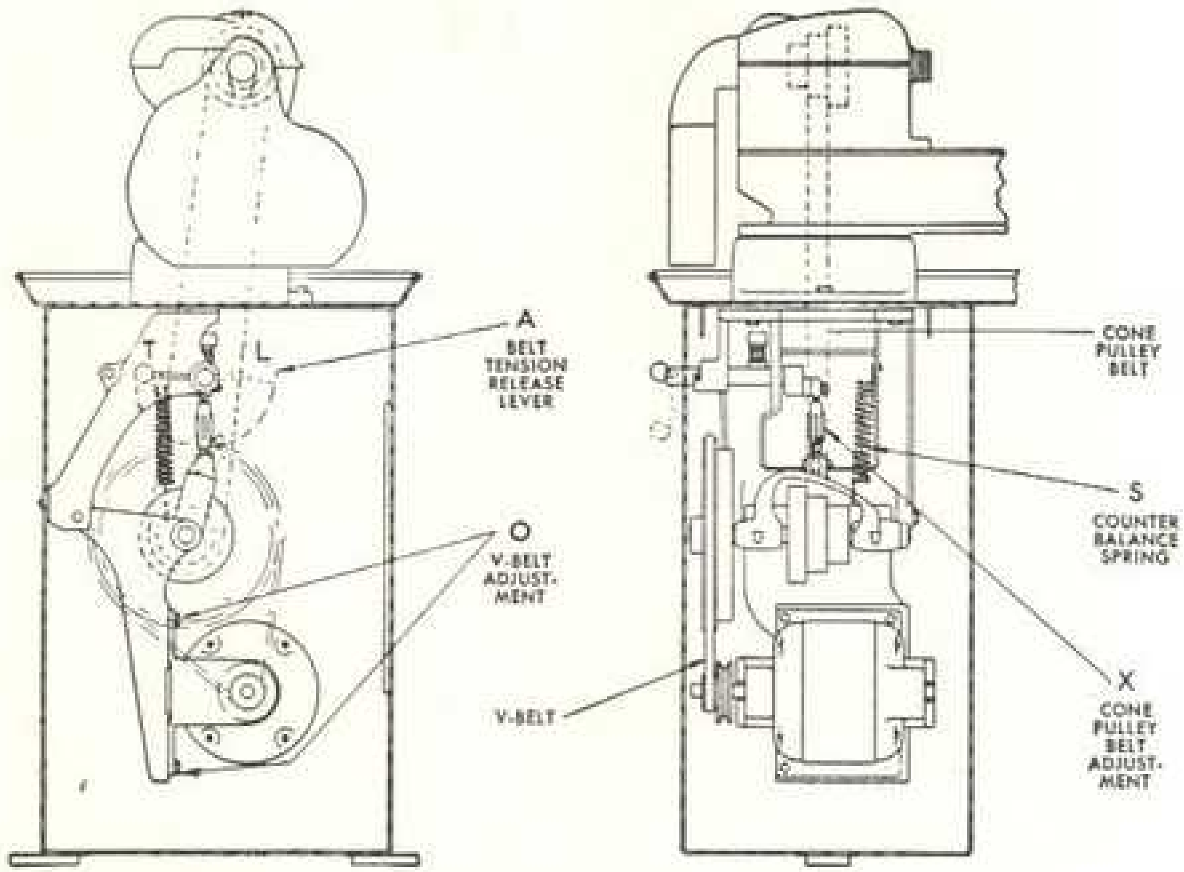
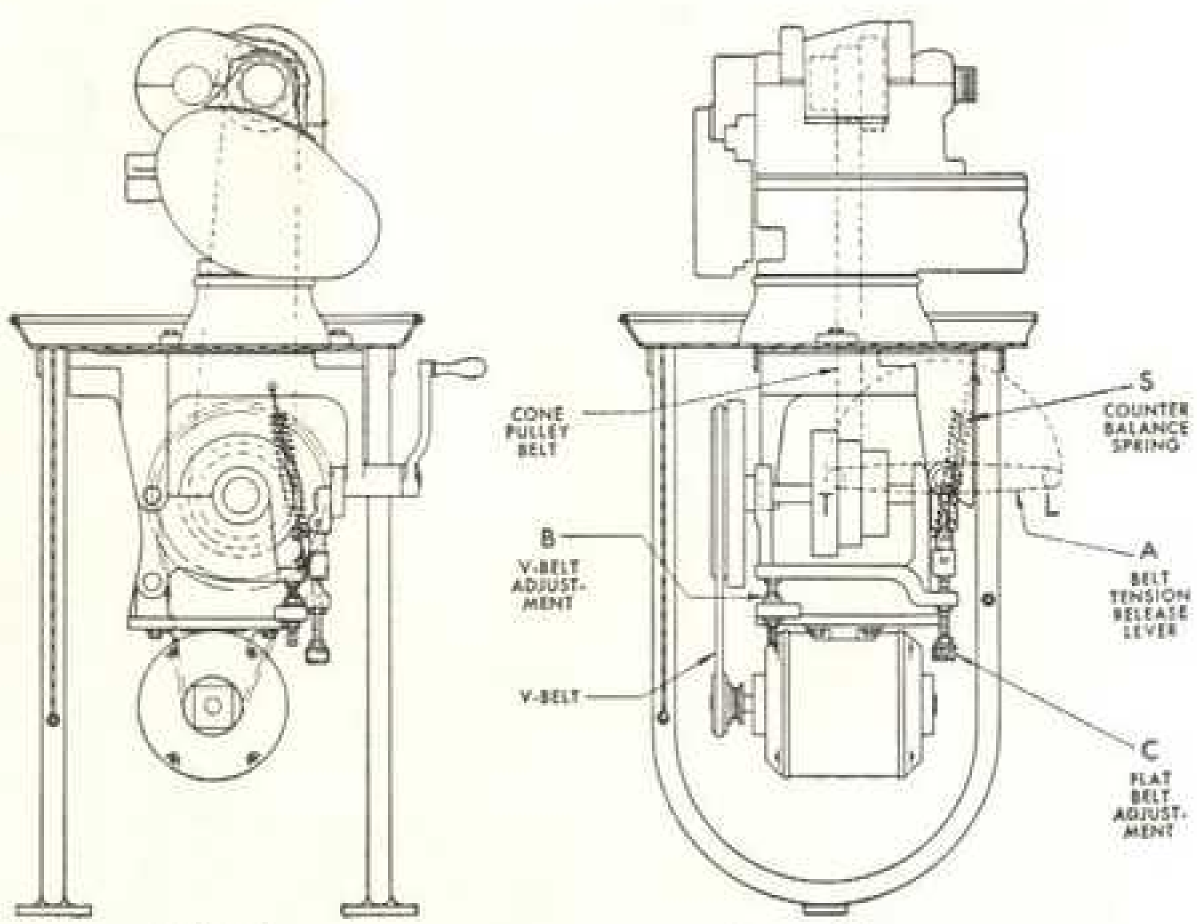


Fig. 10. A Typical Toolroom Job



End View Front View

Fig. 11. Underneath Belt Motor Drive for 9" and Light Ten Lathes



End View Front View

Fig. 12. Underneath Belt Motor Drive for 10" - 1" Collet Lathe

The Underneath Belt Motor Drive

The modern underneath belt motor drive shown in Figs. 11, 12, 13, and 14 is an efficient and practical direct drive equipment for a back-geared screw cutting lathe. This drive is unusually compact and is silent, powerful and economical in operation.

The motor and driving mechanism are fully enclosed in the cabinet leg underneath the lathe headstock. There are no exposed pulleys, belts or gears and no overhead belts or pulleys to obstruct vision or cast shadows upon the work.

Power is transmitted from the motor to the countershaft by V-belt and from the countershaft up through the lathe bed to the headstock cone pulley by a flat leather belt.

Adjustments "B" and "C" are provided for taking up belt stretch and for obtaining any desired tension on the motor belt and cone pulley belt. A belt tension release lever "A" conveniently located on the front of the cabinet leg permits easy shifting of the cone pulley belt. A hinged cover encloses the headstock cone pulley when the lathe is in operation. See page 19.

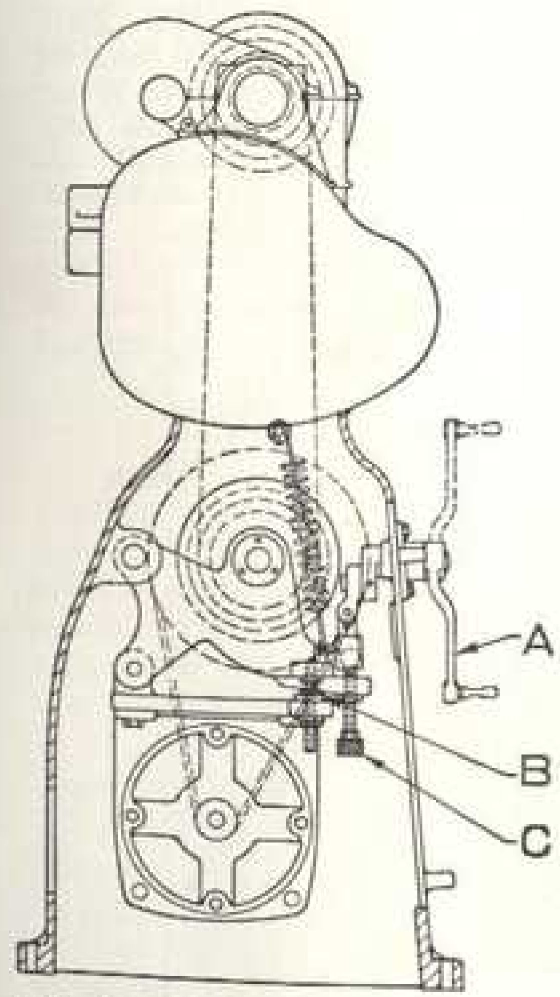


Fig. 13. Cross Section End View of Underneath Belt Motor Drive

Fig. 14. Phantom View of Underneath Belt Motor Drive

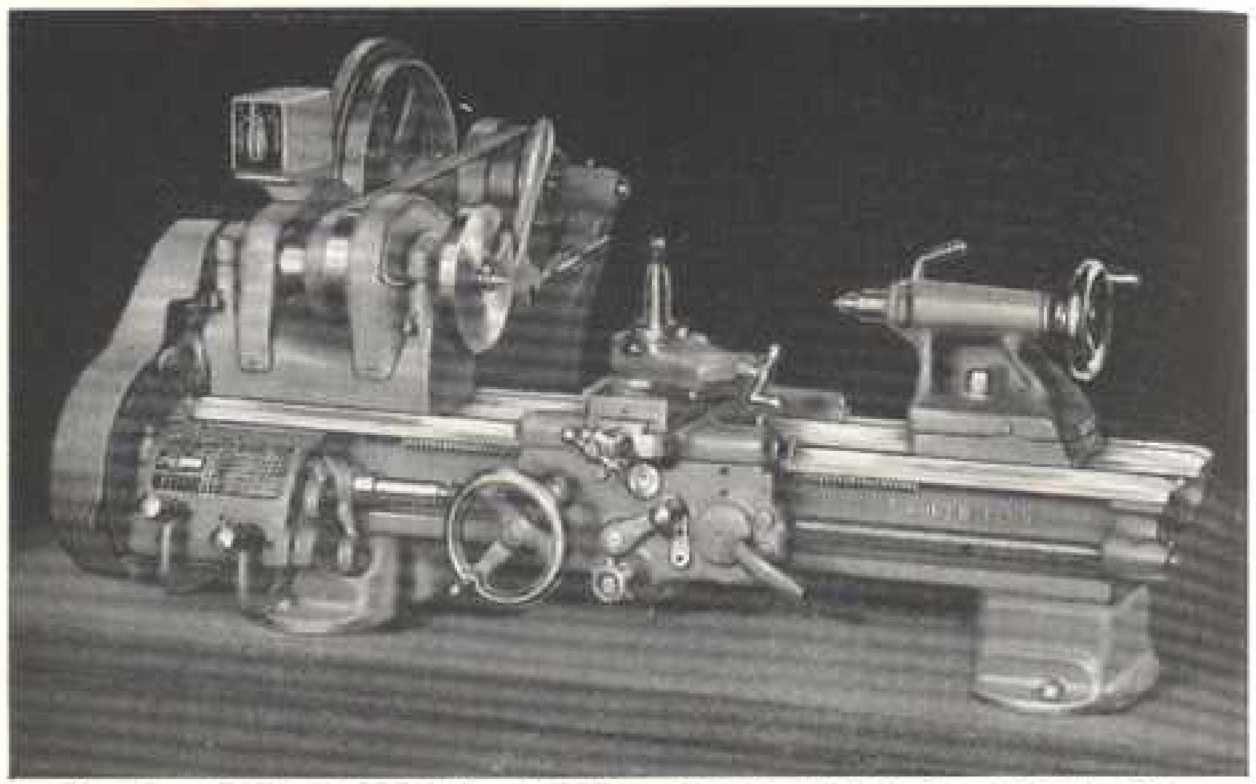


Fig. 15. A 9-inch Model A Bench Lathe with Adjustable Horizontal Motor Drive

Horizontal Motor Drive for Bench Lathes

The illustration above shows a 9-inch swing bench lathe equipped with an adjustable type horizontal motor drive unit. This is one of the most practical types of direct motor drive for a bench lathe.

The construction of the drive is shown below in Fig. 16. Belt tension adjustments "A" and "B" are provided for adjusting the tension of the cone pulley belt and the motor belt. A belt tension release lever "C" permits releasing the cone pulley belt tension so that the belt may easily be shifted from one step of the cone pulley to another. A flat leather belt is usually used between the cone pulleys and a V-belt is used between the motor pulley and the countershaft pulley.

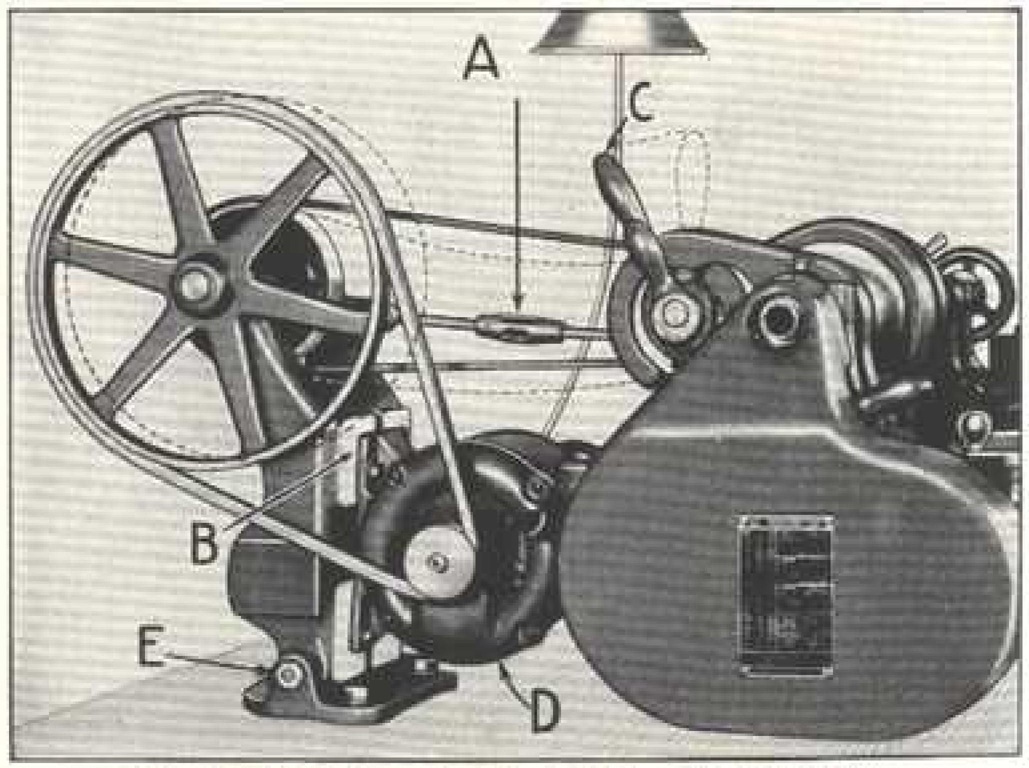


Fig. 16. End View of a Bench Lathe with Adjustable Horizontal Motor Drive

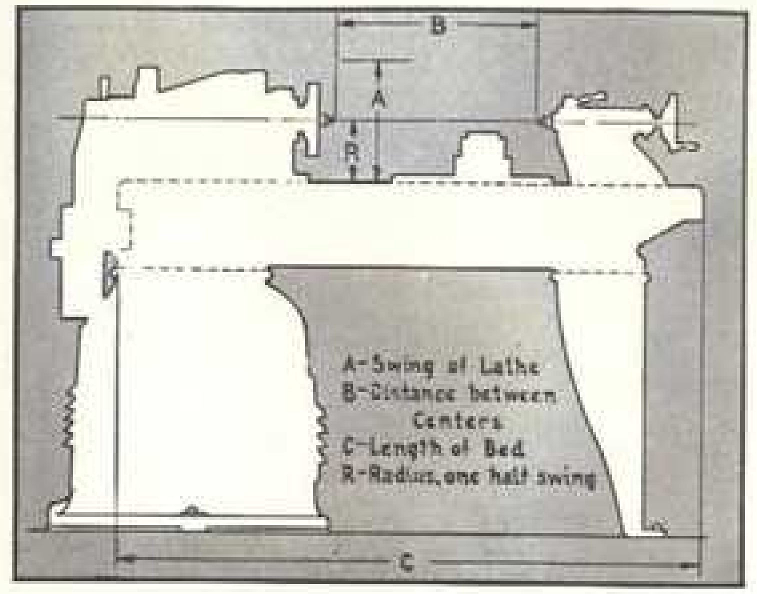


Fig. 17. Size and Capacity of a Lathe

Size and Capacity of the Lathe

In the United States the size of a Screw Cutting Lathe is designated by the swing over bed and the length of bed, as indicated in Fig. 17 above. For example, a 16 in. x 8 ft. lathe is one having a swing over the bed "A" sufficient to take work up to 16 in. in diameter and having a bed length "C" of eight feet.

European tool manufacturers designate the size of a lathe by its radius "R" or center height. For example, an 8-in. center lathe is a lathe having a radius of eight inches. What the European terms an 8-in. center lathe, the American calls a 16-in. swing lathe.

The swing over the tool rest of the lathe is less than the swing over the bed, and the maximum distance between centers "B" is less than the length of the bed. These figures must be considered carefully as they determine the size of work that can be machined between centers.

Selecting a Lathe for the Shop

When selecting a lathe, the most important point to consider is the size of the work. The lathe should be large enough to accommodate the various classes of work that will be handled. This is determined by the greatest diameter and length of work that will be machined in the lathe. The lathe selected should have a swing capacity and distance between centers at least 10% greater than the largest job that will be handled.

Types of Lathes for Various Classes of Work

If the lathe you require is a large one, 13-in. swing or more, the floor leg type is recommended. If the lathe needed is of 9-in. or 10-in. swing, either a bench lathe or a floor leg lathe may be selected. Floor leg lathes are usually more rigid than a lathe mounted on a bench because the heavy cast iron legs provide a sturdy, heavy support. If a bench lathe is used, the bench should be sturdy and rigid and should have a top of 2-in. lumber.

Type of Drive for the Lathe

The high operating efficiency of the modern electric motor has made the individual motor drive the most practical lathe drive in every respect. The lathe is more directly and easily controlled by the operator and, when an instant reversing motor is used, greater efficiency and convenience are obtained.

The overhead countershaft or group drive, which was formerly extensively used, is generally being replaced in modern industrial plants by the direct or individual motor drive because of lower installation and maintenance costs, greater safety for the operator, and the over-all improved shop conditions.

The individual drive makes possible the most efficient arrangement of shop equipment because it permits placing any machine at any angle in any location.

Change Gear Equipment

Quick change gear lathes are preferred in busy shops where frequent changes of threads and feeds are required. Standard change gear lathes are used in production shops on jobs that do not require many changes for threads or feeds, also in small shops that do not have a great deal of lathe work.

Fig. 18-A. Above. Close-up showing hinged guard for bull gear lock pin

Fig. 18. Back-Geared Headstock, Gear Guards Removed

Features the Lathe Should Have

In considering a metal working lathe for the shop it is well to bear in mind that the lathe will be used for many classes of work and that if carefully selected it should give years of satisfactory service.

The Headstock

The headstock is the most important unit of the lathe and should be back-geared, as shown in Fig. 18. The back gears provide the slow spindle speeds and power required for taking heavy cuts on large diameter work. Modern lathes are equipped with back gears having a quick acting bull gear lock which permits engaging or disengaging the back gears without using a wrench.

Fig. 19. Hardened Alloy Steel Headstock Spindle with Superfinished Spindle Bearing Surfaces

Headstock Spindle and Bearings

The lathe headstock spindle should be made of a good quality alloy spindle steel, and for best service should be heat treated after it is machined, and all bearing surfaces, including the taper hole, should be carburized, hardened and ground.

The journal bearing surfaces on the spindle should be "superfinished" to a smoothness of five microinches (.000005")*. When equipped with a superfinished spindle, precision bearing inserts, and proper lubrication facilities, the lathe can be operated at the high speeds essential for the efficient use of modern tungsten-carbide tipped cutter bits and the machining of plastics without danger of overheating or scoring the spindle bearings.

Lathe Bed Construction

The lathe bed is the foundation on which the lathe is built, so it must be substantially constructed and scientifically designed. Fig. 20 shows an end view of a lathe bed, which is an example of modern design.

Prismatic V-ways have been found to be the most accurate and serviceable type of ways for lathe beds and have been adopted by most of the leading machine tool builders. The two outer V-ways (1 and 4) guide the lathe carriage, while the inner V-way and flat way (2 and 3) align headstock and tailstock.

The V-ways of the lathe bed are carefully precision finished so that the headstock, carriage and tailstock are perfectly fitted and aligned parallel to the axis of spindle the entire length of bed.

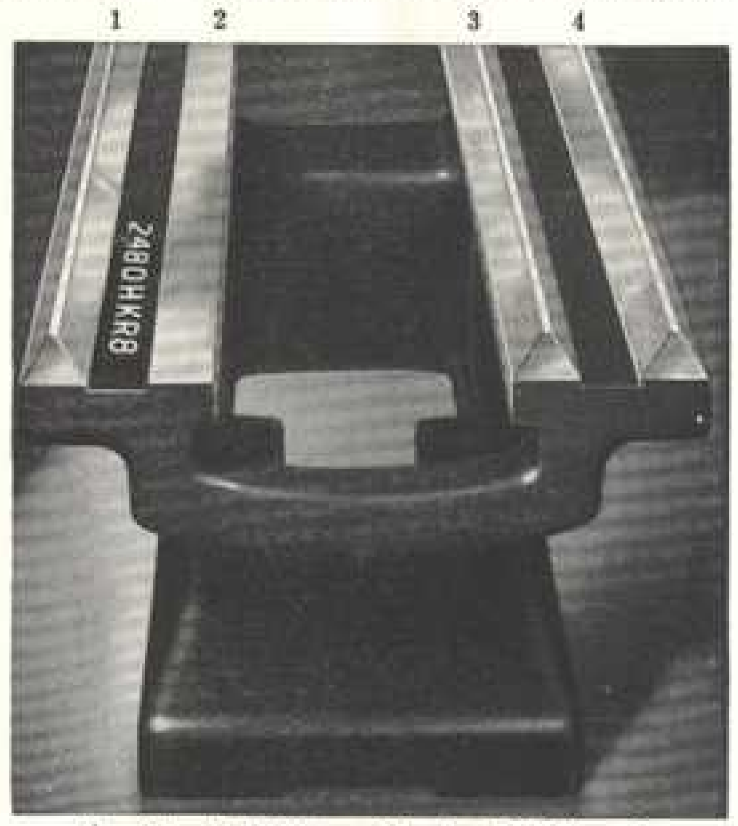


Fig. 20. End View of Lathe Bed Showing Prismatic V-Ways

*Measurements in microinches *rms*.

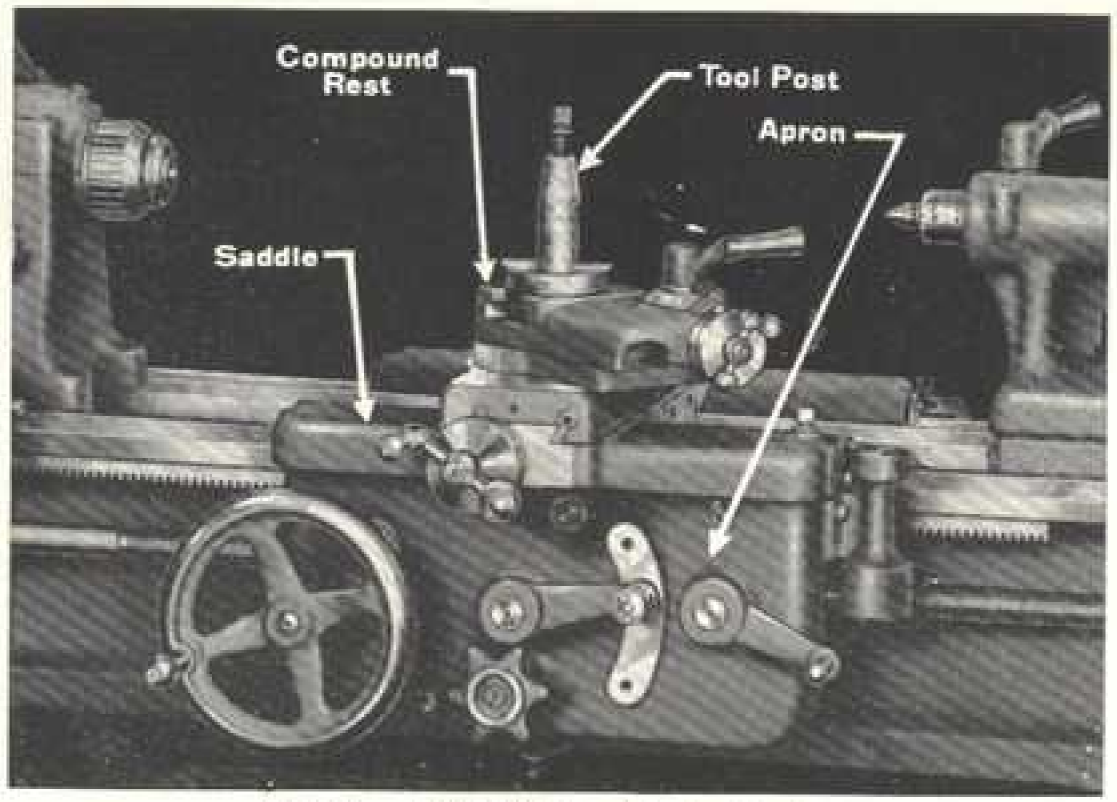


Fig. 21. A Well Designed Lathe Carriage

The Lathe Carriage

The lathe carriage includes the apron, saddle, compound rest and tool post. Since the carriage supports the cutting tool and controls its action, it is one of the most important units of the lathe. The carriage shown in Fig. 21 is modern and practical.

The apron is of double wall construction with all gears made of steel. A powerful multiple disc clutch is provided for driving the power feeds. An automatic safety device prevents the half nuts and automatic feeds from being engaged at the same time.

The threads of the lead screw are used only for thread cutting. A spline in the lead screw drives a worm in the apron which operates the power carriage feeds.

Interior of Apron

The interior of the apron is shown in Fig. 22 at right. The spline in the lead screw which drives the worm for operating the power longitudinal feeds and power cross feeds is clearly shown.

The half nuts for thread cutting are dovetailed into the back wall of the apron.

