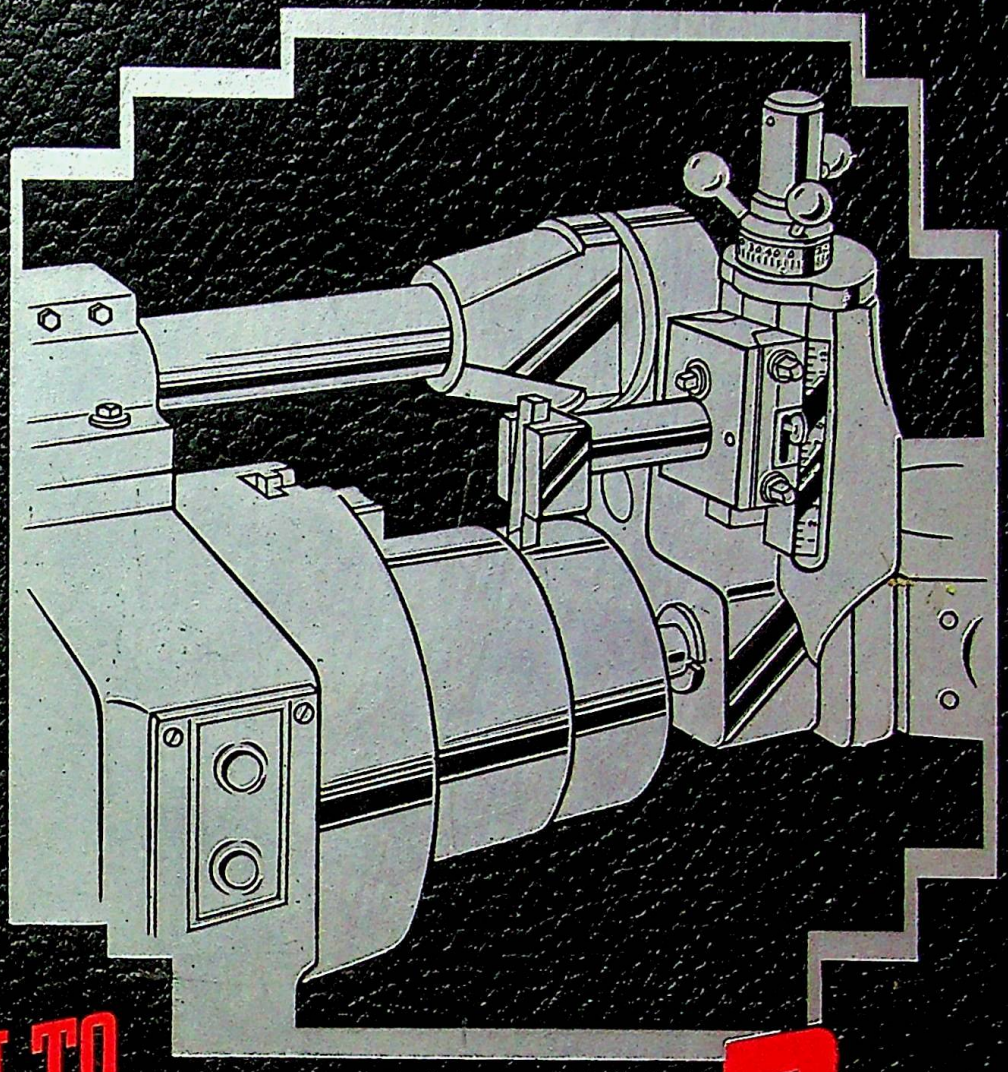


HOW TO Machine Parts on Turret Lathes

A TOOLING GUIDE BOOK

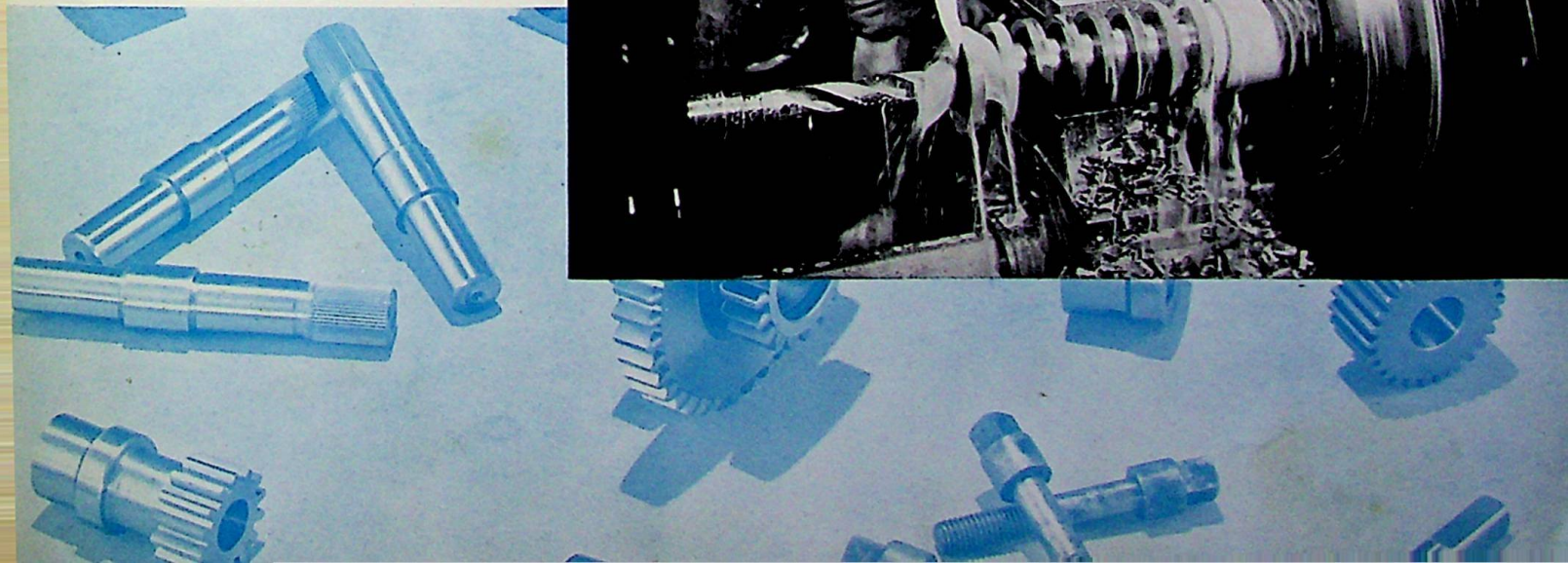
HOW TO MACHINE PARTS
on Turret Lathes

ALL turret lathe jobs are simply a series of basic machining operations such as turning, facing, drilling, boring, reaming and threading. The set-up for any job consists of arranging in proper order, these machining operations.

In general, almost every job can be machined by using any one of several tooling methods. The accuracies and quantities involved determine the method that should be used.

The correct method for tooling turret lathes consists of combining the maximum number of operations that will produce the accuracy and finish required in the shortest possible time. An understanding of all possible tooling methods that may be used, enables the resourceful turret lathe operator to select the proper tooling method.

This book presents the fundamental machining principles for turret lathe operation, and shows examples of the application of turret lathe tools for small, medium, and quantity lot production.



HOW TO PLAN TURRET LATHE TOOLING SETUPS

1 Analyze the job to determine the type of tooling required

Check the job to determine whether the parts are to be produced from bar stock or from castings and forgings.

Bar Work—Parts machined from bar stock usually require the roller-rest type of bar tools that support the work against the cutters.