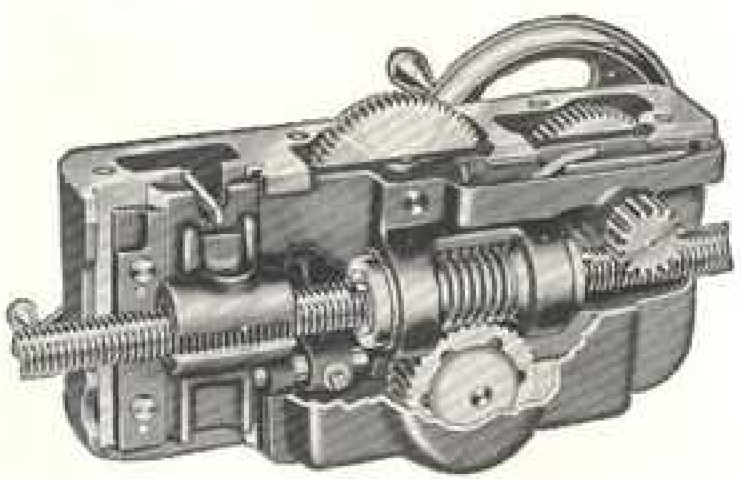


Fig. 22. Interior View of Double Wall Apron

Fig. 23. Leveling the Lathe

Chapter II

SETTING UP AND LEVELING THE LATHE

A new lathe should be very carefully unpacked and installed so that all of the fine accuracy that has been built into the lathe by the manufacturer will be retained.

Do not allow a hammer or crow bar to strike the lathe while unpacking as this may cause serious damage. Look carefully in all packing material for small parts, instruction material, etc. Study all reference books and instruction sheets carefully before setting up the lathe.

Clean the new lathe thoroughly with a stiff brush and kerosene. Wipe with a clean cloth and then immediately cover all unpainted surfaces with a film of good machine oil to prevent rusting. Wipe off the old oil occasionally and do not allow dust, chips or dirt to accumulate. Cover the lathe with a plastic or canvas service cover when not in use. Keep the finished surfaces clean and well oiled and the lathe will retain its new appearance.

Solid Floor Required

It is very important that the lathe be set on a solid foundation and that it is carefully and accurately leveled. An erection plan showing how to set up and level the lathe is included in the shipment of the lathe. For best results the lathe should be set on a concrete foundation. A wood floor should be braced to prevent sagging and vibration if it is not substantially constructed.

The lathe may be leveled by placing shims of hard wood or metal under the legs, as shown in Fig. 23. If the lathe is not leveled it will not set evenly on all four legs and the weight of the lathe will cause the lathe bed to be twisted, throwing the headstock out of alignment with the V-ways of the bed and causing the lathe to turn and bore taper. If the lathe is not level it cannot turn out accurate work.

Use a Precision Level for Leveling the Lathe

Fig. 24. A Precision Level

Use a precision level that is at least twelve inches long and sufficiently sensitive to show a distinct movement of the bubble when a .003 in. shim is placed under one end of the level. Level across the lathe bed at both the headstock end and the tailstock end, as shown in Fig. 23, page 15.

Bolt the Lathe to the Floor

Use lag screws or bolts to secure the lathe to the floor. If the lathe is set on a concrete floor or foundation, mark the location of the bolt holes and drill holes in the concrete with a star drill. Use expansion bolts or set bolts in melted lead or melted sulphur. Check the leveling of the lathe after bolting the lathe to the floor or bench.

Leveling Underneath Belt Motor Driven Lathes

When placing shims under the cabinet leg at the headstock end of the Underneath Motor Drive Lathe, use the shims only at the bolt pads. There should be clearance under the cabinet leg all the way round except at the two pads where the bolts go through the leg into the floor.

Bench Lathes

Bench Lathes should be mounted on a substantial bench, providing rigid support and leveled as outlined above. The bench top should be about 28 in. high and if made of wood should be of 2-in. lumber. The bench should be securely bolted to the floor so there will be no danger of the bench shifting and throwing the lathe out of level. Some bench lathes have leveling screws in the right leg which may be used for making the final leveling adjustments.

Readjust Shims

It may be necessary to readjust the shims under the lathe legs from time to time to compensate for settling of the building, even if the lathe is set on a concrete floor. For this reason the legs should not be bedded in concrete but should be bolted to the floor.

If at any time the lathe does not bore a straight hole, this is an indication that the lathe is no longer perfectly level and the shims should be readjusted.

Checking the Leveling of Lathe

After leveling the lathe, place a bar of steel one inch or larger in diameter in the chuck and machine two collars of equal diameter three or four inches apart, as shown in Fig. 25. Take a very light finishing cut across both of these collars without changing the adjustment of the cutter bit. Measure the diameter of each collar carefully with a micrometer.

If the collars are not the same diameter, this is an indication that the level used in setting up the lathe was not sufficiently sensitive. The leveling may be perfected by adjusting the shims under the front and back legs at the tailstock end of the lathe until the collars on the test piece are turned the same diameter.

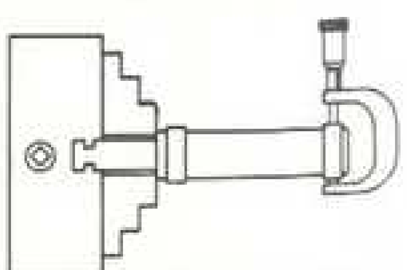
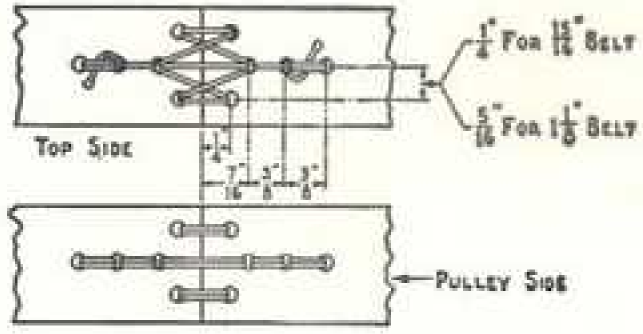


Fig. 25. Method of Testing Leveling of Lathe

Belts for the Lathe Drive

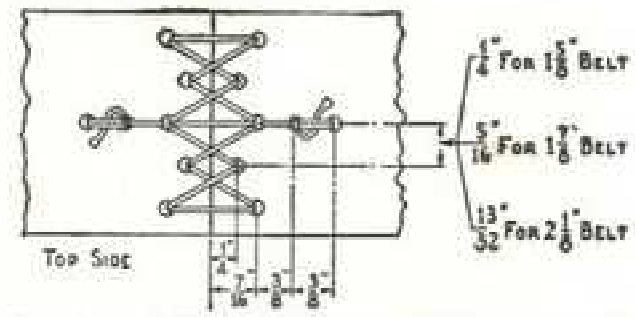
Good quality flat leather belts are best for use on the lathe cone pulleys. They have sufficient elasticity to transmit power efficiently and will give excellent service without slipping if they are kept clean and the tension is properly adjusted as instructed on page 19. The smooth side of the belt should run next to the pulleys.

V-belts of correct specifications and of good quality should be used where required. Correct tension of V-belts is of greatest importance. Never adjust V-belts tighter than required to pull the load, or run so loose that they creep or slip. Either condition causes V-belt failure.



Cross Section

Spacing of Holes for 15/16" and 1-⅛" Belts



Spacing of Holes for 1-⅝", 1-⅞", and 2-⅛" Belts

Groove Pulley Side for Gut Lacing

Fig. 26. Specifications for Laced Belt Splice

Lacing Leather Belts

Leather belts may be joined by lacing with gut or rawhide thongs, as shown in Figs. 26 and 27.

When measuring for belt length the belt tension device must be adjusted so the cone pulleys are moved toward each other as far as possible. Determine the exact belt length by carefully measuring around the cone pulleys with a steel tape and then subtracting ⅜". This will give the belt tension enough to drive the lathe without requiring any initial adjustment of the belt tension device on the drive. Trim the ends of the belt square and to this length. Punch or drill ⅛" holes in the belt ends as shown. If a round gut lace is used, cut straight grooves on the pulley side, as shown by the cross section in Fig. 26, so the lace will lay flush with the belt surface and run smoothly over the pulleys.

Place the belt around the cone pulleys, mark the center of lace and place the marked midpoint at "A" as shown in Fig. 27. Being careful not to kink the lace, start one end toward "B" and thread this half of the lace in the direction of the arrowheads and finish at "K." Repeat with the other half of the lace, starting toward "C" and ending at "L." Fasten the ends as shown and burn close with a match to prevent them from pulling out. Fig. 27 shows 5 rows of holes, but the method of lacing remains the same whether there are 3, 5, or 7 rows of holes. Do not cross the lacing on the pulley side.

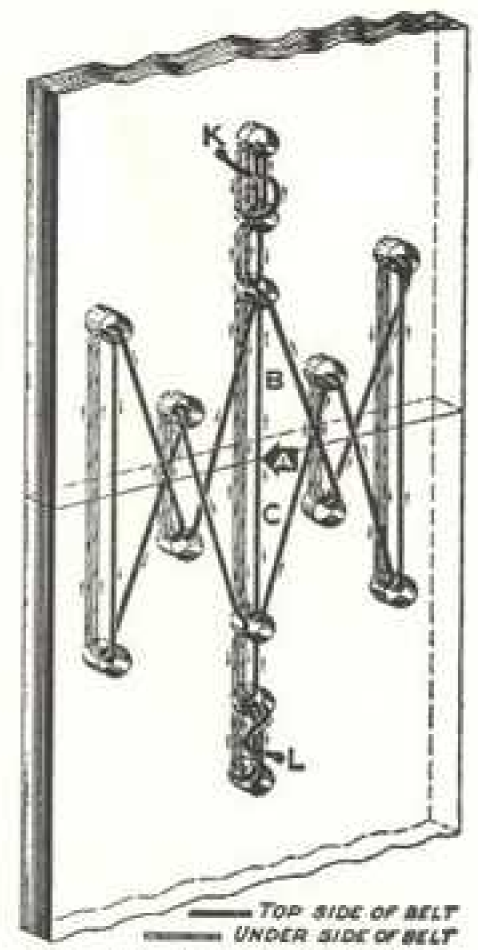


Fig. 27. Method of Lacing Leather Belt

Wire Belt Hooks

There are a number of good wire belt hooks on the market that can be used for splicing belts. Measure for the length of the belt in the same manner as outlined above and then deduct enough more, before cutting, to allow for the connecting pin (See Fig. 28). Wire belt hooks should never be used on any belt which is not completely guarded or which may be shifted while the machine is running.

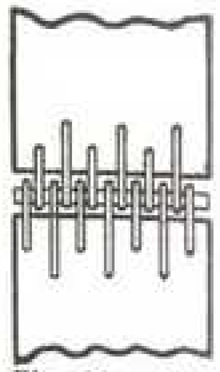


Fig. 28. Wire Belt Hooks

Glued Belt Splice

The cemented endless belt splice is preferred by many mechanics because, when properly made, it is very durable and will run over the pulleys more smoothly than a laced or wire hook splice. A good waterproof type of belt cement should be used. Experience has shown that a belt splice made with good acetone cement is practically permanent and is not subject to ordinary moisture or oil action.

Measure for the length of the belt to be used, in the same way as for the laced splice, then add five inches for the lap-over to be cemented. After the belt ends have been cut square and to length, the five inch overlapping ends are tapered as shown by the drawing, Fig. 29. Use a belt shave, small plane, or sharp knife to cut smooth, uniform tapers. Prepare two blocks of soft one inch wood, a little wider than the belt, and six inches long.

Place the belt around the cone pulleys and apply cement according to directions of the cement manufacturer. Press the freshly cemented joint together and immediately lay on one of the wood blocks. Nail the belt, through the joint, to the block of wood with two or three small nails. This will prevent the splice from slipping or becoming crooked. Place the other block of wood on top of the joint and clamp firmly, using "C" clamps. Allow the cement to dry thoroughly before removing the clamps. Scrape any excess cement from the surfaces of the belt before using it.

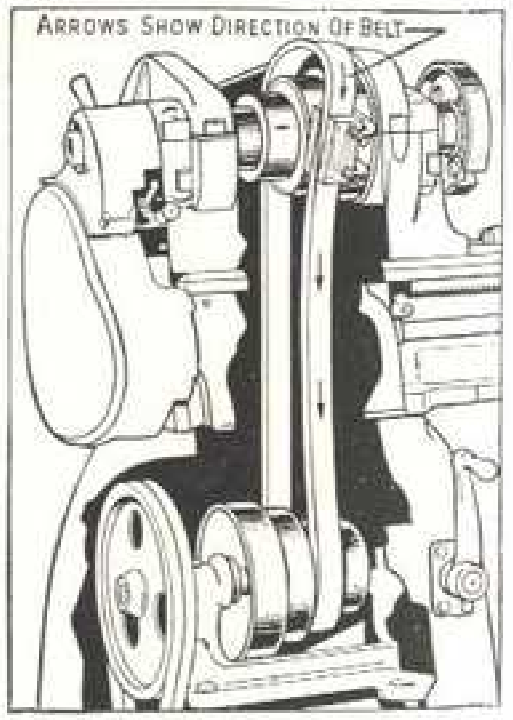


Fig. 29. Cemented Endless Belt Splice

Belt Tension on Lathe Drives

Maintaining the proper running tension for the flat leather belt and V-belts is of the greatest importance. Belts which are allowed to run loose will creep and slip and cause an over-all loss in the cutting efficiency of the lathe, and damage may result to fine work due to variation of cutting speeds. Belts which are run under too much tension overload the lathe and lathe drive. This results in loss of power, excessive bearing wear, causes the motor to run hot, and stretches the belts until they have to be shortened or replaced. Routine checking and adjustment of the belt tension, according to instructions given in the following paragraphs, will keep the lathe efficiency high and repair expenses low.

Horizontal Motor Driven Lathe Belts

The lathe should be stopped before the flat belt is shifted on the cone pulleys. Release the belt tension by pulling lever "C" forward, as shown in Fig. 30, and then shift belt to change spindle speeds.

To change flat belt tension, adjust turnbuckle "A" with lever "C" in the back (or down) position. Test tension by pressing down on belt midway between the cone pulleys. Belt should depress about one inch. If belt slips under power and tension is correct, it is probably oily and should be cleaned with naphtha or benzol. If the belt appears dry and stiff, a little neat's-foot oil will make it pliable.

Adjust V-belt tension by moving motor on its standard. Loosen the four screws at "B," Fig. 30. After moving motor, tighten screws. When properly adjusted V-belt should depress about one inch midway between pulleys, but must still be stretched tight enough to feel alive when tapped with finger tips. Check pivot screws at "E." If necessary, adjust so they are snug and tighten lock nuts.

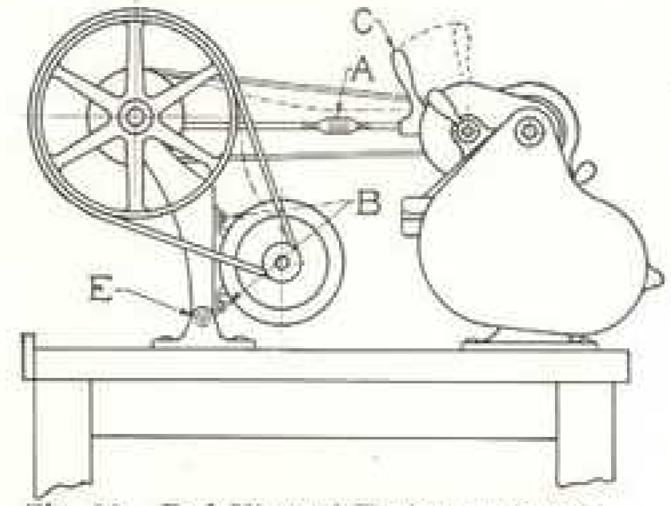


Fig. 30. End View of Horizontal Motor Driven Bench Lathe Showing Belt Tension Adjustment

Underneath Motor Driven Lathe Belts

Belt tension release lever "A" (Fig. 31) permits releasing cone pulley belt tension for shifting belt to change spindle speeds. See drawings of underneath motor drives, pages 8 and 9, Figs. 11, 12, 13, and 14.

Screw "C" adjusts tension of the cone pulley flat belt (see Figs. 12 and 31). This adjustment must be made with lever "A" in running position. The lathe shown in Fig. 11 has turnbuckle for making this adjustment.

Screw "B" adjusts tension of the motor V-belts. Turn nuts above and below motor mounting plate (Figs. 13 and 31). Adjust V-belt tension on lathe shown in Fig. 11, the same as shown in "Horizontal Motor Driven Lathe Belts," above.

Belts should be just tight enough to transmit the required power without slipping. Pressing the hand against a properly adjusted flat belt near the cone pulley should depress belt about ½". The V-belt, midway between pulleys, should depress about 1". Belts may be cleaned with naphtha or benzol and the flat belt treated with neat's-foot oil, as mentioned above on this page.

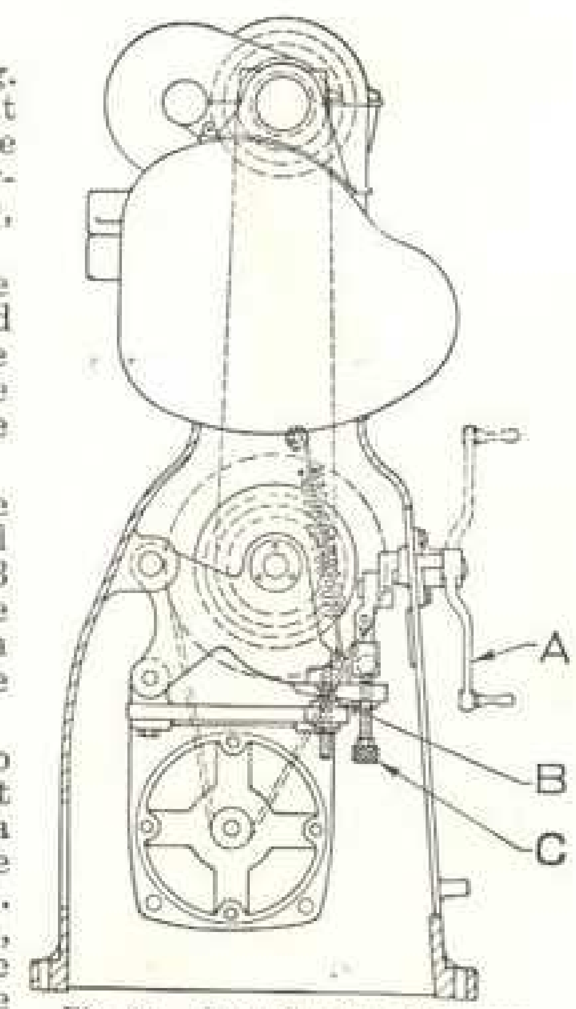


Fig. 31. Cross Section of Underneath Belt Motor Drive Showing Cone Pulley Belt and V-belts

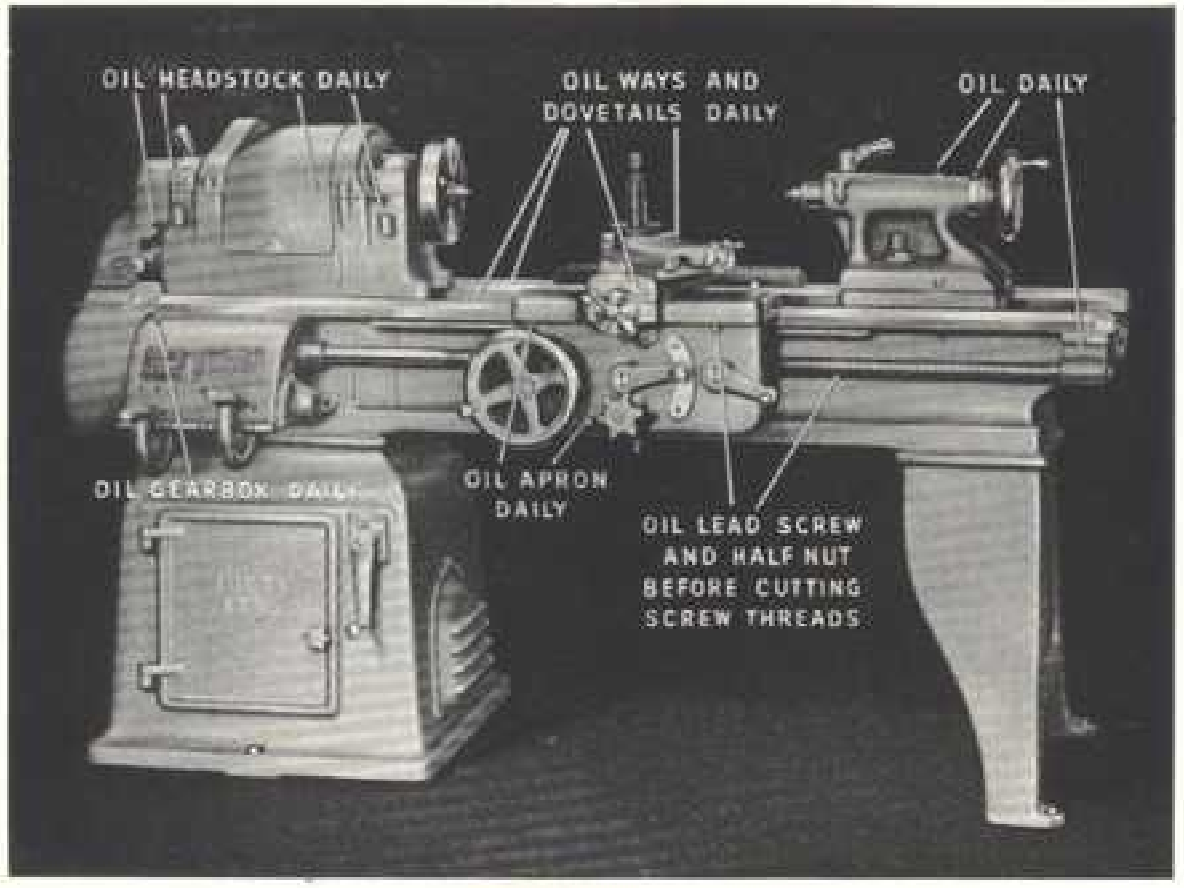


Fig. 32. Oiling Chart for a Lathe

Oiling the Lathe

Oil every bearing of a new lathe before starting it. Use high grade oils of proper viscosity as specified on the metal Lubrication Chart attached to each lathe. The lathe should be oiled twice daily for the first week it is used and once a day thereafter. Never oil the lathe while it is running and be certain that machine oil is used, not automobile engine oil.

Keeping the lathe well oiled has much to do with the length of its life and the quality of the work it will turn out. Follow the directions on the metal lubrication chart carefully if you wish to keep your lathe in first class condition.

Always oil in the same order so that no oil holes will be missed. If you do this the oiling will become a habit and will require only a very short time.

Do not use an excess of oil. A few drops in each oil hole is sufficient, and if more is applied it will only run out of the bearings and get on the lathe, making it necessary for you to clean it more frequently.

Oil the motor and drive bearings as specified in instructions supplied with the lathe. This is very important. Do not allow dust, chips or other debris to collect around the motor so it will overheat. An excessive rise in the motor running temperature will cause damage to its bearings and windings.

After you have completed the process of oiling the lathe and motor drive, wipe off the excess oil around the bearings with a clean cloth or waste. Keep the lathe clean. Do not allow oil, dirt, chips or rust to collect any place on the lathe.

Chapter III

OPERATION OF THE LATHE

Before starting a new lathe, the operator should carefully study the action of the various parts and become thoroughly familiar with the operation of all control levers and knobs.

The principal parts of the lathe are shown below in Fig. 33. Become familiar with the name of each part as they will be referred to frequently in the following pages where detailed information on the operation of the lathe is given.

Do not operate the lathe under power until it is properly set up and leveled, as outlined on page 15. Also make sure that all bearings have been oiled and that the belt tension is correct. Always pull the cone pulley belt by hand to make sure the lathe runs free before starting the lathe under power.

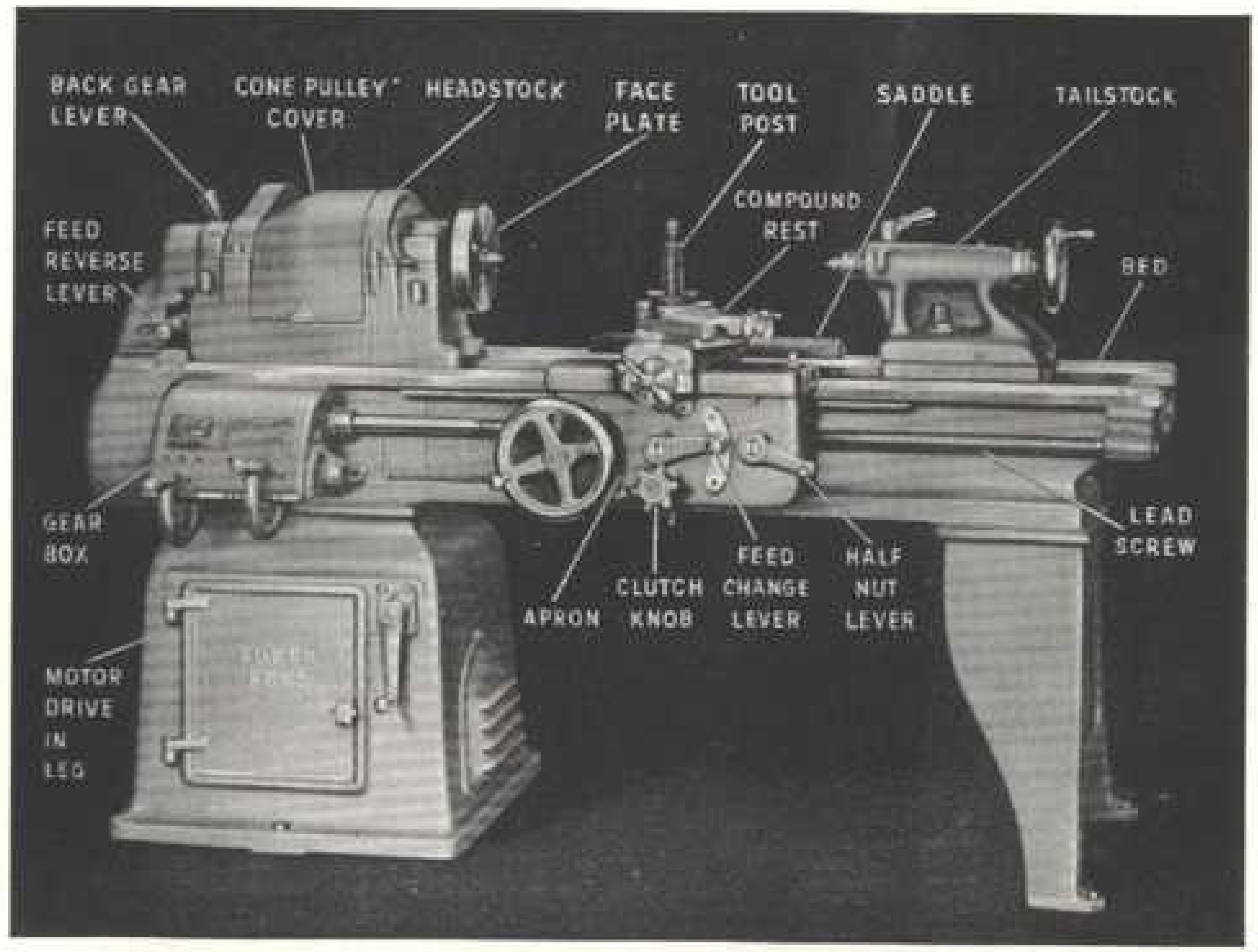


Fig. 33. Names of the Principal Parts of a Lathe

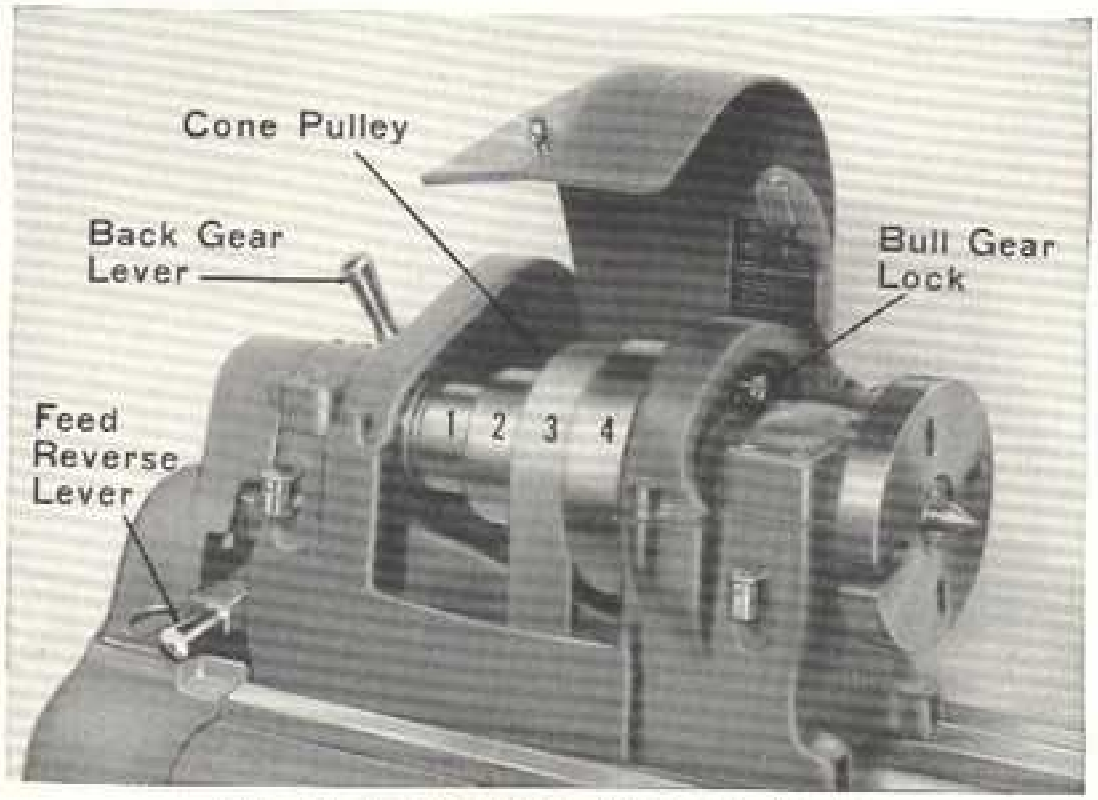


Fig. 34. Operating Parts of Lathe Headstock

Operation of Headstock

Spindle speeds are changed by shifting the belt from one step of the cone pulley to another and by engaging or disengaging the back gears. The cone pulley steps are numbered in the illustration above to correspond with the numbers in the tabulation on page 23, which shows the normal spindle speeds for various sizes of lathes.

Direct Belt Drive

To arrange the lathe headstock for direct belt drive, push the back gear lever back as far as it will go; then pull out and up on the bull gear lock pin and revolve the cone pulley slowly by hand until the bull gear lock slides into position and locks the cone pulley to the spindle.

Back Geared Drive

To engage the back gears for slow spindle speeds, pull the bull gear lock pin out and push it down to disconnect the cone pulley from the spindle; then pull the back gear lever forward. Revolve the cone pulley by hand to make sure the back gears are properly engaged. Do not engage the back gears while the lathe spindle is revolving.

Bull Gear Lock, Plunger Type

On some lathe headstocks the plunger type bull gear lock is used. For direct belt drive on these lathes the bull gear lock pin is pushed in, and for back-geared drive it is pulled out.

Feed Reverse Lever

The feed reverse lever on the left end of the headstock has three positions; up, central and down. The central position is neutral, and when in this position all power carriage feeds are disconnected. When the lever is in either the "up" position or "down" position the power carriage feeds will be in operation. The lathe should always be stopped before the position of the feed reverse lever is changed.

Spindle Speeds of Lathes

The spindle speeds for various sizes of lathes are listed in the tabulation below. The columns under which the speeds are listed are numbered 1, 2, 3, and 4 to correspond with the numbers on the cone pulley steps in Fig. 34, page 22. For example, those spindle speeds that are listed under Column 1 are obtained when the cone pulley belt is placed on the cone pulley step marked 1 in the illustration, Fig. 34.

SPINDLE SPEEDS OF LATHES

Size of Lathe	Type of Drive	Speed Range	Approximate Spindle Speeds in Revolutions Per Minute							
			Direct Belt Drive				Back-Gear Drive			
			1	2	3	4	1	2	3	4
9" Bench	6-speed flat belt	....	680	392	235	...	130	78	50	...
9" Bench & Self-Contained	12-speed flat belt	High Low	1270 692	750 410	446 244	... ...	250* 134	145 81	86 50	... ...
9" Bench	8-speed V-belt	....	640	471	350	267	125	96	69	54
9" Bench & Self-Contained	16-speed V-belt	High Low	1200 640	900 490	662 362	505 272	235* 130	179* 95	130 70	100 54
9" & Light Ten	U.M.D. flat belt	High Low	1365 715	780 410	460 240	... ...	265* 135	155* 78	90 50	... ...
9" & Light Ten	U.M.D. V-belt	High Low	1365 670	1010 495	760 370	570 285	265* 130	195* 95	150* 75	112 52
Light Ten Bench & Self-Contained	12-speed flat belt	High Low	1435 706	844 415	502 244	... ...	276* 137	165* 80	96 48	... ...
Light Ten Bench & Self-Contained	16-speed V-belt	High Low	1365 670	1010 495	760 370	570 285	265* 130	195* 95	150* 75	112 52
10-inch & 10-inch Turret	3-step pulley	High Low High† Low†	1400 740 700 370	898 470 449 235	585 304 292 152	... ...	250* 130 125 65	160* 85 80 42	105 55 52 27	... ...
13-inch	4-step pulley	High Low†	940 470	628 314	418 209	270 135	135 67	90 45	60 30	40 20
13-inch & 13-inch Turret	3-step pulley	High Low†	940 470	497 248	270 135	... ...	135 67	71 35	40 20	... ...
14½-inch	4-step pulley	High Low†	875 437	545 272	350 175	215 107	130 65	80 40	50 25	30 15
14½-inch	3-step pulley	High Low†	875 437	428 214	215 107	... ...	130 65	61 30	30 15	... ...
16-inch	4-step pulley	High Low†	980 490	610 305	390 195	240 120	125 62	80 40	50 25	30 15
16-inch & 2-H	3-step pulley	High Low†	945 475	550 278	300 150	... ...	118 60	70 33	32 20	... ...
16-24-inch	6-speed	....	405	235	130	...	50	30	14	...
16-24-inch	8-speed	....	470	280	175	105	60	35	22	15
16-24-inch	12-speed†	High Low	790 400	460 230	250 125	... ...	100 50	60 29	27 15	... ...
16-24-inch	16-speed†	High Low	900 455	550 274	340 170	203 104	116 60	70 34	45 24	30 15

*It is not recommended that back-gears be engaged when drive is operated at high speed.
†Available only with 2-speed motor.

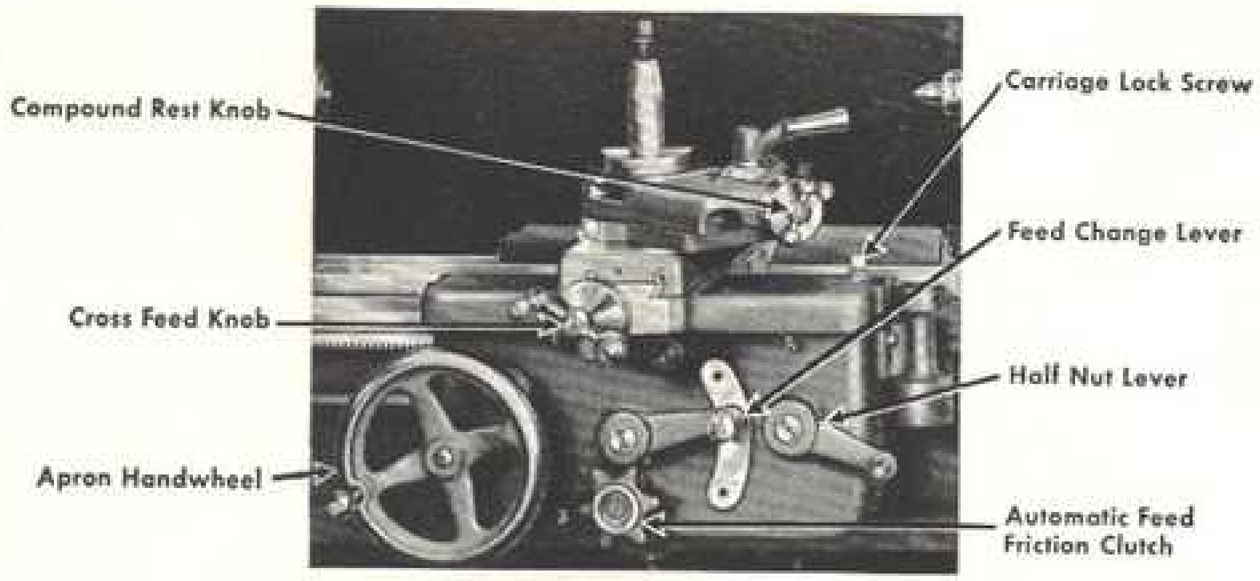


Fig. 35. Operating Parts of Lathe Carriage and Apron

Operation of Lathe Carriage and Apron

The principal operating parts of the lathe carriage and apron are shown above in Fig. 35. The apron hand wheel is turned to move the carriage along the lathe bed, and the cross feed knob and compound rest knob are turned to move the tool rest in and out. The carriage lock screw is used to lock the carriage to the lathe bed. This screw should never be tightened except for facing or cutting-off operations.

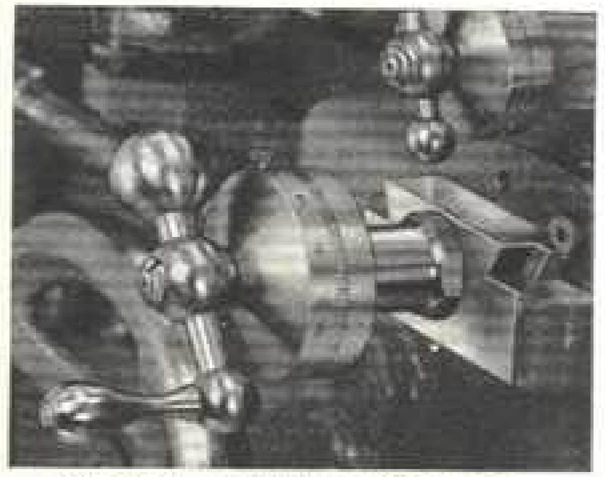


Fig. 35A. Micrometer Collar on Cross Feed Screw

Micrometer Collars

Each graduation of the micrometer collars on the cross feed knob and compound rest knob represents a movement of the compound rest of one-thousandth of an inch. The graduated collars may be set at zero by releasing the set screws which lock them in position.

Power Carriage Feeds

The power feed friction clutch controls the operation of both the power longitudinal feed and the power cross feed. To engage the clutch, turn the club knob to the right; to disengage, turn to the left. The direction of the feed is controlled by the position of the reverse lever on the headstock. (See page 22.)

The feed change lever has three positions: "up" for longitudinal feeds, "down" for cross feeds, and "center" for neutral.

The half nut lever is used only for thread cutting. The feed change lever must be in the "center" or neutral position before the half nuts can be engaged.

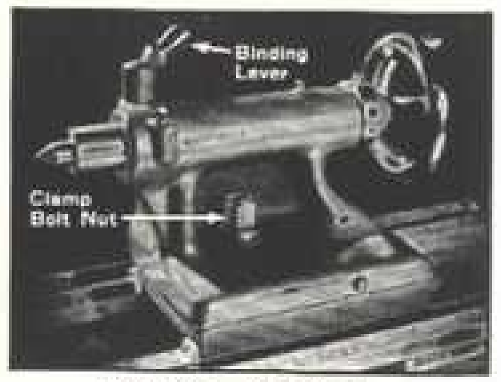


Fig. 36. Tailstock

Operation of Tailstock

The tailstock may be locked on the lathe bed at any position by tightening the clamp bolt nut. To lock the tailstock spindle, tighten the binding lever.

Power Carriage Feeds on Quick Change Gear Lathes

A wide range of power longitudinal feeds and power cross feeds is available on all Quick Change Gear Lathes. To obtain any desired feed it is only necessary to arrange the levers on the gear box according to the direct reading index chart shown in Fig. 38. The threads per inch are shown in large figures on the index chart below. The smaller figures indicate the power longitudinal turning feeds in thousandths of an inch. See page 74.

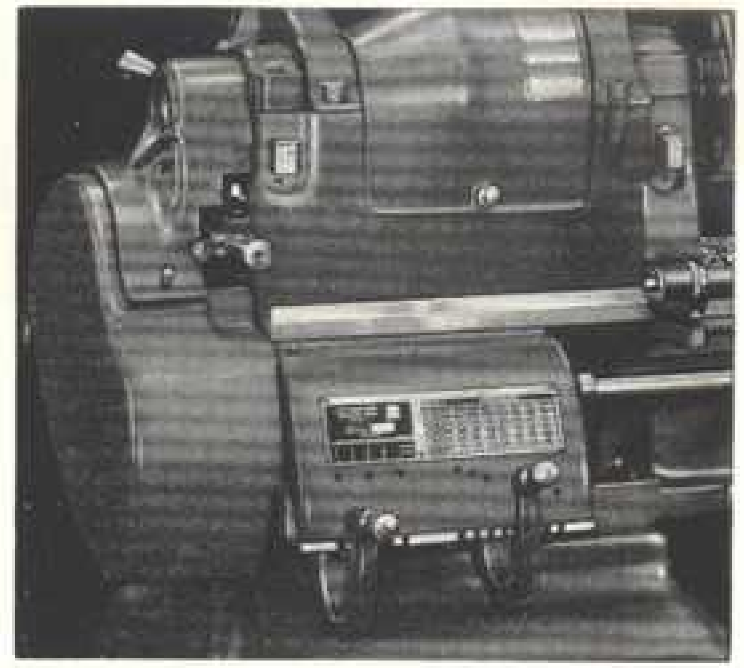
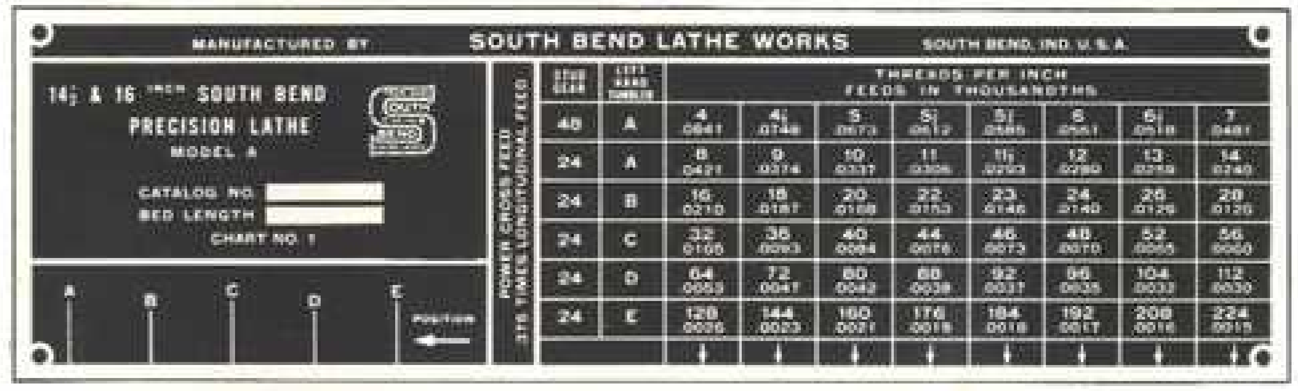


Fig. 37. Quick Change Gear Mechanism



MANUFACTURED BY SOUTH BEND LATHE WORKS SOUTH BEND, IND. U.S.A.

14½ & 16 INCH SOUTH BEND PRECISION LATHE
MODEL A
CATALOG NO.
BED LENGTH
CHART NO. 1

POWER CROSS FEED 3/8 TIMES LONGITUDINAL FEED

STUD GEAR	LEFT HAND TUMBLER	THREADS PER INCH FEEDS IN THOUSANDTHS							
40	A	4 .0841	4½ .0748	5 .0673	5½ .0612	5¾ .0585	6 .0561	6½ .0518	7 .0481
24	A	8 .0421	9 .0374	10 .0337	11 .0306	11½ .0293	12 .0280	13 .0259	14 .0240
24	B	16 .0210	18 .0187	20 .0168	22 .0153	23 .0146	24 .0140	26 .0129	28 .0120
24	C	32 .0105	36 .0093	40 .0084	44 .0076	46 .0073	48 .0070	52 .0065	56 .0060
24	D	64 .0053	72 .0047	80 .0042	88 .0038	92 .0037	96 .0035	104 .0032	112 .0030
24	E	128 .0026	144 .0023	160 .0021	176 .0019	184 .0018	192 .0017	208 .0016	224 .0015

A B C D E POSITION

Fig. 38. Index Chart for Quick Change Gear Lathe

Fig. 39. Standard Change Gear Mechanism

Power Carriage Feeds on Standard Change Gear Lathes

Standard Change Gear Lathes are equipped with a set of independent change gears for cutting screw threads and obtaining various power longitudinal feeds and power cross feeds. Compound gearing is used for fine threads and feeds. See pages 72 and 114.

A large "screw gear" should be placed on the lead screw and a small "stud gear" on the reverse stud. These two gears should be connected with idler gears as shown. To obtain finer or coarser feeds, use a smaller or larger "stud gear."

Notes on Lathe Work

A mixture of red lead and machine oil is a good lubricant for the tailstock center of a lathe.

A precision level that will show an error of .003 in. per foot should be used to level the lathe when installing, as a level lathe will assure precision accuracy of the work.

Clean and oil the threads before screwing a chuck or face plate onto the lathe spindle.

After grinding a tool, hone it to a keen edge with an oil stone—the cutting edge will last longer.

Always make sure the spindle tapers of the lathe are clean and free from burrs and dirt before inserting the lathe centers.

If the face plate or chuck does not run true, examine the shoulder of the lathe spindle and face of hub on face plate or chuck back for burrs, dirt, etc.

When cutting screw threads in steel, use a small brush to spread oil on the work preceding each cut. Lard oil is preferable, but a good machine oil or cutting oil will do.

Use Flat Leather Belts

Flat leather belts are recommended for use on lathe cone pulleys.

Leather belts are better than canvas or rubber belts for use on lathe cone pulleys. Leather belts are more efficient, last longer, have more elasticity and give better service.

If a belt has a tendency to come off from the pulley there is something wrong. Usually the pulleys are out of alignment. Find out what the trouble is and remedy it. Do not try to hold the belt on the pulley with a brace.

Notes on Belts and Pulleys

To find the approximate length of a belt, multiply half the sum of the pulley diameters by 3-1/7 and add twice the distance between the pulley centers.

The smooth side of the belt should always run next to the pulley.

Keep belts clean and dry. Do not allow moisture, machine oil or dirt to collect on them.

A pulley should be about 10% wider than the belt.

Driving pulleys for shifting belts should have flat face, all other pulleys should be crowned.

For stepped or flanged pulleys double ply belting is better than single ply belting.

Don't shift a moving belt by hand; use a stick or belt shifter.

Never put a belt on a pulley while it is revolving rapidly.

A belt may run crooked if the ends are not cut square before lacing, or if laced unevenly.

Don't run belts too tight, or with the flesh side next to the pulley.

Chapter IV

LATHE TOOLS AND THEIR APPLICATION

In order to machine metal accurately and efficiently, it is necessary to have the correct type of lathe tool with a keen, well supported cutting edge, ground for the particular kind of metal being machined, and set at the correct height.

High speed steel cutter bits mounted in forged steel holders, as shown in Figs. 40, 46, 48 and 50, are the most popular type of lathe tools. The 10-in-1 Tool Block shown in Fig. 50A may be used in place of the individual tool holders if desired. See page 98.

The boring tool, cutting-off tool, threading tool and knurling tool are required for various classes of work that cannot be readily accomplished with the regular turning tool.

Fig. 40. Tool Holder with Cutter Bit

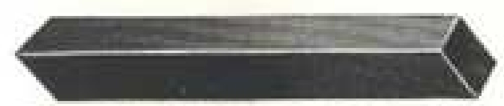


Fig. 41. Unground Cutter Bit

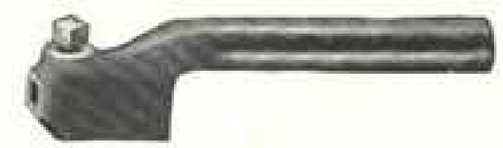


Fig. 41-A Holder for Grinding Cutter Bits

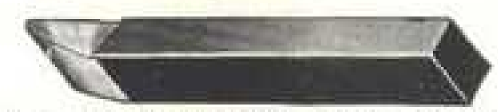
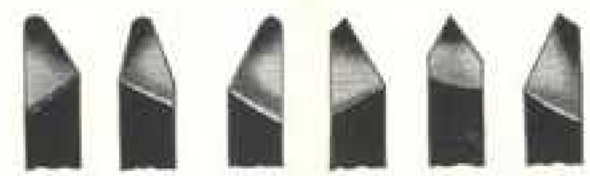


Fig. 42. Cutter Bit After Grinding



A L. H. Turning | B Round Nose | C R. H. Turning | D L. H. Side | E Threading | F R. H. Side

Fig. 44. Set of Ground Cutter Bits

Fig. 43. Boring Tool

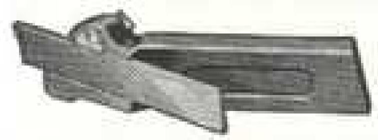


Fig. 45. Cutting-off Tool

Fig. 46. Straight Tool Holder

Fig. 47. Threading Tool

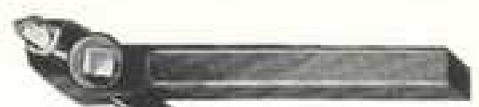


Fig. 48. Left Hand Tool Holder

Fig. 49. Knurling Tool

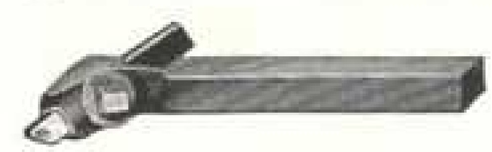


Fig. 50. Right Hand Tool Holder

Fig. 50A. 10-in-1 Tool Block. See page 98.

Correct Height of Cutting Edge

The cutting edge of the cutter bit should be about 5° above center, or 3/64 in. per inch in diameter of the work, as shown in Fig. 51 at right, for ordinary straight turning. The position of the cutter bit must be taken into consideration when grinding the various angles, as the height of the cutter bit determines the amount of front clearance necessary to permit free cutting.

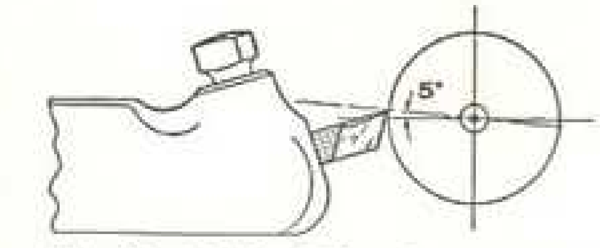


Fig. 51. Cutting Edge Above Center

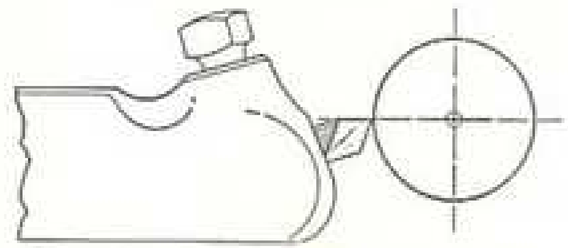


Fig. 52. Cutting Edge On Center

The cutting edge of the cutter bit should always be placed exactly on center, as shown in Fig. 52, for all types of taper turning and boring, and for cutting screw threads, also for turning brass, copper and other tenacious metals.

Tool Angle Varies

The included angle of the cutting edge of a cutter bit is known as the tool angle or angle of keenness and varies with the texture of the work to be machined. For example, when turning soft steel a rather acute angle should be used, but for machining hard steel or cast iron the cutting edge must be well supported and therefore the angle is less acute.

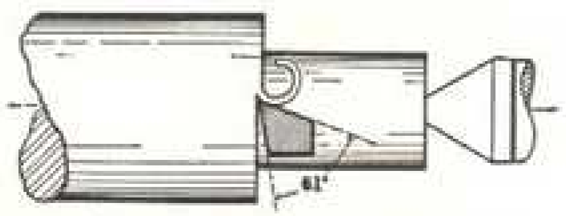


Fig. 53. Tool Angle for Steel

It has been found that an included angle of 61° is the most efficient tool angle for machining soft steel. This is the angle of the cutter as shown in Fig. 53. For machining ordinary cast iron, the included angle of the cutting edge should be approximately 71°. However, for machining chilled iron or very hard grades of cast iron, the tool angle may be as great as 85°.

Cutter Bit Grinding Gauge

A cutter bit grinding gauge, shown in Figs. 54-A, 54-B, and 54-C, is helpful for grinding the correct angles on the cutter bit.

Fig. 54-A. Checking Side Clearance

Fig. 54-B. Checking Front Clearance

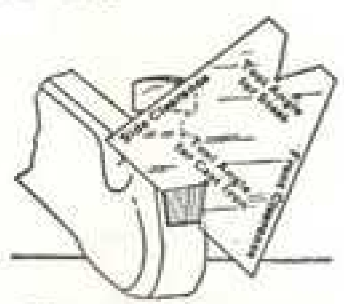


Fig. 54-C. Checking Tool Angle

Grinding Lathe Tool Cutter Bits

The angle of the cutter bit with the bottom of the tool holder must be taken into consideration when grinding cutter bits.

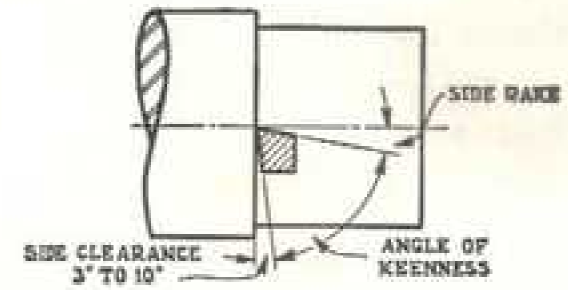


Fig. 55. Correct Side Clearance and Side Rake of Cutter Bit

The side clearance (Fig. 55) is to permit the cutting edge to advance freely without the heel of the tool rubbing against the work.

The front clearance (Fig. 56) is to permit the cutting edge to cut freely as the tool is fed to the work.

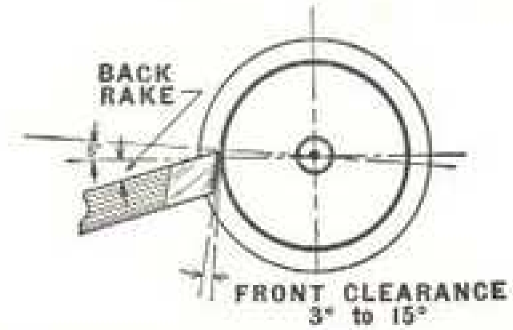


Fig. 56. Correct Front Clearance and Back Rake of Cutter Bit

Too much clearance will weaken the cutting edge so that it will break; but insufficient clearance will prevent the tool from cutting.

Side rake and back rake (Figs. 55 and 56) also facilitate free cutting. For cast iron, hard bronze and hard steel, very little side rake or back rake are required. (See page 28.)

The angle of keenness (Fig. 55) may vary from 60° for soft steel to nearly 90° for cast iron, hard steel, bronze, etc.

Figs. 57 to 61, inclusive, show the various steps in grinding a cutter bit for general machine work. Honing the cutting edge (Fig. 62) will improve the quality of the finish and lengthen the life of the tool.

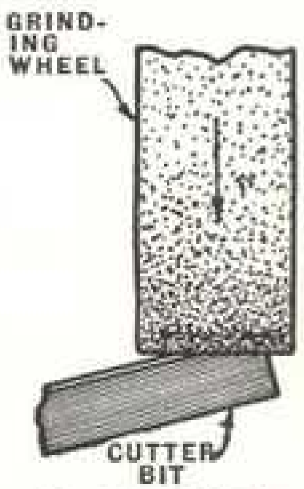


Fig. 57. Grinding Left Side of Cutter Bit

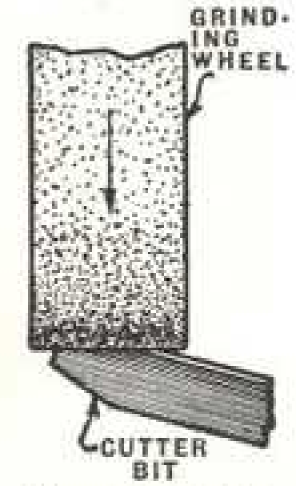


Fig. 58. Grinding Right Side of Cutter Bit

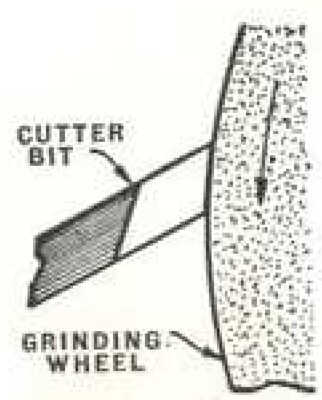


Fig. 59. Grinding Front of Cutter Bit

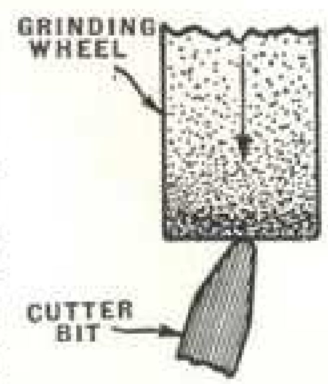


Fig. 60. Rounding End of Cutter Bit

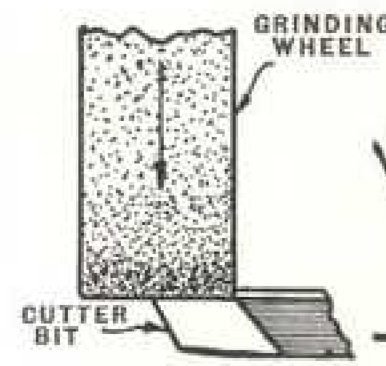


Fig. 61. Grinding Side Rake and Back Rake

Fig. 62. Honing the Cutting Edge of Cutter Bit with an Oil Stone

Cutter Bit for Rough Turning

Figs. 63 and 64 illustrate an excellent tool for taking heavy roughing cuts to reduce the diameter of a steel shaft to the approximate size desired. This tool will cut freely but does not produce a very smooth finish. When using this type of tool it is advisable to leave sufficient stock for a finishing cut with the round nosed tool shown at the bottom of the page.

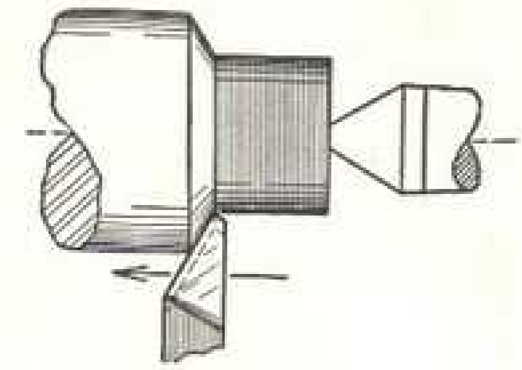


Fig. 63. Application of Roughing Tool

Grind the tool to the shape shown in Fig. 64, and see Figs. 55 and 56 on page 29 for information on grinding the correct front clearance, etc.

The cutting edge of the tool is straight and the point is only slightly rounded. A very small radius at the point (approximately $\frac{1}{64}$ in.) will prevent the point of the tool from breaking down but will not impair the free cutting quality of the tool.

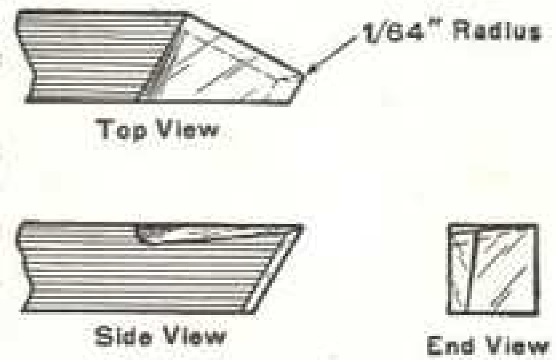


Fig. 64. Detail of Roughing Tool

The tool angle or included angle of the cutting edge of this tool should be approximately 61° for ordinary machine steel. If a harder grade of alloy or tool steel is to be machined, the angle may be increased, and if free cutting Bessemer screw stock is to be machined, the angle may be slightly less than 61°.

Hone the cutting edge of the tool with a small oil stone. This will lengthen the life of the tool and it will cut better.

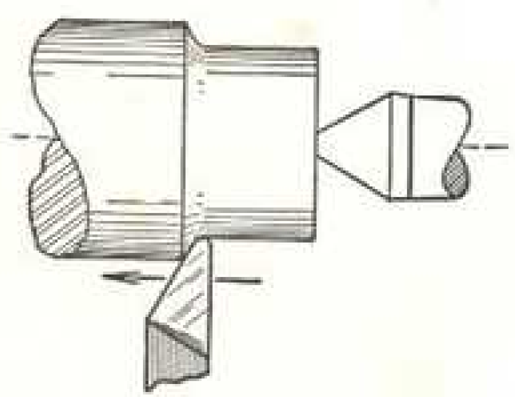


Fig. 65. Application of Finishing Tool

Cutter Bit for Finish Turning

Figs. 65 and 66 illustrate a round nosed turning tool for taking finishing cuts. The tool is very much the same shape as the more pointed tool for rough turning shown above, except that the point of the tool is rounded. (Approximately $\frac{1}{32}$ in. to $\frac{1}{16}$ in. radius.)

This tool will produce a very smooth finish if, after grinding, the cutting edge is well honed with an oil stone and a fine power carriage feed is used.

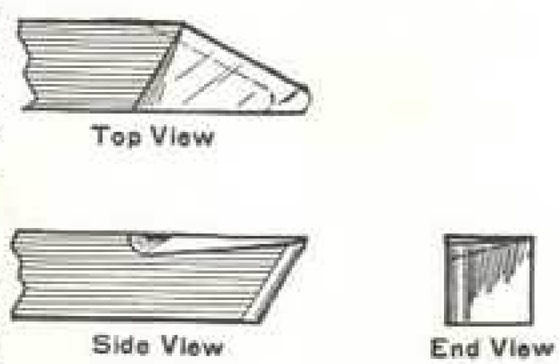


Fig. 66. Detail of Finishing Tool

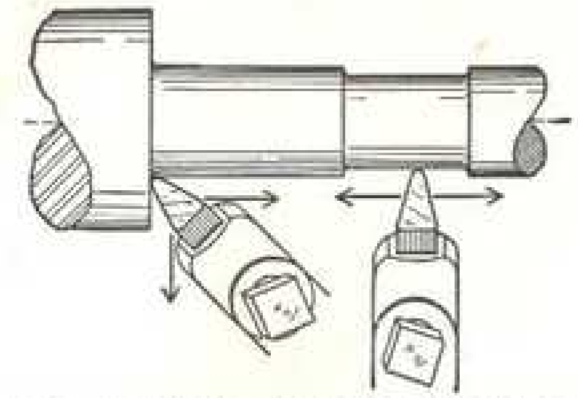


Fig. 67. Application of Round Nosed Tool

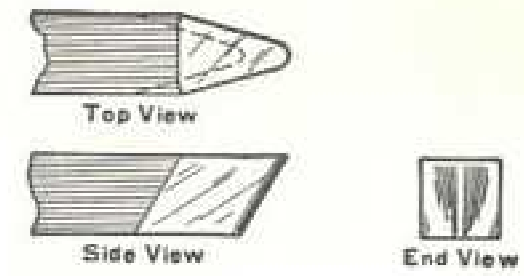


Fig. 68. Detail of Round Nosed Tool Bit

Round Nosed Turning Tool

The round nosed turning tool shown above is ground flat on top so that the tool may be fed in either direction, as indicated by the arrows in Fig. 67. This is a very convenient tool for reducing the diameter of a shaft in the center. The shape of the cutter bit is shown in Fig. 68, and the correct angle for the front clearance and side clearance can be obtained by referring to Figs. 55 and 56, page 29.

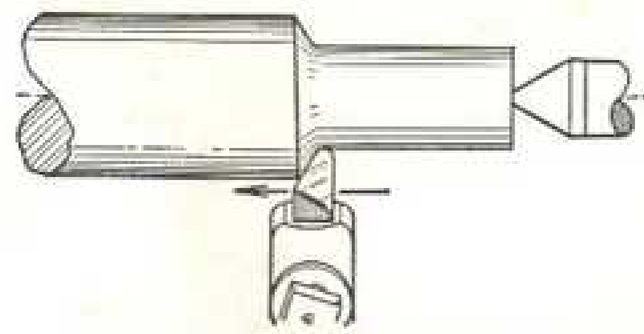


Fig. 69. Application of Right Hand Turning Tool

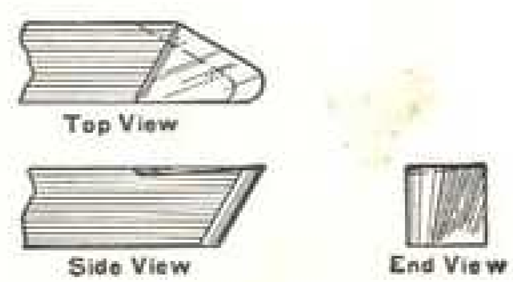


Fig. 70. Detail of Right Hand Turning Tool

Right Hand Turning Tool

The right hand turning tool shown above is the most common type of tool for general all around machine work. This tool is used for machining work from right to left, as indicated by the arrow in Fig. 69. The shape of the cutter bit is shown in Fig. 70. See page 29 for correct angles of clearance.

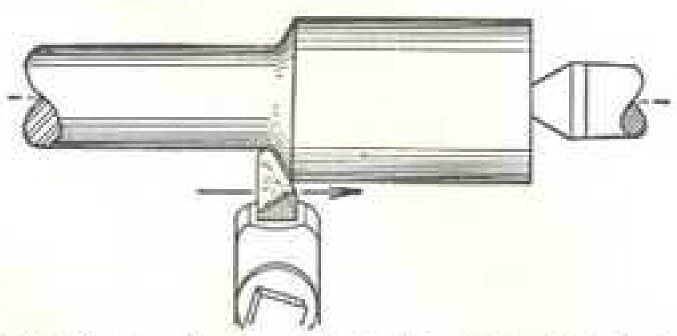


Fig. 71. Application of Left Hand Turning Tool

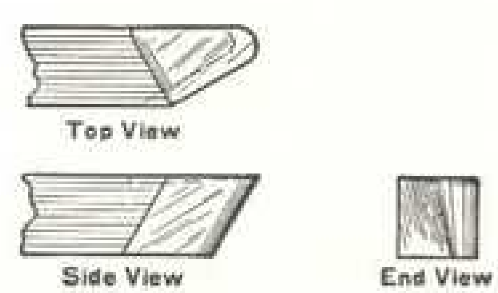


Fig. 72. Detail of Left Hand Turning Tool

Left Hand Turning Tool

The left hand turning tool illustrated in Figs. 71 and 72 is just the opposite of the right hand turning tool shown in Figs. 69 and 70. This tool is designed for machining work from left to right.

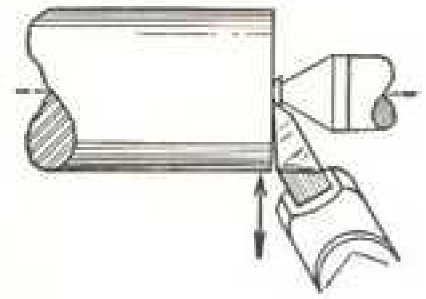


Fig. 73. Application of Right Hand Side Tool

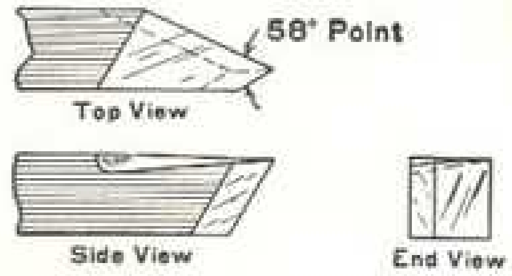


Fig. 74. Detail of Right Hand Side Tool

Right Hand Side Tool

The right hand side tool is intended for facing the ends of shafts and for machining work on the right side of a shoulder. This tool should be fed outward from the center, as indicated by the arrow in Fig. 73. The point of the tool is sharp and is ground to an angle of 58° to prevent interference with the tailstock center. When using this cutter bit care should be taken not to bump the end of the tool against the lathe center, as this will break off the point. See page 29 for correct angle of side clearance and front clearance.

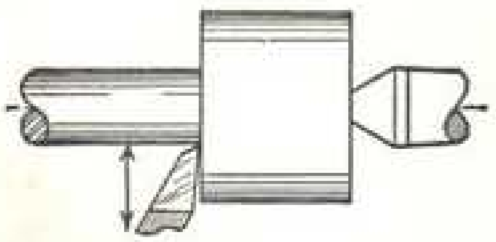


Fig. 75. Application of Left Hand Side Tool

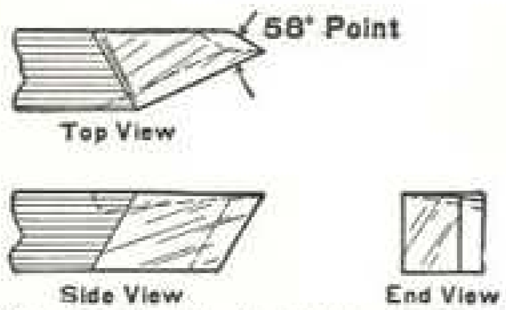


Fig. 76. Detail of Left Hand Side Tool

Left Hand Side Tool

The left hand side tool shown in Figs. 75 and 76 is just the reverse of the right hand side tool shown in Figs. 73 and 74. This tool is used for facing the left side of the work, as shown in Fig. 75.

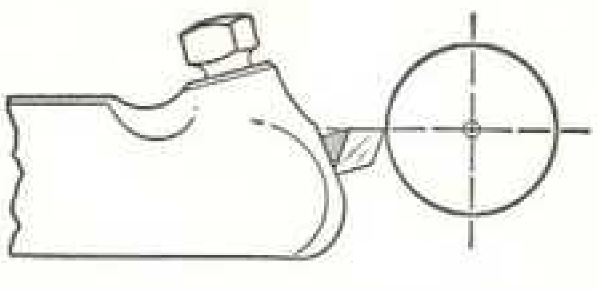


Fig. 77. Application of Screw Thread Cutting Tool

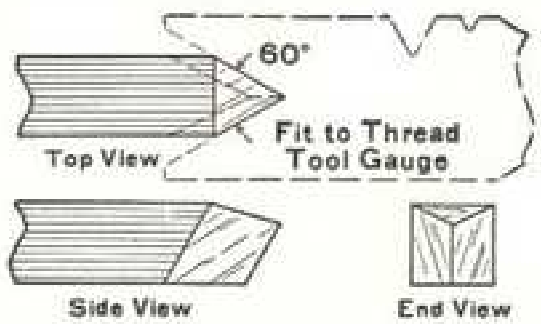


Fig. 78. Detail of Thread Cutting Tool

Thread Cutting Tool

Figs. 77 and 78 show the standard type of cutter bit for cutting United States or American National Form screw threads. The cutter bit is usually ground flat on top, as shown in Fig. 77, and the point of the tool must be ground to an included angle of 60°, as shown in Fig. 78. Careful grinding and setting of this cutter bit will result in perfectly formed screw threads. When using this type of cutter bit to cut screw threads in steel, always keep the work flooded with lard oil in order to obtain a smooth thread. Machine oil may be used if no lard oil is available.

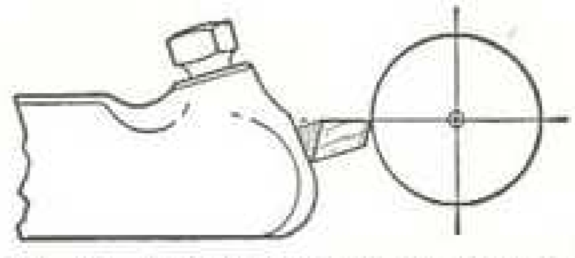


Fig. 79. Application of Brass Turning Tool

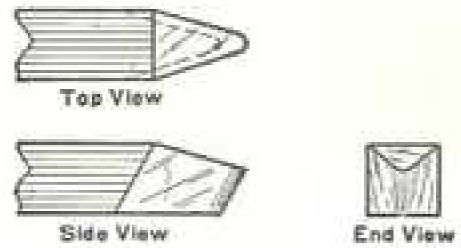


Fig. 80. Detail of Brass Turning Tool

Brass Turning Tool

The brass turning tool shown above is similar to the round nosed turning tool illustrated in Figs. 67 and 68, except that the top of the tool is ground flat so that there is no side rake or back rake. This is to prevent the tool from digging into the work and chattering.

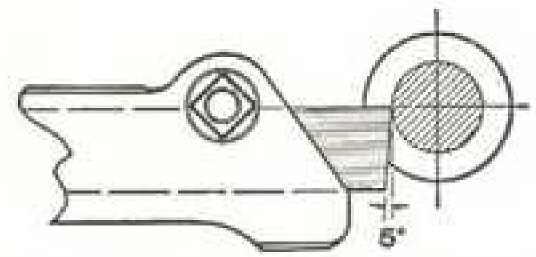


Fig. 81. Application of Cutting-off Tool

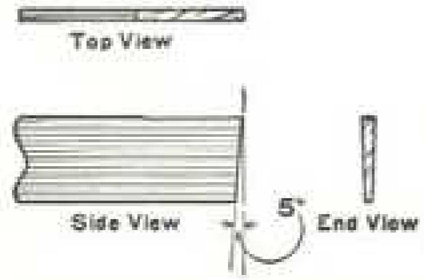


Fig. 82. Detail of Cutting-off Tool

Cutting-off Tool

The cutting-off tool should always be set exactly on center, as shown in Fig. 81. This type of tool may be sharpened by grinding the end of the cutter blade to an angle of 5° as shown in Fig. 82. The sides of the blade have sufficient taper to provide side clearance, so do not need to be ground. When cutting off steel always keep the work flooded with oil. No oil is necessary when cutting off cast iron.

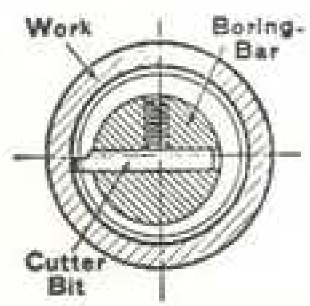


Fig. 83. Application of Boring Tool

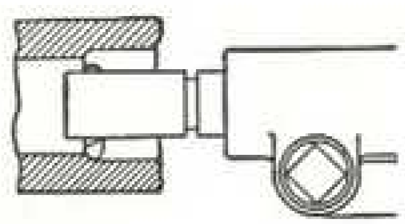


Fig. 84. Detail of Boring Tool

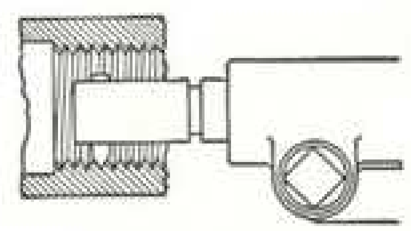


Fig. 85. Inside Threading Tool

Boring Tool and Inside Threading Tool

The boring tool is ground exactly the same as the left hand turning tool shown in Figs. 71 and 72 on page 31, except the front clearance of boring tool must be ground at a slightly greater angle so that the heel of the tool will not rub in the hole of the work. The inside threading tool is ground the same as the screw thread cutting tool shown in Figs. 77 and 78 on page 32, except that the front clearance must be increased for the same reason as for the boring tool.

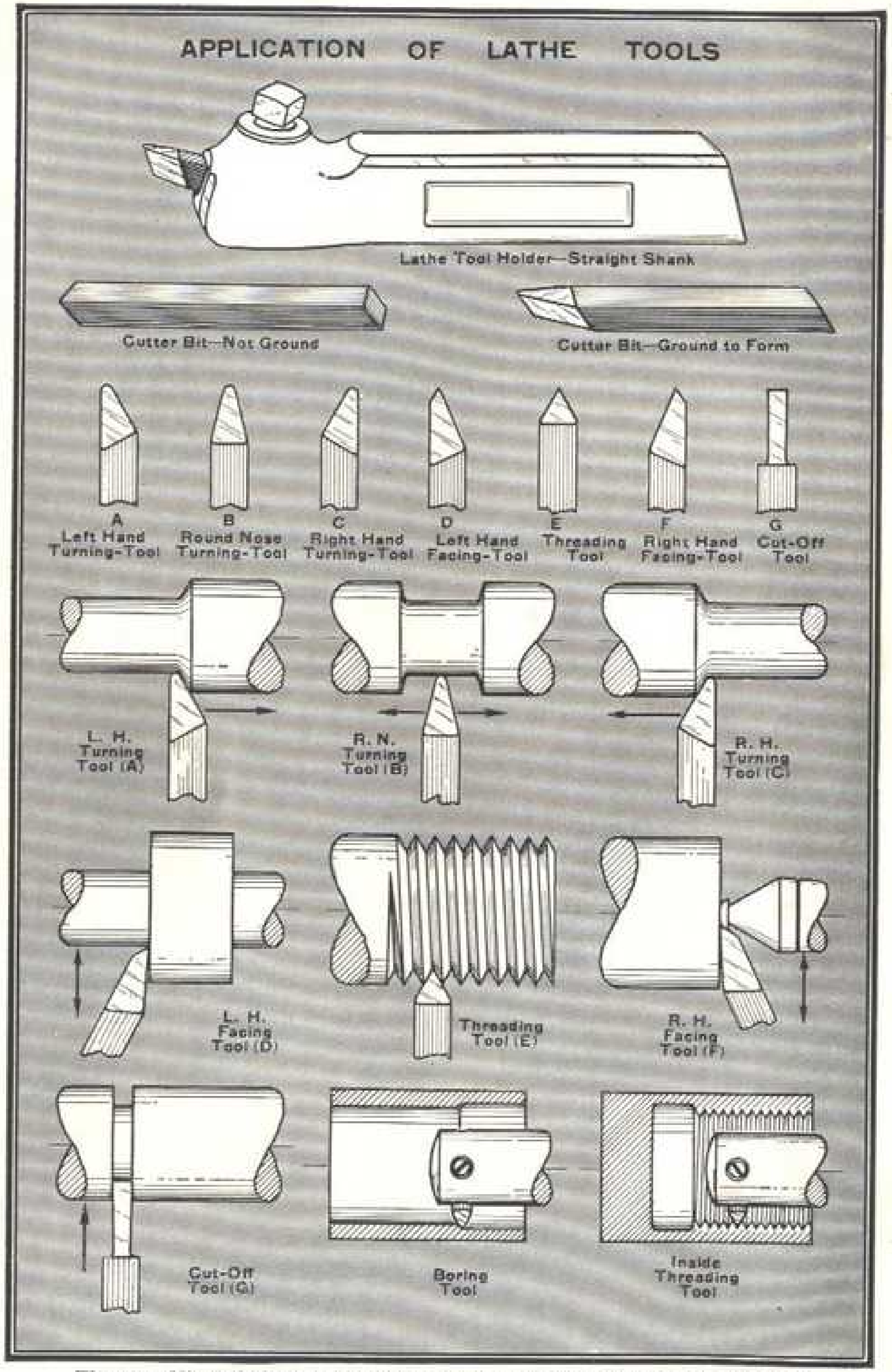


Fig. 86. Nine of the Most Popular Shapes of Lathe Tool Cutter Bits and Their Application

Stellite Cutter Bits

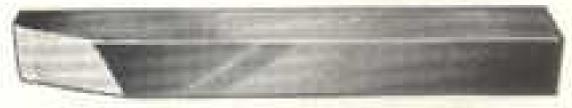


Fig. 87. Stellite Cutter Bit

Stellite cutter bits will stand higher cutting speeds than high speed steel cutter bits. Stellite is also used for machining hard steel, cast iron, bronze, etc.

Stellite is a non-magnetic alloy which is harder than ordinary high speed steel. It will stand very high cutting speeds and the tool will not lose its temper even though heated red hot from the friction generated by taking the cut.

Stellite is more brittle than high speed steel, and for this reason should have just enough clearance to permit the tool to cut freely, as the cutting edge must be well supported to prevent chipping and breaking.

Tungsten Carbide Cutting Tools

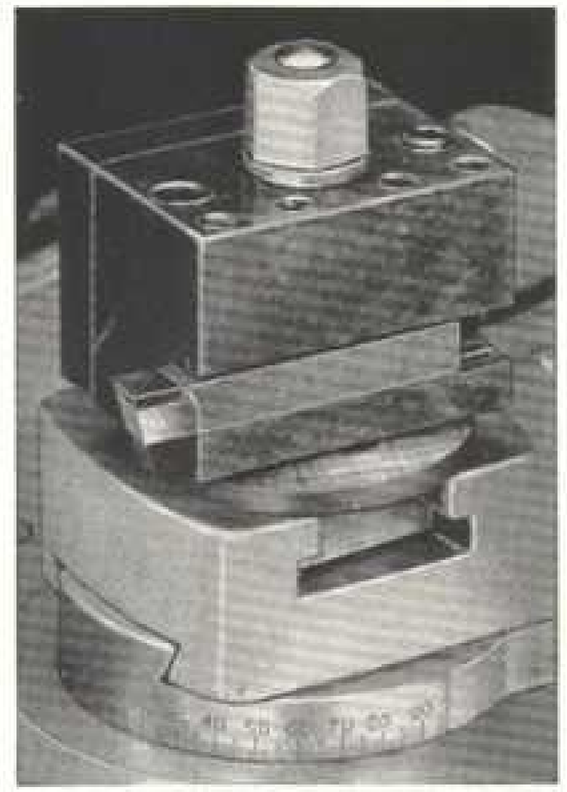


Fig. 88. Carbide Tipped Cutting Tool Mounted in 10-in-1 Tool Holder for Rigid Support

Tungsten carbide tipped cutting tools are used for manufacturing operations where maximum cutting speeds are desired, and are highly efficient for machining cast iron, alloyed cast iron, copper, brass, bronze, aluminum, babbitt and abrasive non-metallic materials such as fibre, hard rubber and plastics. Cutting speeds may vary from 110 to 650 surface feet per minute, depending on the depth of cut and the feed.

Tungsten carbide tipped cutter bits must be ground on a special grade of grinding wheel, as they are so hard they cannot be satisfactorily ground on the ordinary grinding wheel. The cutting edge must be well supported to prevent chipping and should have just enough clearance to permit the tool to cut freely.

Tantalum Carbide Cutting Tools

Tantalum carbide is a term applied to a combination of tungsten carbide and tantalum carbide. Tantalum carbide tipped cutting tools are similar to tungsten carbide tools, but are used mostly for machining steel.

Fig. 88A. Machining a Steel Shaft at High Speed with Carbide Tipped Cutting Tool

Titanium Carbide Cutting Tools

Titanium carbide is a term applied to a combination of tungsten carbide and titanium carbide. Titanium carbide is interchangeable with tantalum carbide in its uses.

Cutting Tools for Non-Ferrous Materials

The machinability of non-ferrous materials such as copper, bronze, aluminum, and plastics varies greatly, and such materials often require specially ground cutting tools. The cutting speeds also vary greatly and have an important effect on tool life and surface finish. Suggested cutting speeds and tool angles for machining the most common non-ferrous materials are given in the table below. Also see page 50.

Machining Soft Metals

Aluminum, magnesium alloys, and other comparatively soft metals require keen edged tools with more clearance, front rake, and side rake than the harder metals. To increase the amount of back rake, the cutting edge of the tool is sometimes placed high above center. This, of course, cannot be done when turning tapers or facing, and frequent readjustment is necessary when the diameter of the work varies.

When machining tenacious metals such as pure copper the cutting tool should be honed to a very keen cutting edge to prevent tearing the work and producing a rough finish. Light cuts at medium feeds with a round nose tool having 1/32" to 1/16" nose radius usually produce best results.

Machining Plastics

Because of the great variety of plastic materials, many problems are encountered which require some thought and resourcefulness in grinding cutting tools. Hot set molded plastics often contain abrasive fillers which dull the cutting edge quickly unless it is well supported by minimum clearance angles. However, other plastic materials may require very large clearance angles to prevent the tool from dragging. Laminated plastics and vulcanized fibre should be machined at high speeds, as the cutting edge of the tool will dull quickly at lower speeds.

CUTTING SPEEDS AND TOOL ANGLES FOR NON-FERROUS MATERIALS

See Figs. 55 and 56 page 29 for tool angle diagrams

Material	Cutting Speed f. p. m.	Front Clearance Degrees	Side Clearance Degrees	Back Rake Degrees	Side Rake Degrees
Aluminum*	300–400	7	8	30	20
Brass—Leaded	300–700	6	7	0	0
Bronze—Free Cutting	300–700	6	5	0	1½
Bronze—Readily Machinable	150–300	10	8	7	7
Bronze—Tough	75–150	12	15	15	25
Copper—Pure	75–150	7	7	10	25
Die Castings	225–350	7	7	8	10
Magnesium Alloy	275–400	8	8	6	4
Monel Metal	50–170	6	6	7	12
Plastics—Cast Resin	200–600	10	12	30	25
Plastics—Cold Set Molded	200–600	10	10	0	0
Plastics—Hot Set Molded	200–600	6	6	10	20
Plastics—Laminated	200–600	8	8	30	30
Stainless Steel	50–150	8	8	9	0
Wood	400–800	20	20	30	30

*Kerosene lubricant used.

These are suggested starting angles for general work. Slightly smaller or larger angles may prove more efficient, depending on the texture of the material machined and the type of cutting tool used.

Chapter V

HOW TO TAKE ACCURATE MEASUREMENTS

The ability to take accurate measurements can be acquired only by practice and experience. Careful and accurate measurements are essential to good machine work. All measurements should be made with an accurately graduated steel scale or a micrometer. Never use a cheap steel scale or a wood ruler, as they are likely to be inaccurate and may cause spoiled work.

An experienced mechanic can take measurements with a steel scale and calipers to a surprising degree of accuracy. This is accomplished by developing a sensitive "caliper feel" and by carefully setting the calipers so that they "split the line" graduated on the scale.

Setting an Outside Caliper

A good method for setting an outside caliper to a steel scale is shown in Fig. 96. The scale is held in the left hand and the caliper in the right hand. One leg of the caliper is held against the end of the scale and is supported by the finger of the left hand while the adjustment is made with the thumb and first finger of the right hand.

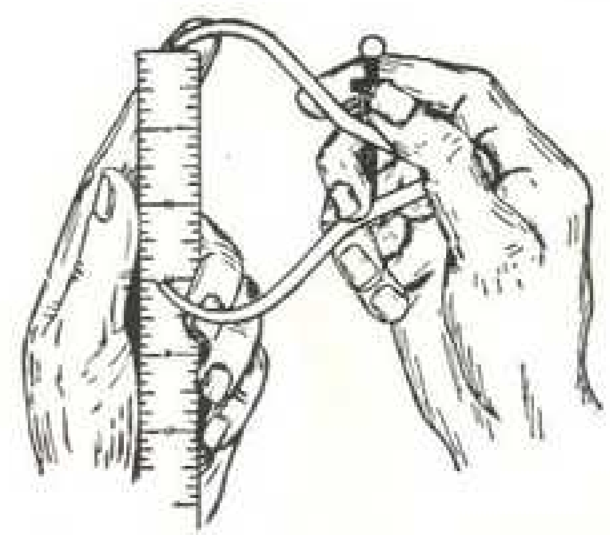


Fig. 96. Setting an Outside Caliper

Measuring with Calipers

The proper application of the outside caliper when measuring the diameter of a cylinder or a shaft is shown in Fig. 97. The caliper is held exactly at right angles to the center line of the work and is pushed gently back and forth across the diameter of the cylinder to be measured. When the caliper is adjusted properly, it should easily slip over the shaft of its own weight. Never force a caliper or it will spring and the measurement will not be accurate.

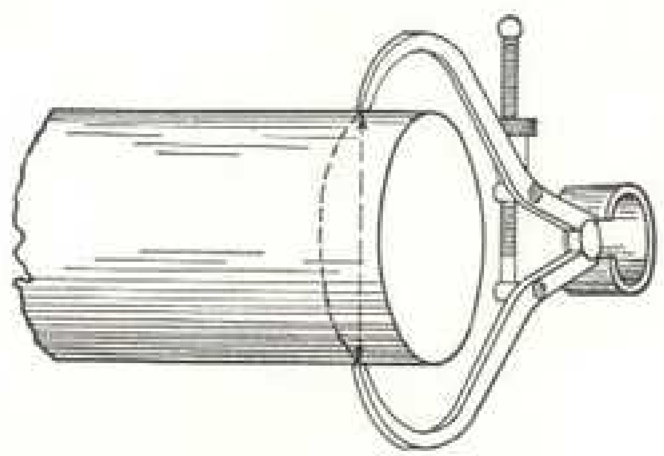


Fig. 97. Measuring with an Outside Caliper

Setting Inside Calipers

To set an inside caliper for a definite dimension, place the end of the scale against a flat surface and the end of the caliper at the edge and end of the scale. Hold the scale square with the flat surface. Adjust the other end of the caliper to the required dimension.

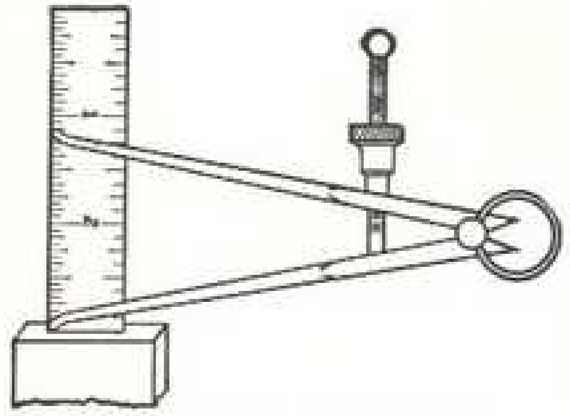


Fig. 98. Setting an Inside Caliper

Measuring Inside Diameters

To measure an inside diameter, place the caliper in the hole as shown on the dotted line and raise the hand slowly. Adjust the caliper until it will slip into the hole with a very slight drag. Be sure to hold the caliper square across the diameter of the hole.

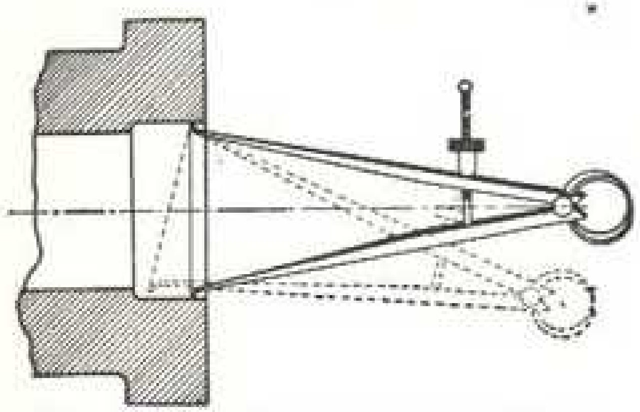


Fig. 99. Measuring with Inside Caliper

Transferring Measurements

In transferring measurement from an outside caliper to an inside caliper, the point of one leg of the inside caliper rests on a similar point of the outside caliper, as shown in Fig. 100. Using this contact point as a pivot, move the inside caliper along the dotted line shown in illustration, and adjust with the thumb screw until you feel your measurement is just right.

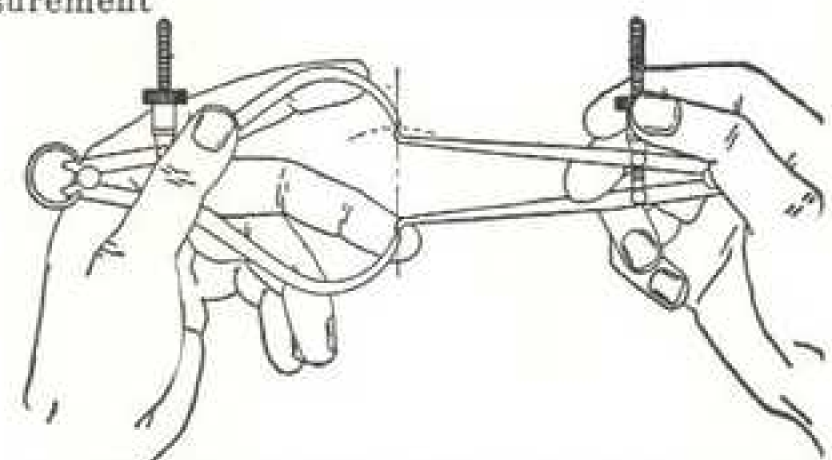


Fig. 100. Transferring a Measurement from an Inside Caliper to an Outside Caliper

Hermaphrodite Caliper

The hermaphrodite caliper shown in Fig. 101 is set from the end of the scale exactly the same as the outside caliper.

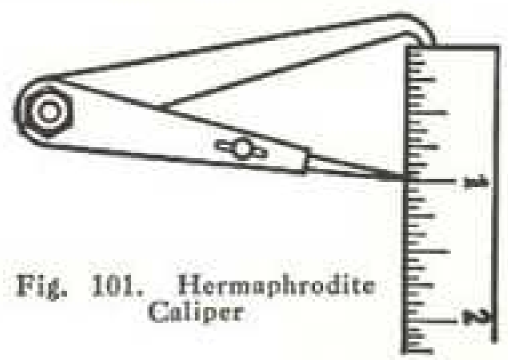


Fig. 101. Hermaphrodite Caliper

Caliper Feel

The accuracy of all contact measurements is dependent upon the sense of touch or feel. The caliper should be delicately and lightly held in the finger tips, not gripped tightly. If the caliper is gripped tightly, the sense of touch is very much impaired.

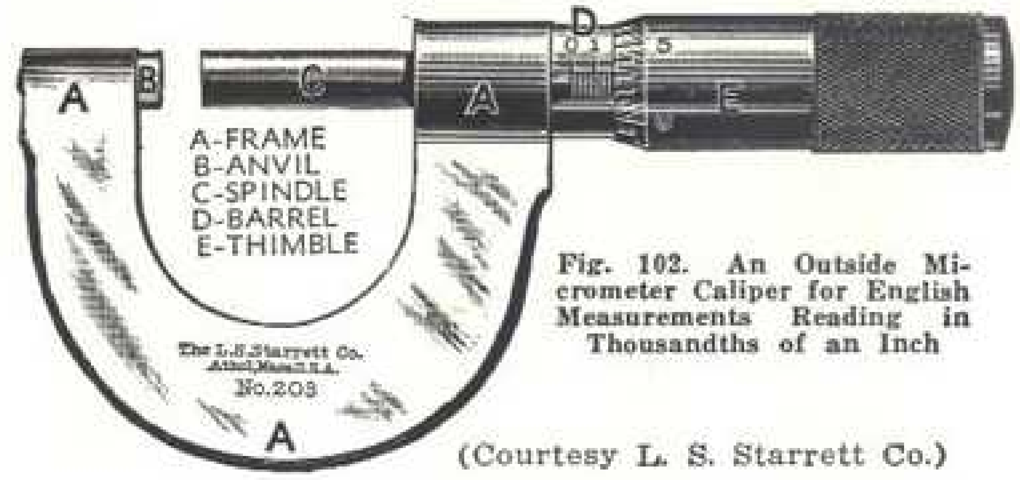


Fig. 102. An Outside Micrometer Caliper for English Measurements Reading in Thousandths of an Inch

(Courtesy L. S. Starrett Co.)

How to Read a Micrometer (English Measurement)

Each graduation on the micrometer barrel "D" represents one turn of the spindle or .025 in. Every fourth graduation is numbered and the figures represent tenths of an inch since 4x.025 in. = .100 in. or $\frac{1}{10}$ of an inch.

The thimble "E" has twenty-five graduations, each of which represents one-thousandth of an inch. Every fifth graduation is numbered, from five to 25.

The micrometer reading is the sum of the readings of the graduations on the barrel and the thimble. For example, there are seven graduations visible on the barrel in the illustration above. Since each graduation represents .025 in., the reading on the barrel is 7x.025 in. or .175 in. To this must be added the reading on the thimble which is .003 in. The correct reading is the sum of these two figures or .175 in. + .003 in. = .178 in. Therefore this micrometer is set for a diameter of .178 in.

Metric System Micrometer

Micrometers for measuring in the Metric system are graduated to read in hundredths of a millimeter as shown at right in Fig. 103. For each complete revolution the spindle travels ½ mm or .50 mm, and two complete revolutions are required for 1.00 mm. Each of the upper set of graduations on the barrel represent 1 mm. (two revolutions of the spindle) and every fifth graduation is numbered 0, 5, 10, 15, etc. The lower set of graduations subdivides each millimeter division into two parts.

The beveled edge of the thimble is divided into 50 graduations, each of which represents .01 mm.

The micrometer reading is the sum of the readings on the barrel and the thimble. For example, in Fig. 103 there are three millimeter graduations visible on the barrel, also a ½ mm graduation. The reading on the thimble is .36 mm. Therefore, the reading is 3.00 mm + .50 mm + .36 mm = 3.86 mm.

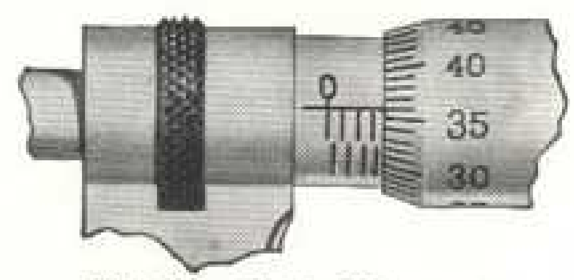


Fig. 103. Metric Micrometer (Courtesy Brown & Sharpe Mfg. Co.)

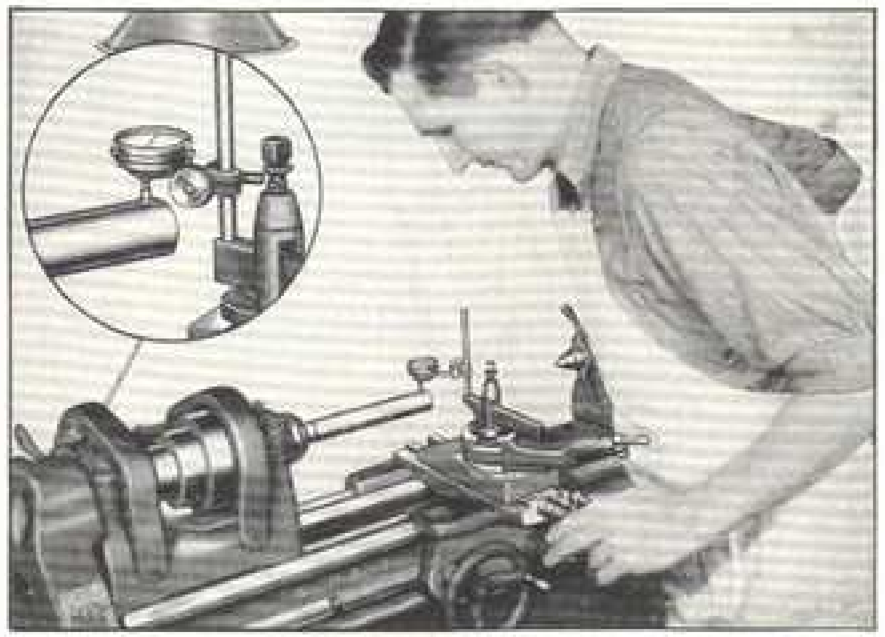


Fig. 104. Testing Headstock Spindle with Test Bar and Test Indicator

The Accuracy of a Screw Cutting Lathe

In manufacturing the back-geared screw cutting lathe, accuracy is given the most careful attention. A few of the accuracy tests are shown below. The illustration above shows the method of testing the headstock spindle of a lathe to see that the taper of the spindle runs true and that the axis of the spindle is parallel to the ways of the lathe.

The test bar is made of steel and may be from 10 in. to 12 in. long, depending on the size of the lathe. It is machined between centers and ground on the taper shank and also on the two larger diameters where the indicator readings are taken, as shown below. A dial test indicator used with this bar, as shown above, will disclose an error of one ten-thousandth of an inch.

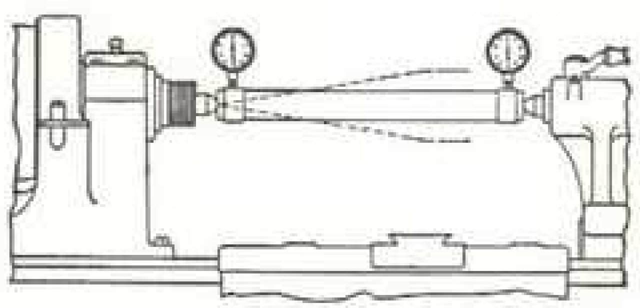


Fig. 105. Testing Alignment of Tailstock Spindle and Headstock Spindle

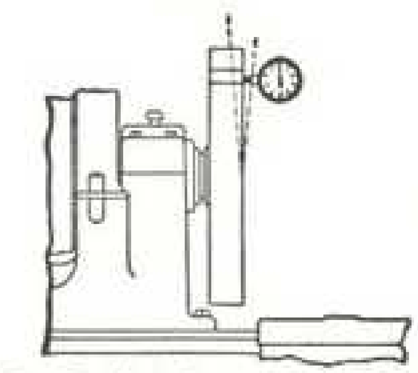


Fig. 106. Testing Amount of Concavity of Face Plate with Dial Indicator

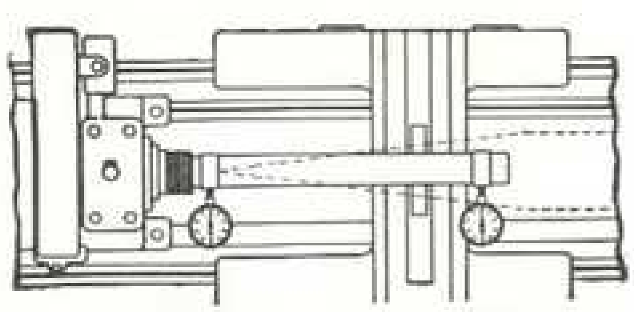


Fig. 107. Testing Alignment of Headstock Spindle with Ways of Lathe Bed

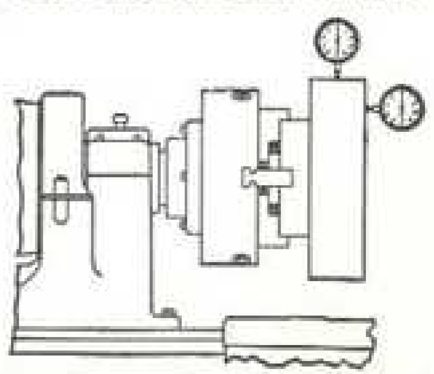


Fig. 108. Testing Accuracy of Chuck Jaws on Diameter and Face

Use of Toolmaker's Buttons

Toolmaker's buttons are small bushings used for accurately locating drill jig plates and similar work on the face plate of the lathe for boring holes to given center-to-center distances.

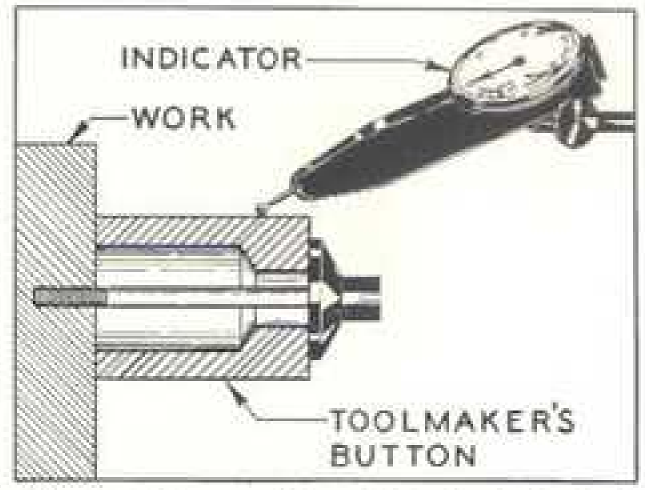


Fig. 109. Cross-section of Toolmaker's Button as used for Locating Work on Face Plate of Lathe

The locations of the holes to be bored are first carefully laid out on the work in the usual way, using scale measurements. Each point is then center punched, drilled and tapped for the small screw used to attach the toolmaker's button to the work. The hole through the button is much larger than the screw which passes through it permitting the button to be adjusted in any direction to conform with the exact location in which the hole is to be bored in the work. See Fig. 109.

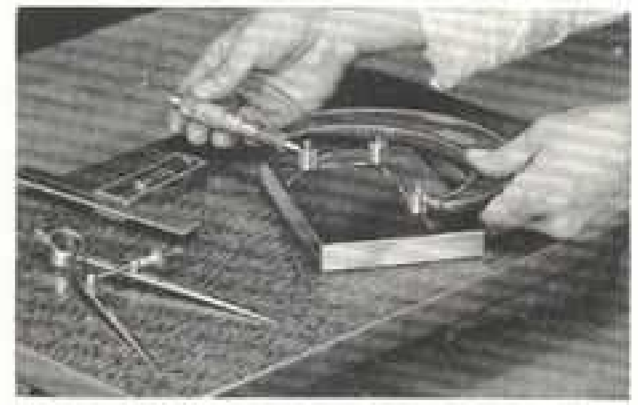


Fig. 110. Measuring Across Toolmaker's Buttons Mounted on Jig Plate

The screws holding the buttons on the work are adjusted so that a light tap with a very small brass or lead hammer will move the button a fraction of a thousandth. Measuring with micrometer or vernier caliper or with precision gauge blocks, the buttons can be adjusted with extreme accuracy. See Fig. 110. Also see Fig. 359 page 121.

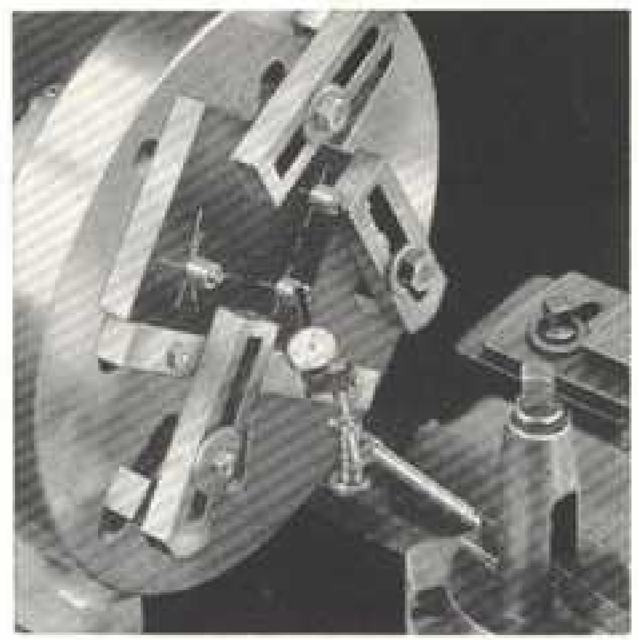
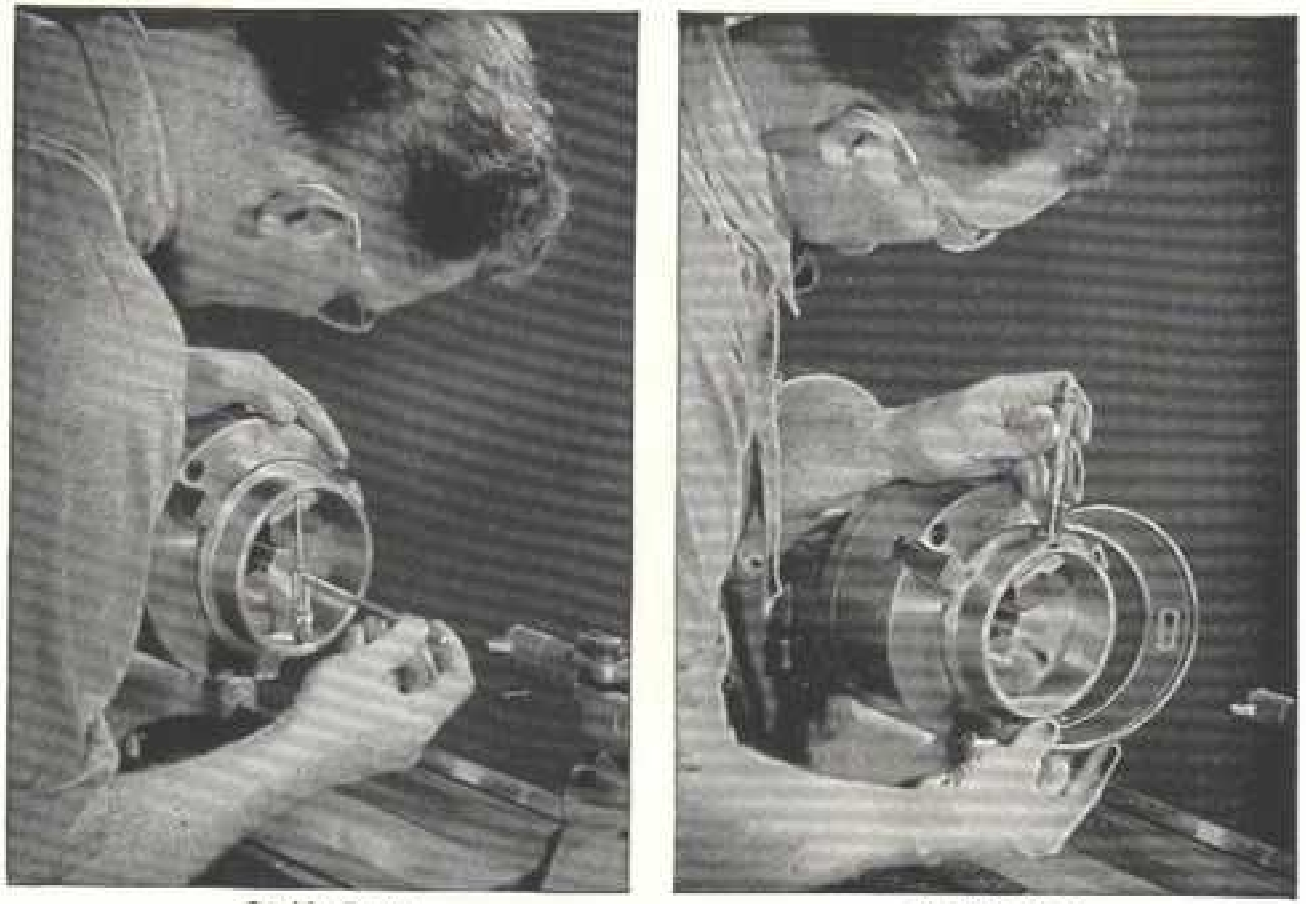


Fig. 111. Locating Work on Face Plate with Toolmaker's Button and Indicator

After all buttons are properly located on the work, the screws are tightened to lock them securely in position. Locations are checked to be sure all buttons are still in exactly the correct position and the work is then lightly clamped on the face plate with the button indicating the position of the first hole to be bored approximately centered. A dial indicator is used to check the centering as shown in Fig. 111. The lathe spindle is slowly revolved by hand and necessary re-adjustments are made until the button runs dead true. The work may then be clamped tightly on the face plate and the hole bored.

After the first hole is bored, each additional hole is located and bored in turn by the same process. When this method is carefully followed, the center distances between the holes can be held to extremely close tolerances.



Inside Type Outside Type

Fig. 111. Using Micrometers to Measure Work in the Lathe

Using Micrometers

To obtain accurate and consistent measurements with micrometers, it is necessary for the user to develop a sense of "feel" for the correct tension of the micrometer against the work and then exercise due care in taking measurements and readings. The inside micrometer is used to measure internal diameters and is read in the same manner as the outside micrometer, as described on page 39. Micrometers should be checked frequently with master gauge blocks to insure against any inaccuracy developing in the instruments themselves.

Compound Rest Adjustment for Fine Cuts

When the compound rest is set at approximately 84° (84° 16′ to be exact) each graduation on the compound rest graduated collar represents an angular movement of .001 in., and a cross-feed movement of .0001 in. or a reduction in the diameter of the work of .0002 in.

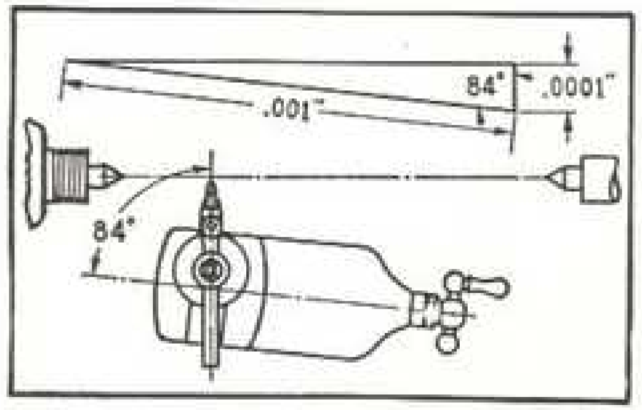


Fig. 112. Compound Rest Set for Precision Cross-feed Adjustment

This method of adjusting the cutting tool will be of help when taking fine precision finishing cuts fractional thousandths in depth. See page 100.

This method can also be used to advantage for final grinding operations performed with the tool post grinding attachment on the lathe.

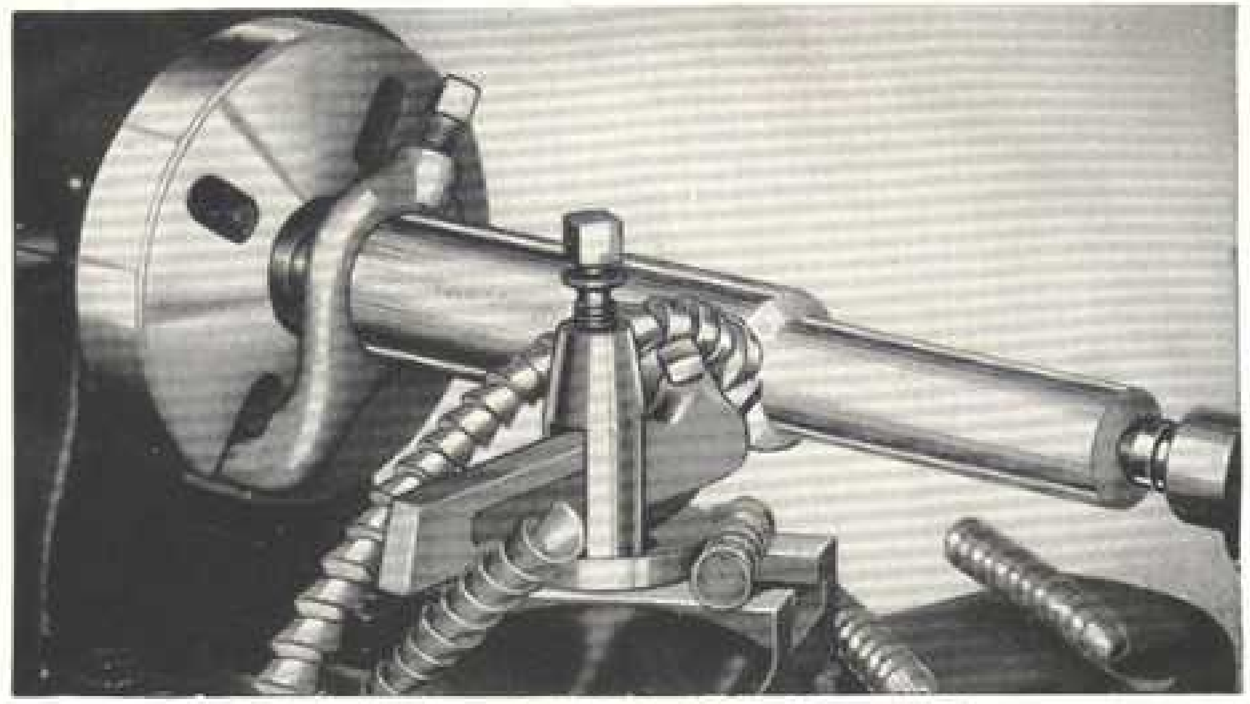


Fig. 113. Turning a Steel Shaft Mounted Between Centers

Chapter VI

PLAIN TURNING

The illustration above shows the lathe in operation machining a shaft between the lathe centers. Whenever possible, work should be mounted in this way for machining as heavier cuts may be taken because the work is supported on both ends.

Locating Center Holes

There are several good methods for accurately locating the center holes which must be drilled in each end of the work before it can be mounted on the lathe centers for machining.

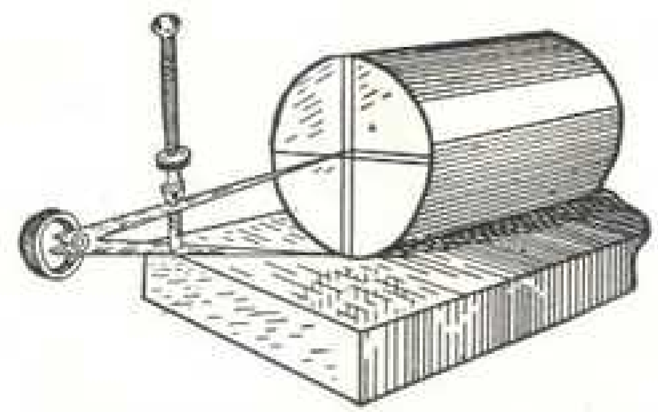


Fig. 114. Locating Centers with Dividers

Divider Method

Chalk the ends of the shaft, set the dividers to approximately one-half the diameter of the shaft, and scribe four lines across each end, as shown in Fig. 114.

Combination Square Method

Hold the center head of a combination square firmly against the shaft, as shown in Fig. 115, and scribe two lines close to the blade across each end of the shaft.

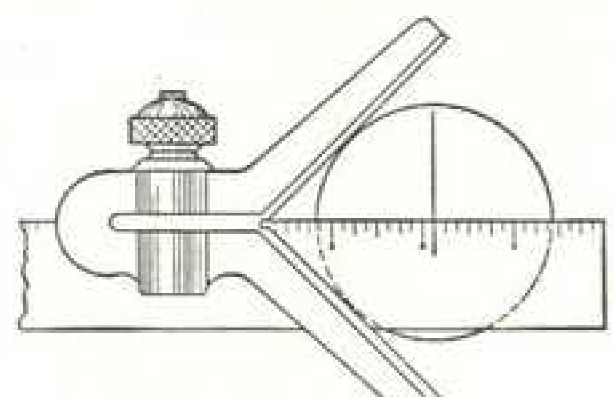


Fig. 115. Use of Center Head to Locate Centers

Hermaphrodite Caliper Method

Chalk each end of the work, set the hermaphrodite caliper a little over half the diameter, and scribe four lines as shown in Fig. 116.

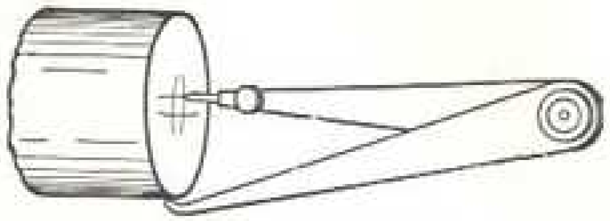


Fig. 116. Centering with Hermaphrodite Calipers

Centering Irregular Shapes

Work that is irregular in shape may be centered with a surface gauge and V-block, as shown in Fig. 117.

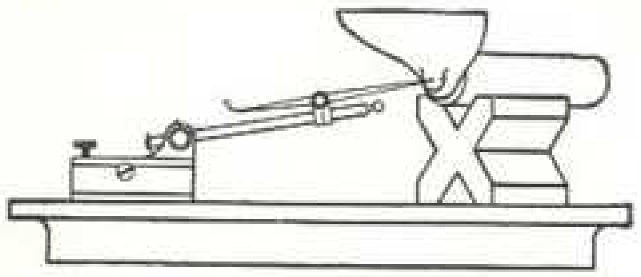


Fig. 117. Centering an Irregular Shape

Bell Center Punch

The bell centering cup is placed over the end of the work and the center punch or plunger is struck a sharp blow with the hammer, automatically locating the center.

Punching the Center

Place the center punch vertically at the center point and tap with a hammer, making a mark sufficiently deep so that the work will revolve on the center points when placed in the lathe.

Test on Centers

After a piece has been center punched it should be tested on centers, as shown in Fig. 120, to make sure that the centers are accurately located. Spin the work with the left hand and mark the high spots on each end of the cylinder with a piece of chalk in the right hand.

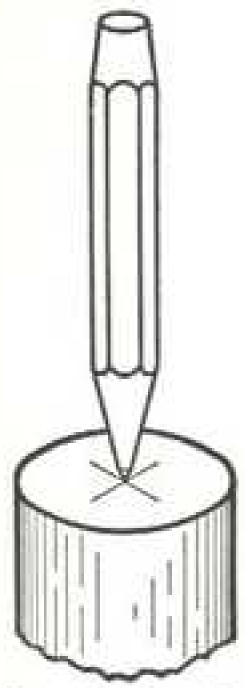


Fig. 118. Punching the Center

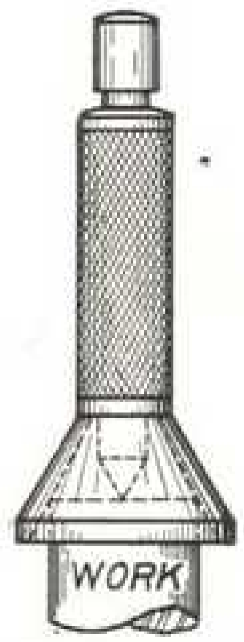


Fig. 119. Bell Center Punch

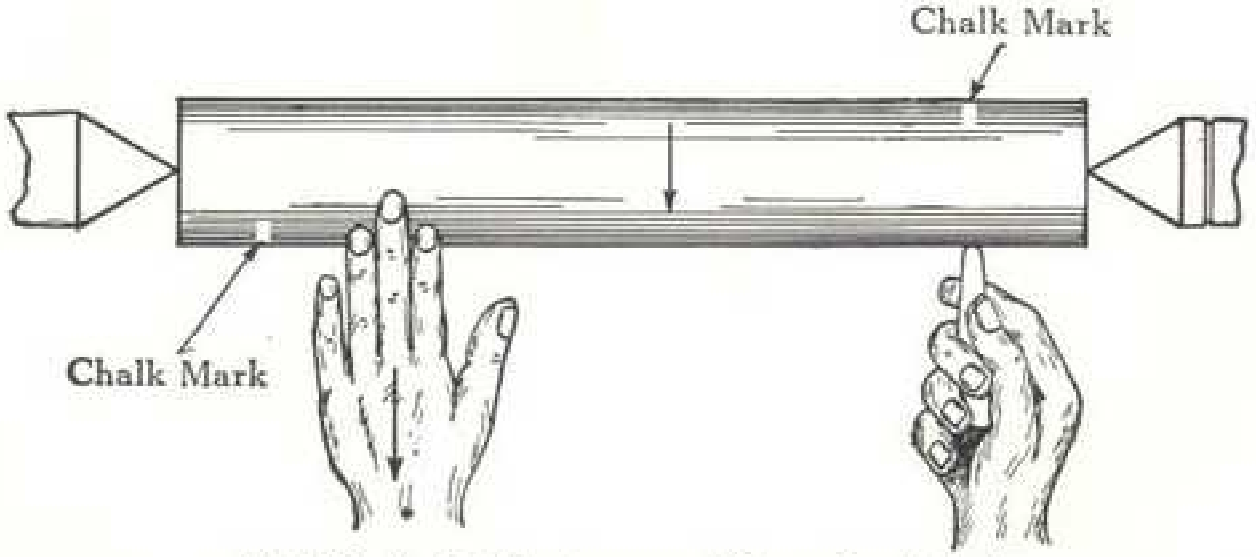


Fig. 120. Testing the Accuracy of Center Punch Marks

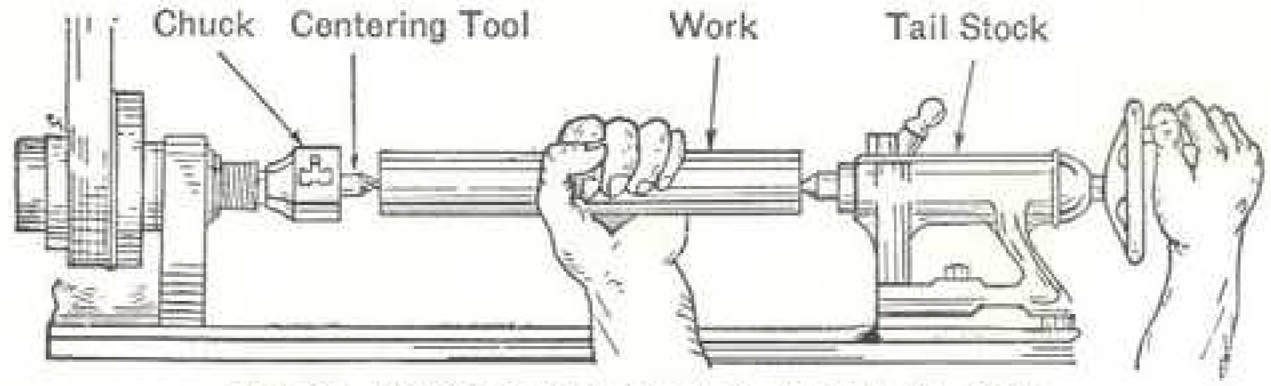


Fig. 121. Drilling the Center Hole in the End of a Shaft

Changing Location of Center Holes

If the centers have not been accurately located, the position of the center punch mark can be changed by placing the center punch at an angle, as shown in Fig. 122, and driving the center over. The shaft should be securely clamped in a vise while this is done.

Fig. 122. Changing the Location of a Center Punch Mark

Drilling the Center Holes

After the centers have been accurately located, center holes should be drilled and countersunk in each end of the shaft. This may be done in the lathe, as shown in Fig. 121, or in a drill press. A combination center drill and countersink, shown in Fig. 124, or a small twist drill followed by a 60° countersink, shown in Fig. 123, may be used.

Center Drill and Countersink

The combination center drill and countersink is usually used for drilling center holes. Several standard sizes suitable for various sizes of work are available, as listed in the tabulation below.

Some care should be exercised in drilling the center holes. The spindle speed should be about 150 r. p. m. and the drill should not be crowded. If the drill is crowded and the point is broken off in the work it may be necessary to heat the end of the shaft to a cherry red and allow it to cool slowly so that the drill point will be annealed and can be drilled out.

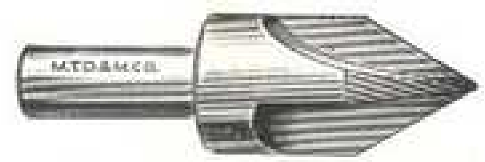
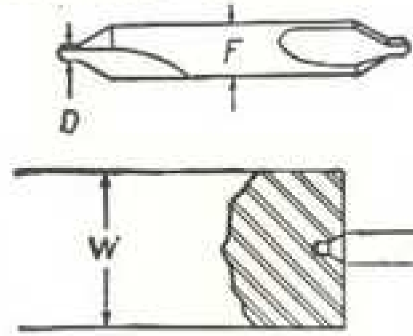


Fig. 123. A 60° Countersink

Fig. 124. Combination Center Drill and Countersink

SIZE OF CENTER HOLE FOR 3/16 IN. TO 4 IN. DIAMETER SHAFTS



Diameter of Work W	Large Diameter of Counter-sunk Hole C	Diameter of Drill D	Diameter of Body F
3/16 in. to 5/16 in.	1/8 in.	5/64 in.	3/16 in.
3/8 in. to 1 in.	3/16 in.	7/64 in.	1/4 in.
1 1/4 in. to 2 in.	1/4 in.	1/8 in.	5/16 in.
2 1/4 in. to 4 in.	5/16 in.	3/16 in.	7/16 in.

Drilling Center Holes with a Lathe Chuck

Small diameter rods that can be passed through the headstock spindle and short shafts are easily centered with the aid of a universal chuck, as shown in Fig. 125. When this method is used, the end of the shaft should be faced smooth before drilling the center hole.

The unsupported end of the shaft should not extend more than 10 in. beyond the chuck jaws. Shafts that are too large to pass through the headstock and too long to be held firmly by the chuck jaws alone can be supported on the outer end in a center rest (See pages 66 and 92.)

Correct Center Hole

To be correct, the center hole must be the size required for the diameter of the shaft, as listed in the tabulation on page 45, and the countersink must fit the center point perfectly, as shown in Fig. 126. There must also be sufficient clearance at the bottom of the countersink.

When drilling center holes, allow for the thickness of the metal that will be faced off of the end; otherwise, the center holes will be too small to support the shaft after the ends are faced.

Poorly Drilled Center Holes

One of the most common causes of unsatisfactory lathe work is poorly drilled center holes. Fig. 127 shows a shallow center hole with incorrect angle and no clearance for the tip of the center point. Fig. 128 shows a center hole that has been drilled too deep. Accuracy cannot be expected when center holes are poorly made, and the lathe centers may be damaged.

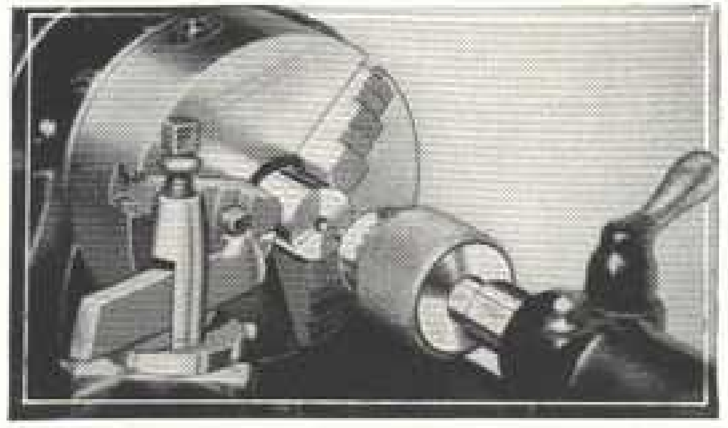


Fig. 125. Drilling a Center Hole with Stock Held in Lathe Chuck and Drill in Tailstock Spindle Chuck

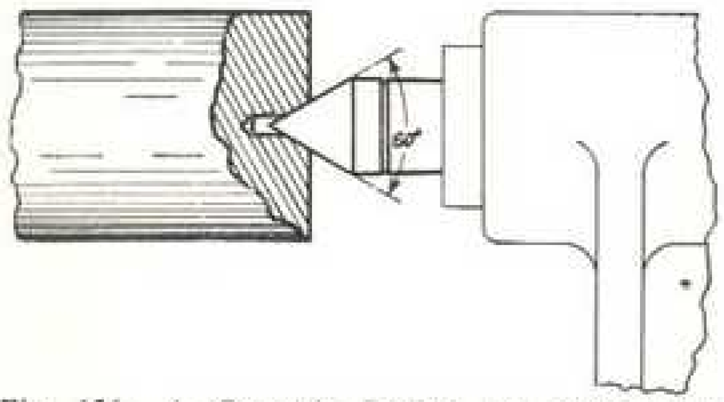


Fig. 126. A Correctly Drilled and Countersunk Hole Fits the Lathe Center Perfectly

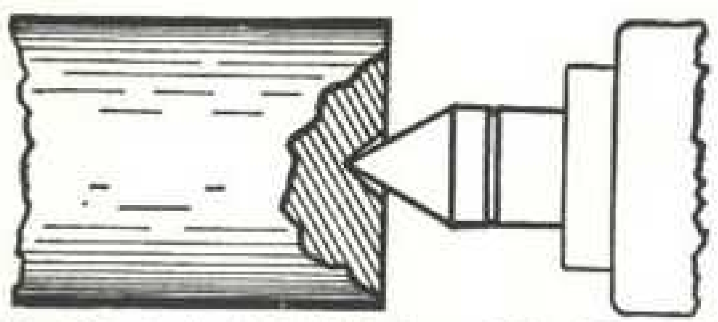


Fig. 127. A Poorly Drilled Center Hole, Too Shallow and Incorrect Angle

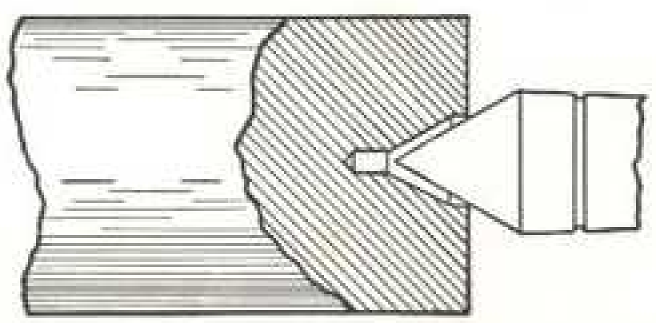


Fig. 128. An Incorrect Center Hole, Drilled Too Deep to Fit Center

Fig. 129. Standard Lathe Dog

Fig. 130. Safety Lathe Dog

Lathe Dogs for Driving Work on Centers

The common lathe dog shown in Fig. 129 is the most popular type. Fig. 130 shows a safety lathe dog which has a headless set screw and is not likely to catch in the operator's sleeve. Fig. 132 shows a clamp lathe dog, used principally for rectangular work in the lathe. When attaching the lathe dog to the work, make sure that the set screw is securely tightened.

Mounting Centers in the Lathe Spindles

Before mounting the lathe centers in the headstock or tailstock spindle, thoroughly clean the centers, the tapered holes and the spindle sleeve "A," Fig. 131. A very small chip or a little dirt will cause the center to run out of true. Use cloth and stick to clean taper hole. Do not insert finger in revolving spindle.

Removing the Lathe Centers

With a piece of rag in your right hand, hold the sharp point of the headstock center, and with the left hand give the center a sharp tap with a rod through the spindle hole. Fig. 133 shows a steel rod with a small bushing attached for removing the headstock spindle center and taper sleeve.

To remove the tailstock center, turn the tailstock handwheel to the left until the end of the tailstock screw bumps the end of the center. This will loosen the center and it may be removed from the spindle.

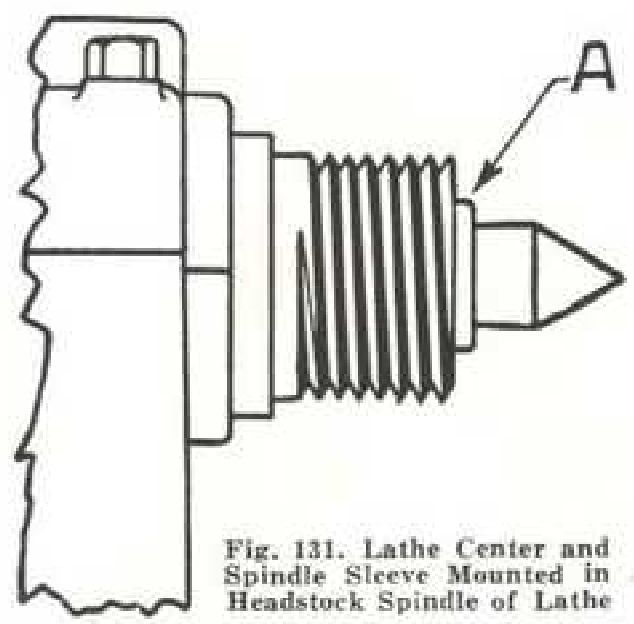


Fig. 131. Lathe Center and Spindle Sleeve Mounted in Headstock Spindle of Lathe

Fig. 132. Clamp Lathe Dog

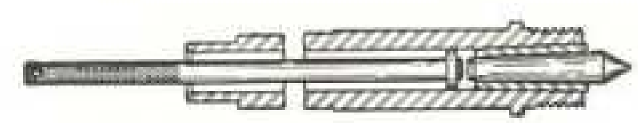


Fig. 133. Knock Out Bar for Removing Headstock Spindle Center

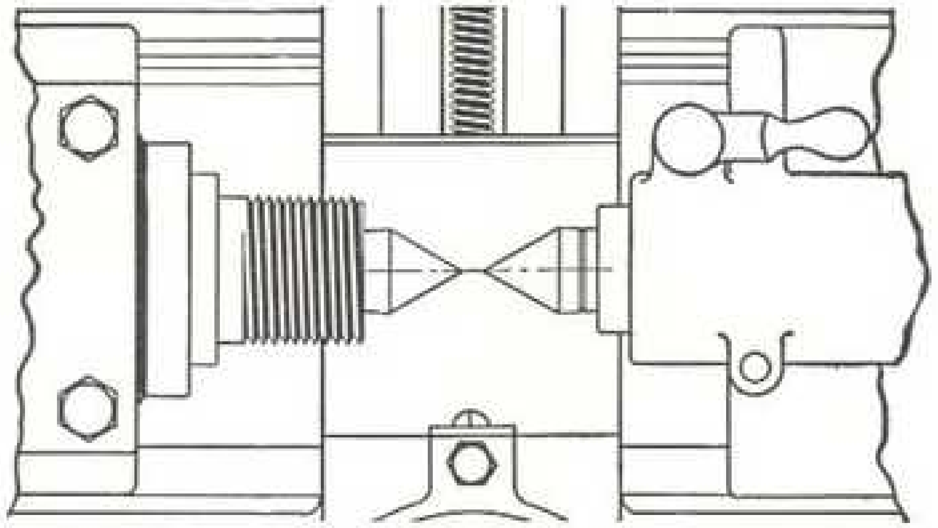


Fig. 134. Checking the Alignment of the Lathe Centers

Check Alignment of Centers

Before mounting work between the lathe centers they should be checked for alignment, as shown in Fig. 134. If the tailstock center does not line up, loosen the tailstock clamp bolt and set over the tailstock top in the proper direction by adjusting the tailstock set over screws. (See page 51.)

Mounting the Work Between Centers

Place a drop of oil in the center hole for the tailstock center point before mounting the work between centers. The tail of the lathe dog should fit freely into the slot of the face plate so that the work rests firmly on both the headstock center and the tailstock center, as shown in Fig. 136. Make sure that the lathe dog does not bind in the slot of the face plate, as shown in Fig. 135.

The tailstock center should not be tight against the work, but should not be too loose. The work must turn freely, for if the tail center is too tight it will stick and may be ruined.

Expansion of Work

When work is machined in the lathe it may become hot and expand. The expansion of work mounted between centers will cause it to bind, making it necessary to stop the lathe and readjust the tailstock center. When machining a long shaft, several readjustments of the tailstock center may be required.

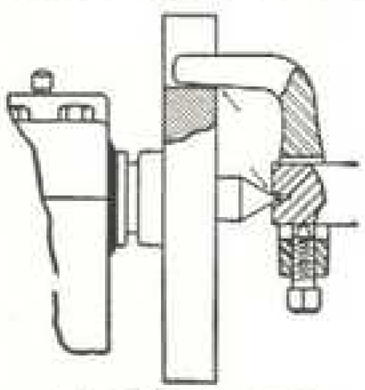


Fig. 135. Incorrect Mounting

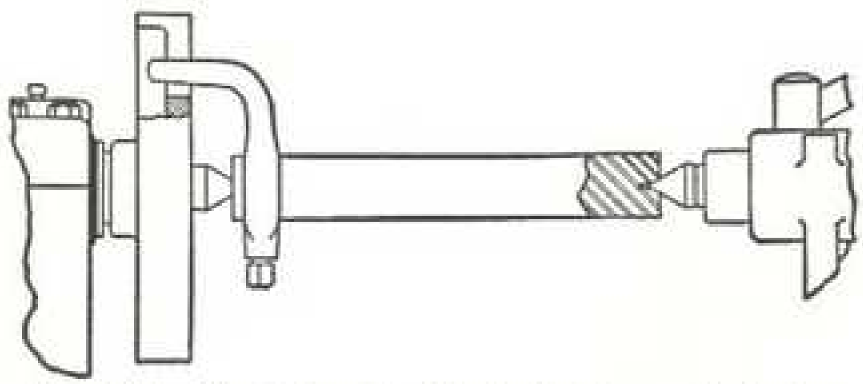


Fig. 136. Work Properly Mounted Between the Lathe Centers, Ready to Machine

Facing the Ends

Before turning the diameter of a shaft, the ends should be faced square. Grind the cutter bit as shown in Fig. 74, page 32, and set the cutting edge exactly on center, as shown in Fig. 137. Be careful not to break the point of the tool against the tailstock center. Feed the tool out to face the end, as shown in Fig. 138.

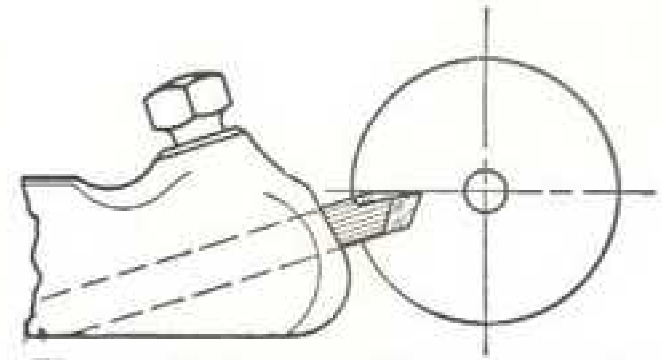


Fig. 137. Position of Cutter Bit for Facing the End of a Shaft

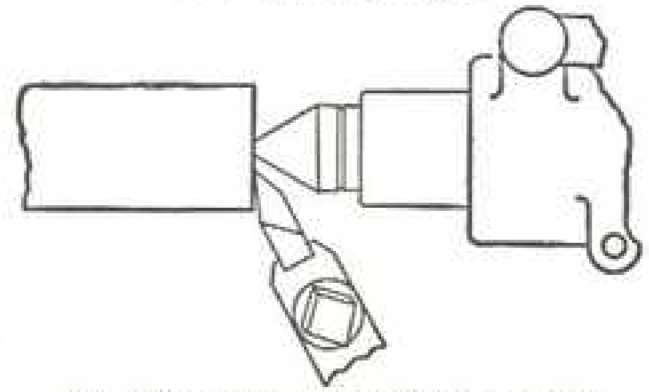


Fig. 138. Facing the End of a Shaft

Position of Tool for Turning

Grind the cutter bit for turning as shown in Fig. 64, page 30. The cutting edge of the cutter bit and the end of the tool holder should not extend over the edge of the compound rest any farther than necessary. (See "A" and "B," Fig. 139.)

The tool should be set as shown in Fig. 140 so that if the tool slips in the tool post it will not dig into the work, but instead it will move in the direction of the arrow away from the work.

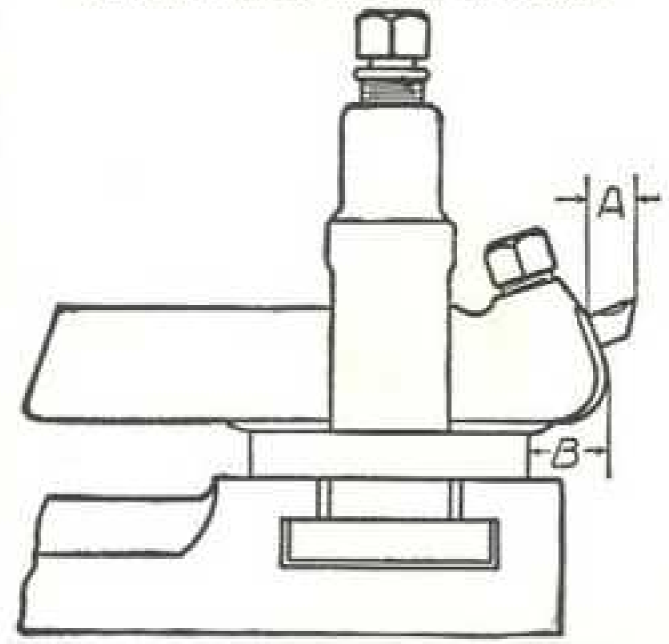


Fig. 139. Position of Tool in Tool Post

Direction of Power Feed

The feed of the tool should be toward the headstock, if possible, so that the pressure of the cut is on the head spindle center which revolves with the work.

Rate of Power Feed

The rate of the power feed depends on the size of the lathe, the nature of the work, and the amount of stock to be removed.

On a small lathe a feed of .008 in. per revolution of the spindle may be used, but on larger sizes of lathes feeds as coarse as .020 in. are often used for rough turning. Care must be taken when turning long slender shafts as a heavy cut with a coarse feed may bend the shaft and ruin the work.

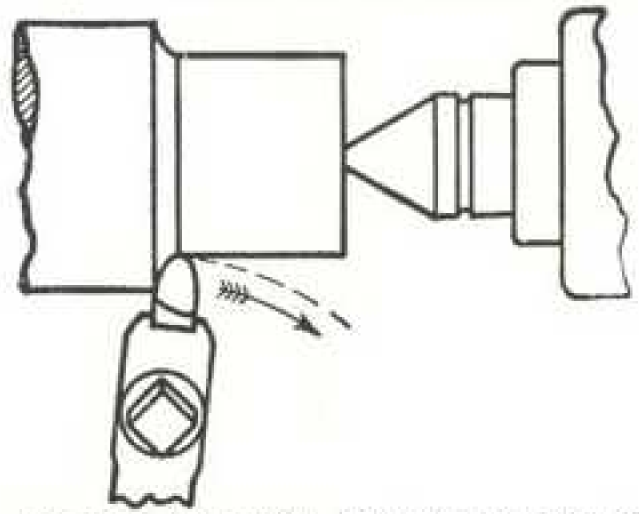


Fig. 140. Top View Showing Position of Tool for Turning

Cutting Speeds for Turning

The most efficient cutting speed for turning varies with the kind of metal being machined, the depth of the cut, the feed and the type of cutter bit used. If too slow a cutting speed is used, much time may be lost, and if too high a speed is used the tool will dull quickly. The following cutting speeds are recommended for high speed steel cutter bits:

CUTTING SPEEDS IN SURFACE FEET PER MINUTE

Kind of Metal	Roughing Cuts .010 in. to .020 in. Feed	Finishing Cuts .002 in. to .010 in. Feed	Cutting Screw Threads
Cast Iron	60 f. p. m.	80 f. p. m.	25 f. p. m.
Machine Steel	90 f. p. m.	100 f. p. m.	35 f. p. m.
Tool Steel, Annealed	50 f. p. m.	75 f. p. m.	20 f. p. m.
Brass	150 f. p. m.	200 f. p. m.	50 f. p. m.
Aluminum	200 f. p. m.	300 f. p. m.	50 f. p. m.
Bronze	90 f. p. m.	100 f. p. m.	25 f. p. m.

See also pages 98 and 108.

If a cutting lubricant is used, the above speeds may be increased 25% to 50%. When using tungsten-carbide tipped cutting tools, the cutting speeds may be increased from 100% to 800%. See page 108.

To find the number of revolutions per minute required for a given cutting speed, in feet per minute, multiply the given cutting speed by 12 and divide the product by the circumference (in inches) of turned part.

Example: Find the number of revolutions per minute for 1 in. shaft for a cutting speed of 90 ft. per minute.

$$\frac{90 \times 12}{3.1416 \times 1} = 343.77 \text{ r. p. m.}$$

Spindle speeds for various diameters and metals are listed in the tabulation below to eliminate the necessity of making calculations. Refer to page 23 for spindle speeds of various sizes of lathes.

SPINDLE SPEEDS IN R.P.M. FOR TURNING AND BORING
Calculated for Average Cuts with High Speed Steel Cutter Bits

Diameter in Inches	Alloy Steels 50 f. p. m.	Cast Iron 75 f. p. m.	Machine Steel 100 f. p. m.	Hard Brass 150 f. p. m.	Soft Brass 200 f. p. m.	Aluminum 300 f. p. m.
1	191	287	382	573	764	1146
2	95	143	191	287	382	573
3	64	95	127	191	254	381
4	48	72	95	143	190	285
5	38	57	76	115	152	228
6	32	48	64	95	128	192
7	27	41	55	82	110	165
8	24	36	48	72	96	144
9	21	32	42	64	84	126
10	19	29	38	57	76	114
11	17	26	35	52	70	105
12	16	24	32	48	64	96
13	15	22	29	44	58	87
14	14	20	27	41	54	81
15	13	19	25	38	50	75
16	12	18	24	36	48	72

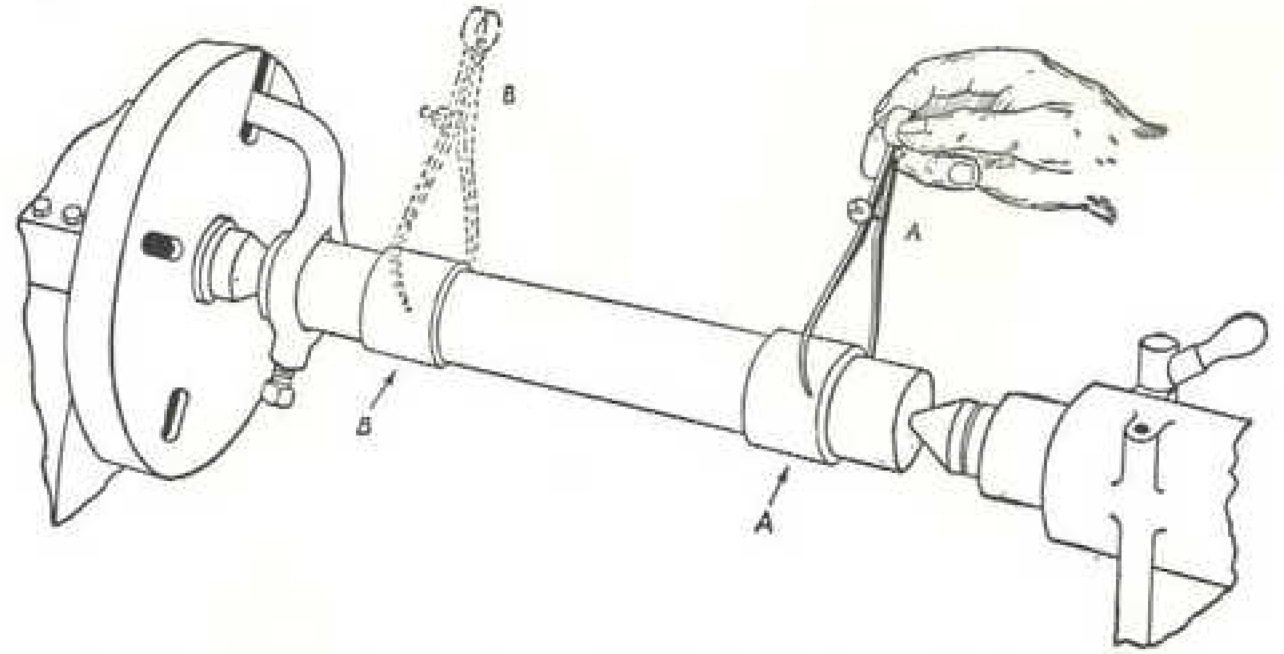


Fig. 141. Testing the Alignment of the Lathe Centers for Straight Turning

Testing Alignment of Centers

After taking the first roughing cut across a shaft, check the diameter at each end of the cut with calipers or micrometers to make sure the lathe is turning straight. Sometimes when the position of the tailstock is changed for a different length of work, it will require adjustment. This is especially true on old lathes which may have worn spots and burrs on the bed.

Fig. 141 shows a good method of testing for the alignment of the lathe centers. Two collars, A and B, turned on a shaft about 1½ in. in diameter and 10 in. long, are machined with a fine finishing cut without changing the adjustment of the cutting tool. Collar A is measured, and without making any adjustment on the caliper, collar B is tested to see how it compares with collar A. If collar A is not the same diameter as collar B, then the adjustment of centers is not correct, and the tailstock top should be adjusted in the direction required.

Adjustment of Tailstock Top

The tailstock top is adjusted by releasing one of the adjusting screws of the tailstock top and tightening the opposite screw a similar distance. Then take another test cut on the collars, measure and continue this operation until the desired degree of accuracy is obtained.

There is a mark on the end of the tailstock where the bottom and top join to show the relative position of the tailstock top and bottom. For fine, accurate work, this mark should not be depended upon, but the alignment test should be made as described above to be sure that the centers are in line.

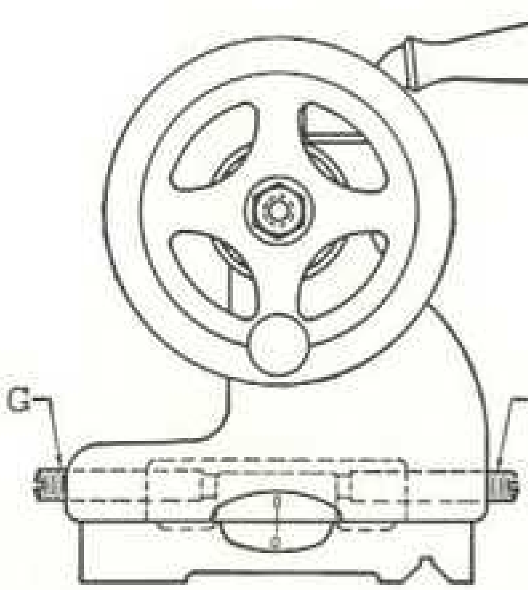


Fig. 142. Tailstock Set on Center

Machining to a Shoulder

A good method for locating a shoulder on a shaft is shown in Fig. 143. After chalking the shaft, set the hermaphrodite calipers to the required dimension and scribe a line around the revolving shaft with the sharp point on the caliper.

Fig. 144 shows the use of a round nosed turning tool for finishing a shoulder having a fillet corner. (See page 31, Fig. 67.)

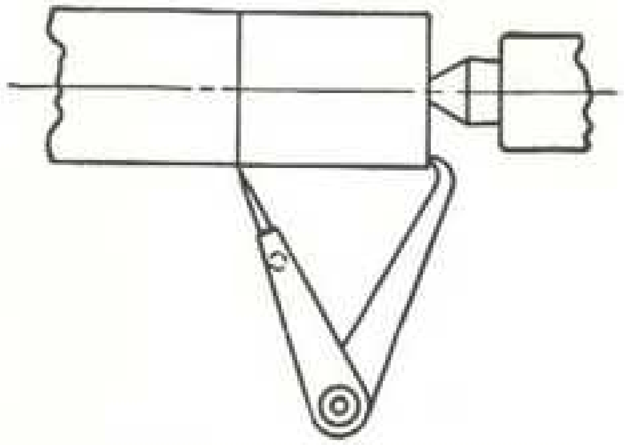


Fig. 143. Measuring with Hermaphrodite Caliper to Locate a Shoulder

Locating Shoulders with a Parting Tool

In production work where a quantity of pieces are required, shoulders are usually located with a parting tool, as shown in Fig. 146, before the diameter is machined.

When a square corner is required, as for a bearing, it is customary to neck or undercut the shoulder slightly, as shown in Fig. 145.

A firm joint caliper is convenient for measuring when facing the ends of a shaft to length or for measuring between two shoulders, as shown in Fig. 147.

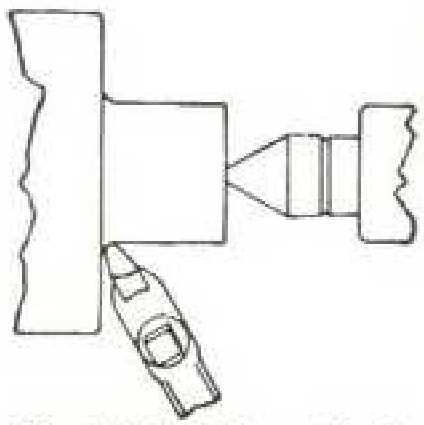


Fig. 144. Finishing a Shoulder with a Fillet

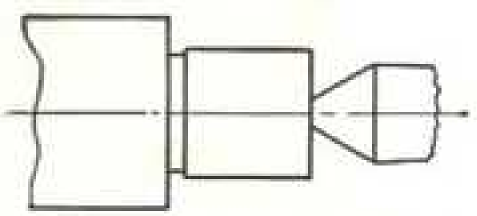


Fig. 145. Detail of a Shoulder with a Recess

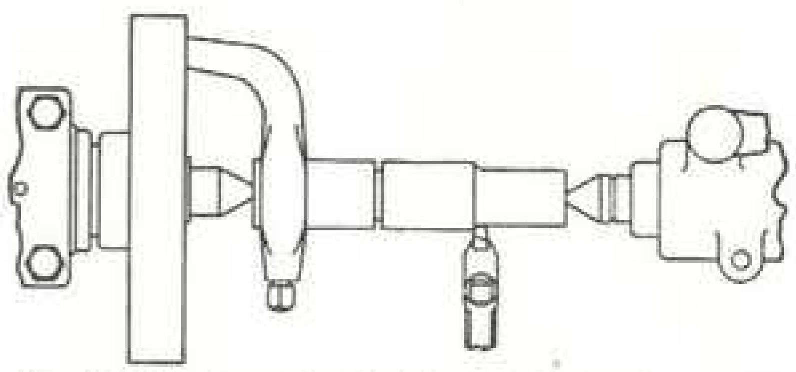


Fig. 146. Location of a Shoulder Marked with a Parting Tool Before Turning the Diameter

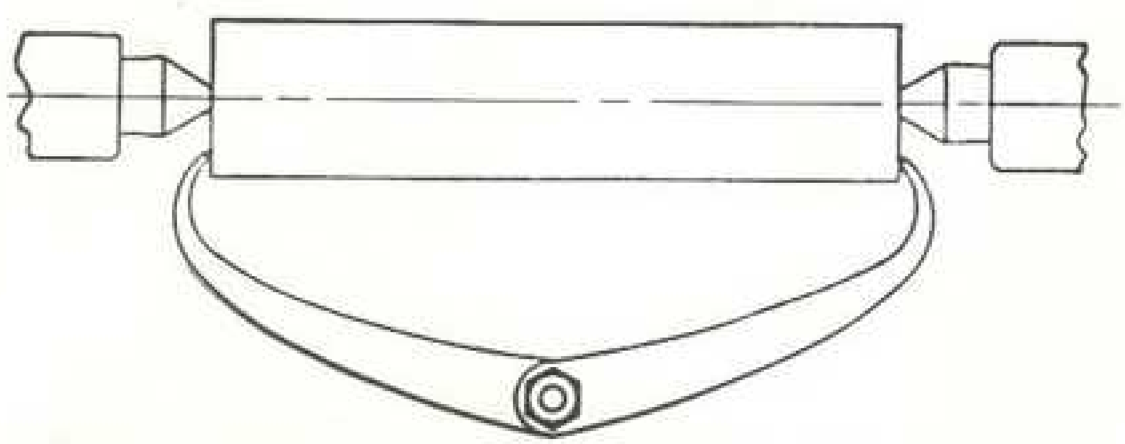


Fig. 147. Measuring the Length of a Shaft with a Firm Joint Caliper

Fig. 148. Machining a Shaft in an Independent Chuck

Chapter VII

CHUCK WORK

Work that cannot readily be mounted between the lathe centers is usually held in a chuck, as shown above, for machining. Several types of chucks are used, but the most popular are the 4-jaw Independent chuck and the 3-jaw Universal chuck shown below.

A 4-jaw Independent chuck has four reversible jaws, each of which may be independently adjusted. This type of chuck is recommended if the lathe is to have but one chuck, as it will hold square, round and irregular shapes in either a concentric or an eccentric position.

The 3-jaw Universal chuck is used for chucking round and hexagonal work quickly, as the three jaws move simultaneously and automatically center the work. Two sets of jaws are required, one set for external chucking and the other for internal chucking.

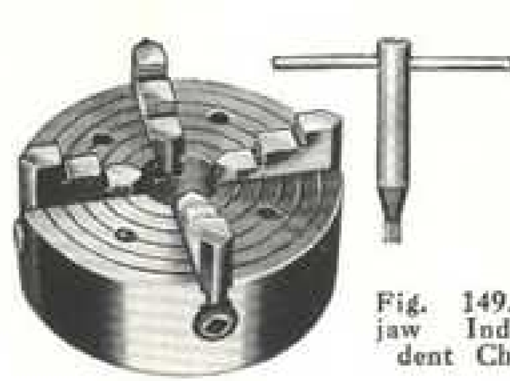


Fig. 149. 4-jaw Independent Chuck

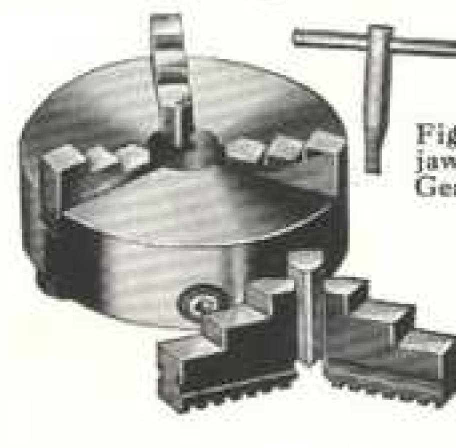


Fig. 150. 3-jaw Universal Geared Scroll Chuck

Mounting Chuck on Spindle

Before mounting a chuck or a face plate on the lathe spindle, thoroughly clean and oil the threads of the spindle and the chuck back. Also clean the shoulder of the spindle where the chuck back fits against it. A very small chip or burr at this point will prevent the chuck from running true.

Hold the chuck against the spindle nose with the right hand and arm and turn the lathe spindle cone with the left hand to screw the chuck onto the spindle just tight enough to hold it securely.

Do not run the lathe with power while screwing the chuck onto the spindle, and do not spin the chuck up to the shoulder or it may be very difficult to remove.

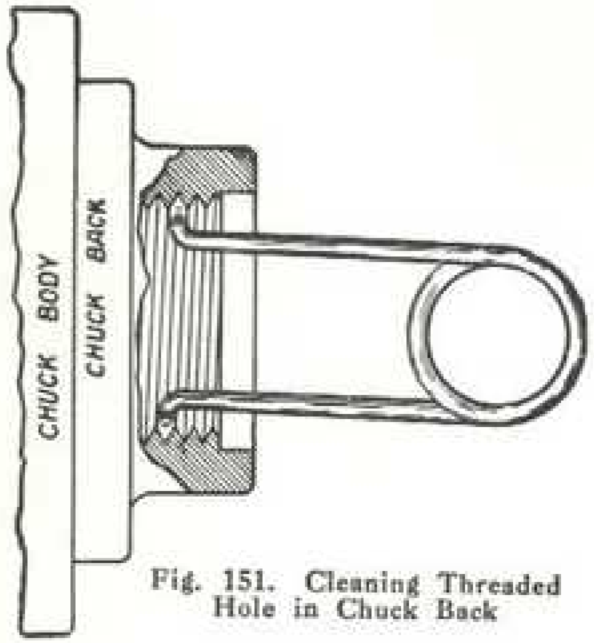


Fig. 151. Cleaning Threaded Hole in Chuck Back

The Independent Chuck

The independent chuck is used more than any other type of chuck because it will hold practically any shape and can be adjusted to any degree of accuracy required.

Concentric rings scribed on the face of the chuck permit centering round work approximately, as it is placed in the chuck. To center more accurately, the lathe is started and a piece of chalk is held lightly against the revolving work, as shown in Fig. 152. The lathe is then stopped and the jaw opposite the chalk mark is loosened slightly. The opposite jaw is then tightened. The test is repeated until the work is centered with the necessary accuracy. All four jaws must be securely tightened before starting to machine the work.

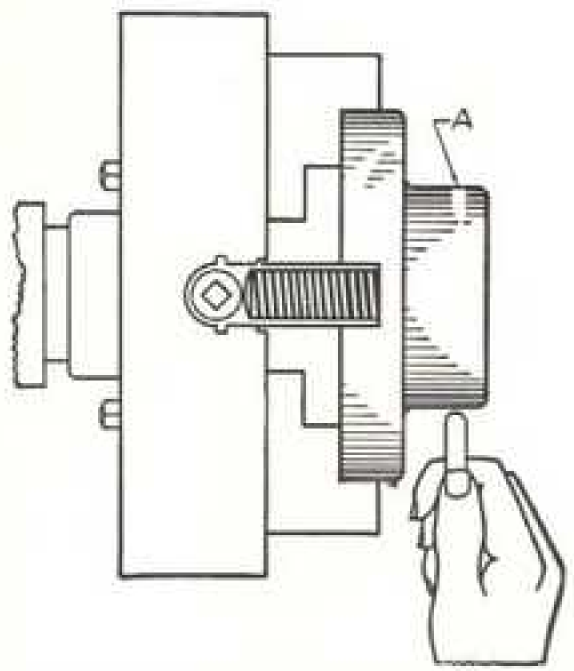


Fig. 152. Centering Work in an Independent Chuck

Use of Center Indicator

The center indicator is used for accurately centering work that has been laid out and center punched for drilling and boring. The short end of the center indicator is placed in the center punch mark and the tailstock center point is brought up close to the opposite end, as shown in Fig. 153. For accurate work, the long end of the indicator should remain stationary when the lathe spindle is revolved.

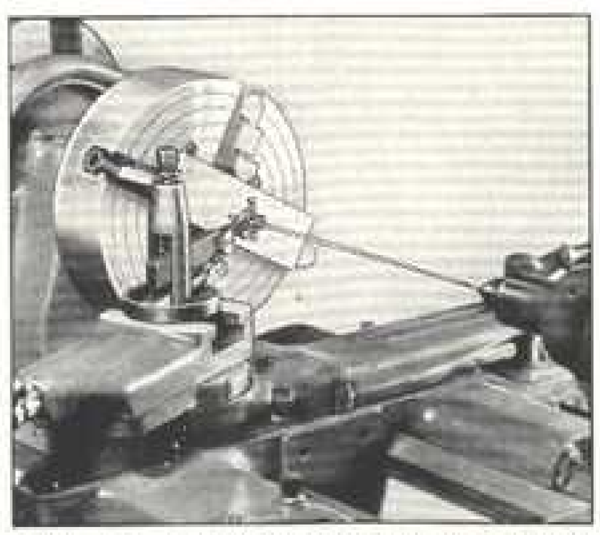


Fig. 153. Centering Work with a Center Indicator

Centering Work With Dial Test Indicator

A sensitive dial indicator may be used for accurately centering work having a smooth surface. The dial of the indicator is graduated to read in thousandths of an inch so that practically any required degree of accuracy may be obtained.

The indicator is placed in contact with the part to be centered, as shown in Fig. 154, and the hand on the indicator dial is watched as the lathe spindle is revolved slowly by hand. The chuck jaws are adjusted as described on page 54 until the required degree of accuracy is obtained.

The part to be centered should also be tested on the face for wobble as shown in Fig. 155.

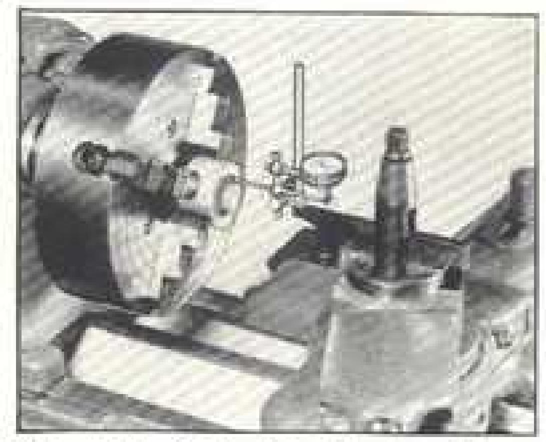


Fig. 154. Centering Work with a Dial Test Indicator

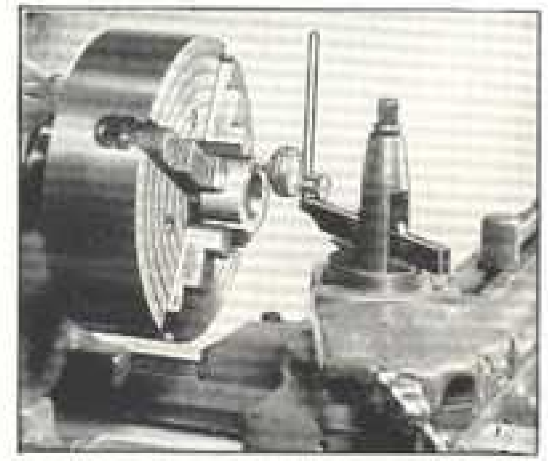


Fig. 155. Testing Face of Work with Dial Indicator for Wobble

Removing Chuck from Lathe Spindle

To start a chuck so it can be removed from the lathe spindle, engage the back gears, place a wood block between the chuck jaw and back ways of bed, as shown in Fig. 156, and turn cone pulley by hand. After starting the chuck, place a board across the bed ways to protect them from damage in case the chuck is dropped off the spindle. This procedure also applies to face plates.

Fig. 156. Removing a Chuck from Lathe Spindle

Practical Sizes of Chucks

Lathe chucks should be carefully selected for the size of the lathe and the work for which they are to be used. If the chuck is too small, the capacity of the lathe is restricted, but if it is too large the jaws may strike the lathe bed and the chuck will be awkward to use and difficult to handle.

The most practical sizes of chucks for use with various sizes of lathes are listed in the tabulation below.

Practical Sizes of Chucks for Lathes

Size of Lathe	4-Jaw Independent Lathe Chuck	3-Jaw Universal Geared Scroll Chuck
9-in. lathe	6 in.	5 in.
10-in. lathe	6 in.	5 in.
13-in. lathe	7½ in.	6 in.
14½-in. lathe	9 in.	7½ in.
16-in. and 16/24-in. lathes	10 in.	7½ in.

The Universal Chuck

Round and hexagonal work may be chucked quickly in the universal chuck as all three jaws move simultaneously and automatically center the work within a few thousands of an inch. This type of chuck will usually center work within .003 in. when new, but when the scroll becomes worn this degree of accuracy cannot be expected.

Since there is no way to adjust the jaws independently on this type of chuck, it is not used where extreme accuracy is required. The 4-jaw independent chuck should always be used when work must be centered to run dead true. However, if no independent chuck is available shims may be placed between the chuck jaws and the work to compensate for the inaccuracy of universal chuck.

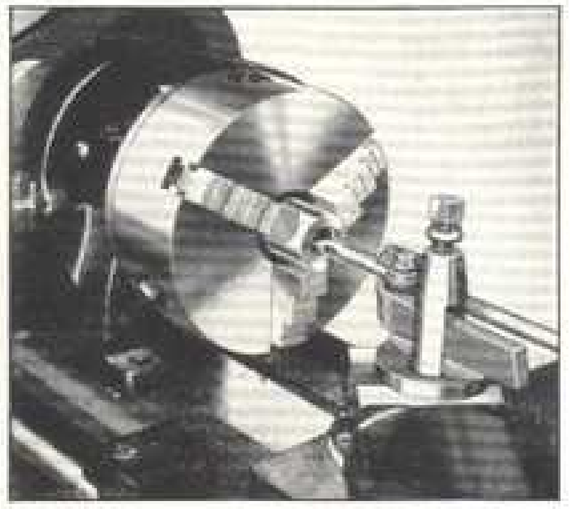


Fig. 157. Round Work Held in Universal Chuck

Fig. 158. Hollow Headstock Spindle Chuck

Headstock Spindle Chuck

The headstock spindle chuck, shown in Figs. 158 and 159, is similar to a drill chuck except that it is hollow and is threaded so that it may be screwed on to the spindle nose of the lathe.

This type of chuck is suitable for holding bars, rods and tubes that are passed through the headstock spindle of the lathe, also other small diameter work. It is more accurate than the average universal chuck and will usually center work within .002 in.

The headstock spindle chuck is inexpensive and for some classes of work it may be used instead of the more expensive draw-in collet chuck.

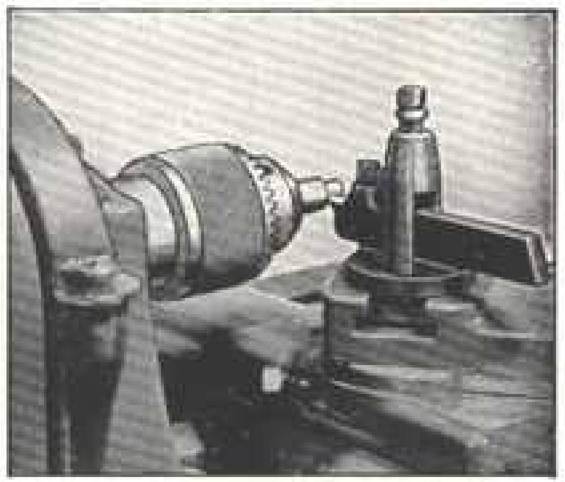


Fig. 159. Machining a Shaft in a Hollow Headstock Chuck

Drill Chuck

Drill chucks are used in both the headstock spindle and the tailstock spindle of the lathe for holding drills, reamers, taps, etc. There are several types of drill chucks on the market and some do not have sufficient accuracy and holding power for satisfactory use on the lathe. A good drill chuck will hold drills concentric within .002 in. or .003 in. and should have a wrench or a pinion key for tightening.

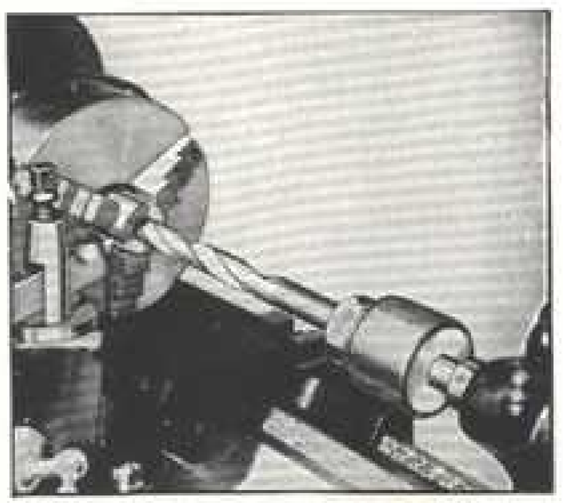


Fig. 160. Drill Chuck Mounted in Tailstock Spindle

Fig. 161. Machining a Part Held in a Draw-in Collet Chuck

Draw-in Collet Chuck

The draw-in collet chuck is the most accurate of all types of chucks and is used for precision work, such as making small tools and manufacturing small parts for watches, typewriters, radios, etc. The collets are made for round, square and other shapes, as shown in Figs. 162, 164 and 165. The work held in the collet should not be more than .001 in. smaller or .001 in. larger than the collet size. Collets are usually made of heat-treated steel, but for some classes of work brass collets are often used.

Fig. 162. Side View and End View of a Spring Collet for Round Work

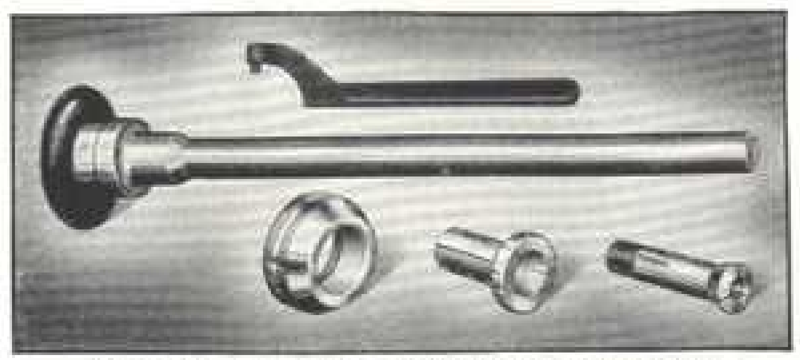


Fig. 163. Handwheel Draw-in Collet Chuck

Fig. 164. Square Collet

Fig. 165. Hexagon Collet

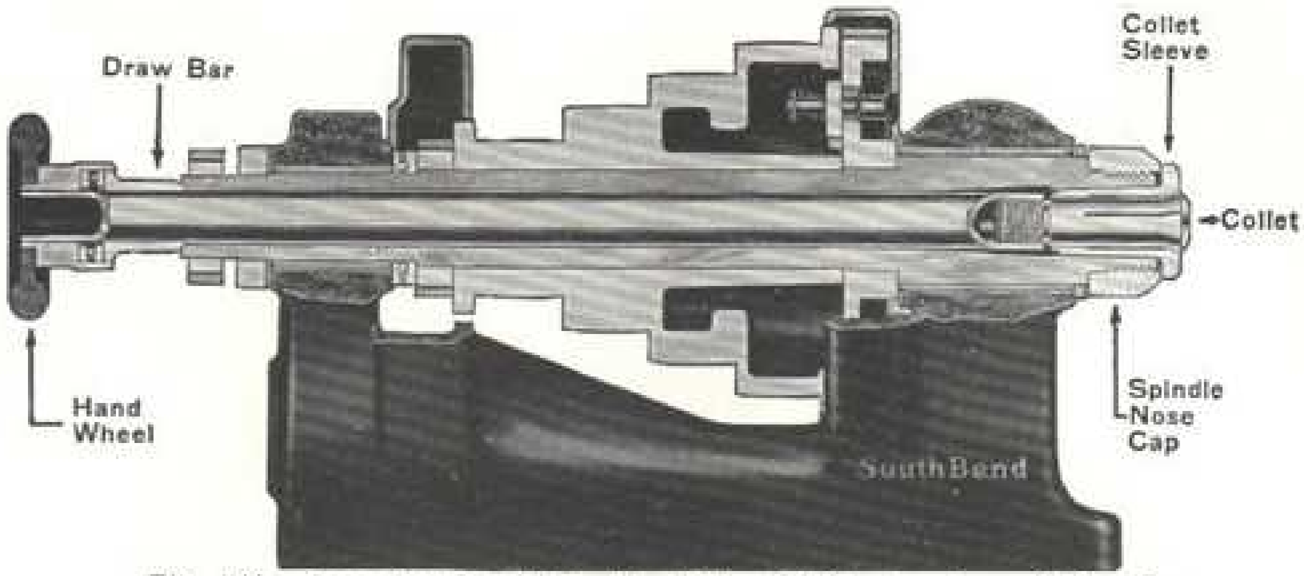


Fig. 166. Cross-Section of Headstock Showing Construction of Draw-in Collet Chuck Attachment

Construction of Draw-in Collet Chuck

The construction of the draw-in collet chuck is shown above in Fig. 166. The hollow draw-bar with handwheel attached extends through the headstock spindle of the lathe and is threaded on the right end to receive the spring collet. Turning the handwheel to the right draws the collet into the tapered closing sleeve and tightens the collet on the work. Turning the handwheel to the left releases the collet.

Fig. 167. Pot Collet

Step Chuck and Closer

The spring collet may be replaced with a step chuck and closer, as shown in Fig. 168, for holding discs such as gear blanks, etc. A pot collet, shown in Fig. 167, may be used in place of the step chuck for small diameters.

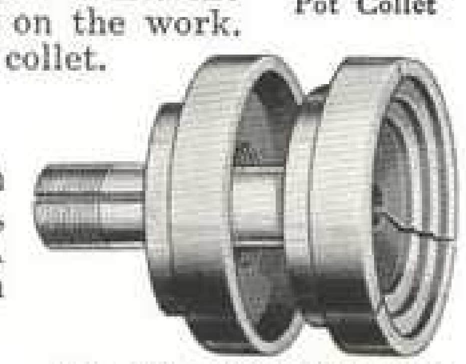


Fig. 168. Step Chuck and Closer

Handlever Draw-in Collect Chuck

The handlever draw-in collet chuck, shown in Fig. 169, is similar to the handwheel type draw-in collet chuck except that the collet is opened and closed by moving the hand lever to the right or left. This permits gripping or releasing the work without stopping the lathe spindle if desired.

Fig. 169. Handlever Type Draw-in Collet Chuck Attachment

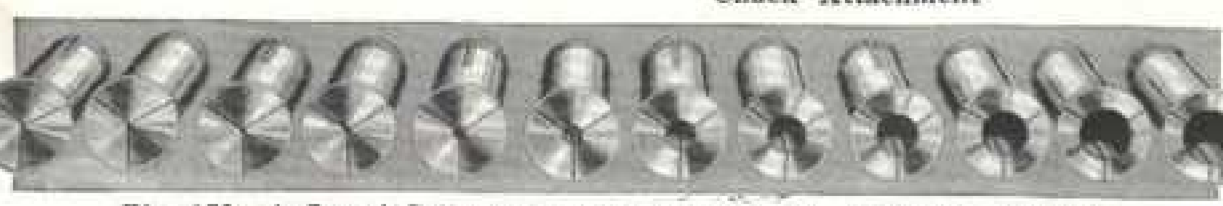


Fig. 170. A Set of Collets for Round Work $\frac{1}{16}$ In. to $\frac{3}{4}$ In. by 16ths

Chapter VIII

TAPER TURNING AND BORING

There are three methods of turning and boring tapers in the lathe: by setting over the tailstock; by using the compound rest; and by using the taper attachment of the lathe. The method used depends on the length of the taper, the angle of taper and the number of pieces to be machined.

Cutter Bit Must Be on Center

The cutting edge of the tool must be set exactly on center, as shown in Fig. 173, to turn or bore an accurate taper. That is, the cutting edge of the lathe tool must be exactly the same height as the point of the tailstock center. The position of the tool applies to all methods of turning and boring tapers.

Taper Turning with Compound Rest

The compound rest of the lathe is usually used for turning and boring short tapers and bevels, especially for bevel gear blanks and for die and pattern work, etc. The compound rest swivel is set at the required angle and the taper is machined by turning the compound rest feed screw by hand. See Figs. 171 and 172.

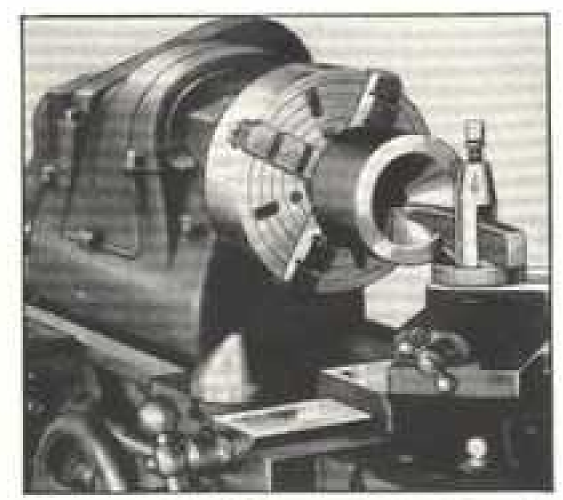


Fig. 171. Machining a Conical Punch and Die with Compound Rest

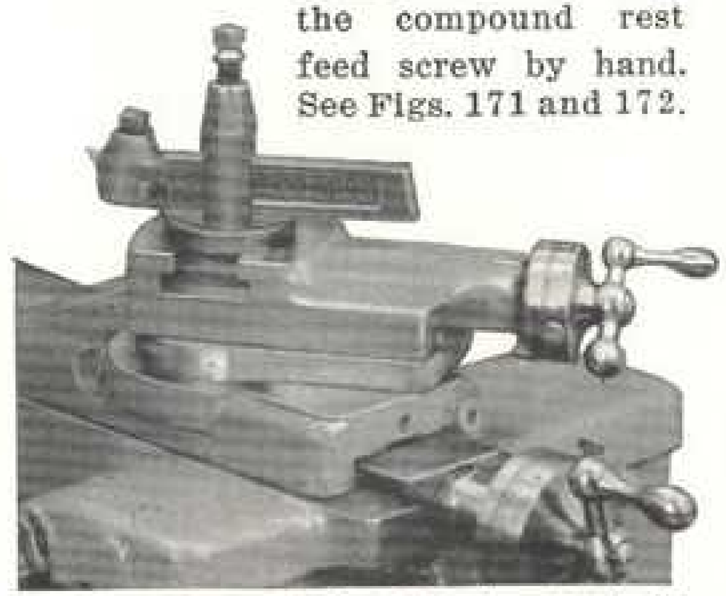


Fig. 172. Compound Rest Set at an Angle for Taper Turning and Boring

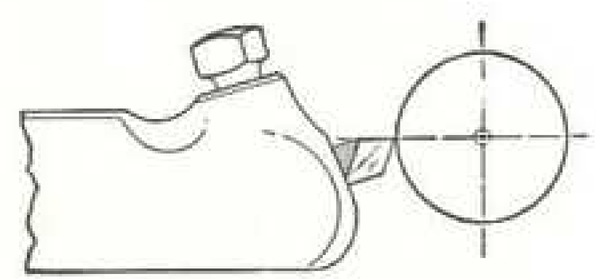


Fig. 173. Lathe Tool Cutter Bit Set on Center for Taper Turning

Truing a 60° Center

A good example of the use of the compound rest for short tapers is shown in Fig. 174. An electric grinding attachment is mounted on the lathe in place of the tool post and the compound rest is swiveled to the correct angle to permit feeding the grinding wheel across the 60° center point to grind it true. Lathe centers are usually too hard to be machined with a cutting tool. See pages 100 and 101.

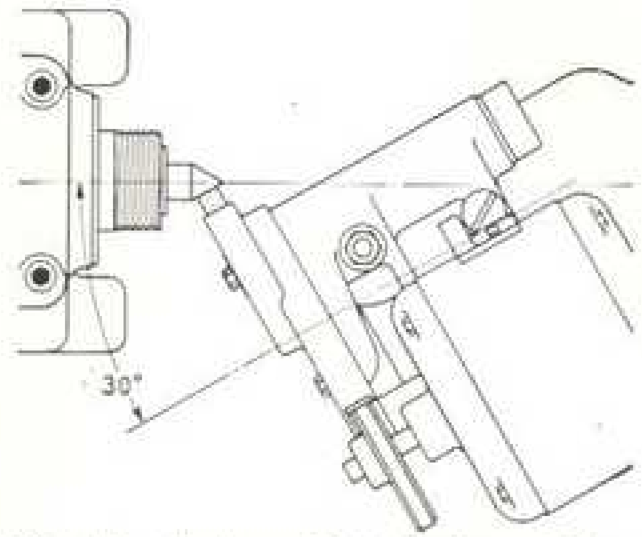


Fig. 174. Truing a 60° Lathe Center Point

Testing the Angle

All angular or bevel turning should be tested with a gauge of some kind, as it is difficult to read the graduations with sufficient accuracy to set the compound rest swivel for an exact taper. Fig. 175 shows the use of a center gauge for testing the 60° angle of a lathe center point.

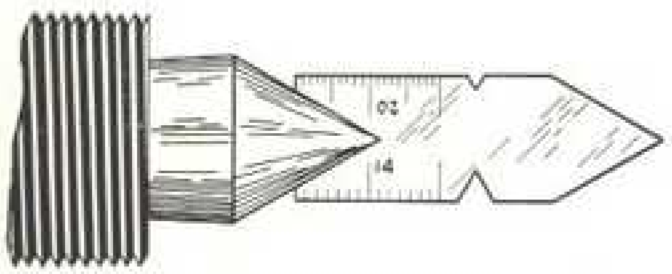


Fig. 175. Testing the Angle of a Lathe Center Point

Taper Turning with Tailstock Set Over

Work that can be machined between centers can be turned taper by setting over the tailstock top, as shown in Figs. 177, 178 and 179. This method cannot be used for boring tapers.

The amount the tailstock top must be set over depends on the amount of the taper per foot and the over-all length of the work. With the same amount of set over, pieces of different lengths will be machined with different tapers, as shown in Fig. 177. Notice that the tailstock center is set over one-half the total amount of the taper for the entire length of the work.

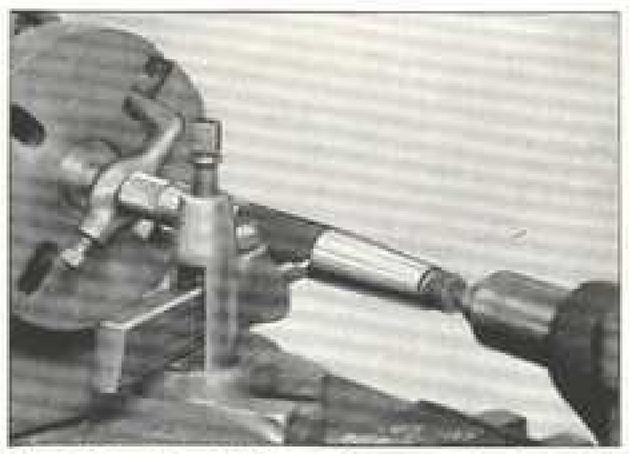


Fig. 176. Machining a Taper with the Tailstock Top Set Over

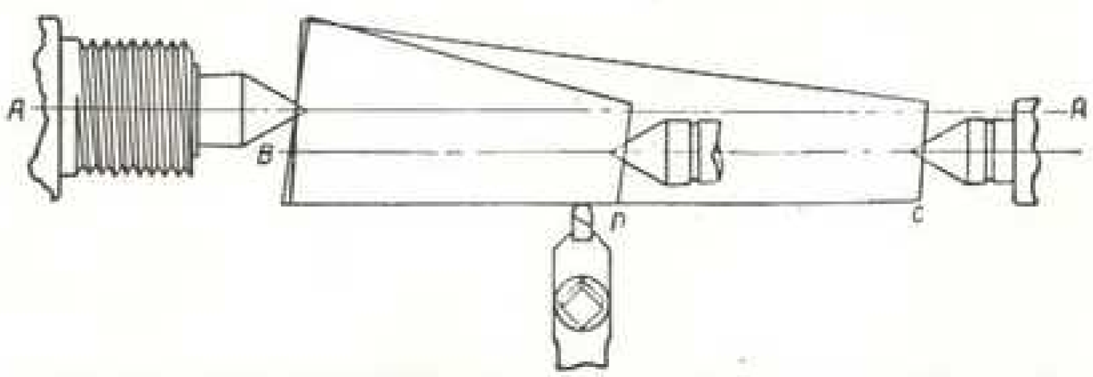


Fig. 177. With the Tailstock Set Over the Same Amount, Pieces of Different Lengths are Machined with Different Tapers

How to Calculate Amount of Setover for Tailstock

Tapers are usually specified in "inches per foot." For example, some Brown & Sharpe tapers are ½ in. per foot. To machine a Brown & Sharpe taper of ½ in. per foot on a shaft exactly one foot long, the center should be set over ¼ in. or .250 in. If the piece is only 10 in. long, then the amount of setover would be $\frac{10}{12}$ of .250 in. or .208 in. The following rules may be used for calculating the amount of setover:

Taper in Inches per Foot Given—Divide the total length of the stock in inches by twelve and multiply this quotient by one-half the amount of taper per foot specified. The result is the amount of setover in inches.

Diameters at Ends of Taper Given—Divide the total length of the stock by the length of the portion to be tapered and multiply this quotient by one-half the difference in diameters; the result is the amount of the setover.

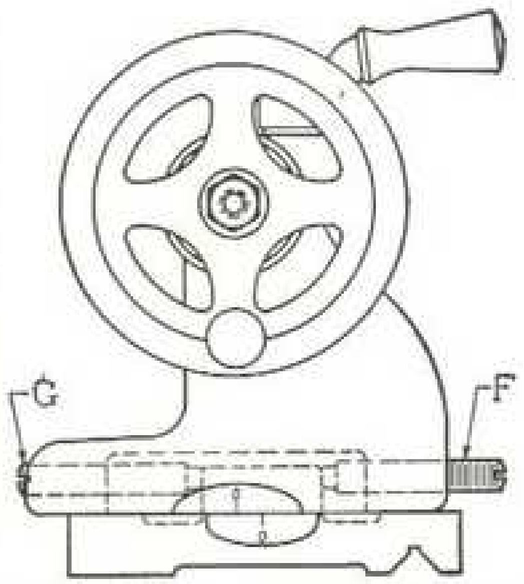


Fig. 178. Tailstock Top Set Off Center for Taper Turning

Adjusting the Tailstock Center

To set over the tailstock center for taper turning, loosen clamping nut of tailstock and back off set screw "F," Fig. 178, the distance required; then screw in set screw "G" a like distance until it is tight, and clamp the tailstock to the lathe bed.

Measuring the Setover

To measure the setover of the tailstock center, place a scale having graduations on both edges between the two centers, as shown in Fig. 179. This will give an approximate measurement.

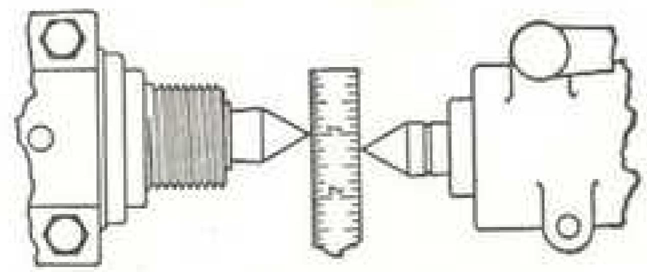


Fig. 179. Measuring the Setover

Fitting Tapers to Gauges

The best way to machine an accurate taper is to fit the taper to a standard gauge. To test the taper, make a chalk mark along the entire length of the taper, place the work in the taper it is to fit and turn carefully by hand. Then remove the work and the chalk mark will show where the taper is bearing.

If the taper is a perfect fit, it will show along the entire length of the chalk mark. If the taper is not perfect, make the necessary adjustment, take another light cut and test again. Be sure the taper is correct before turning to the finished diameter.

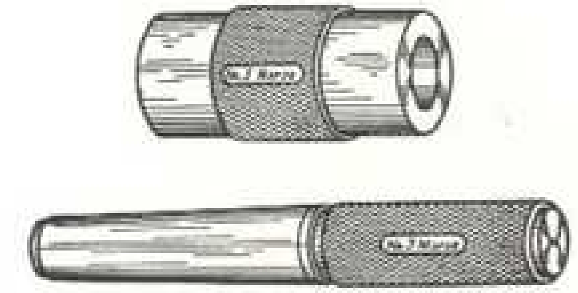


Fig. 180. Morse Standard Taper Plug Gauge and Socket Gauge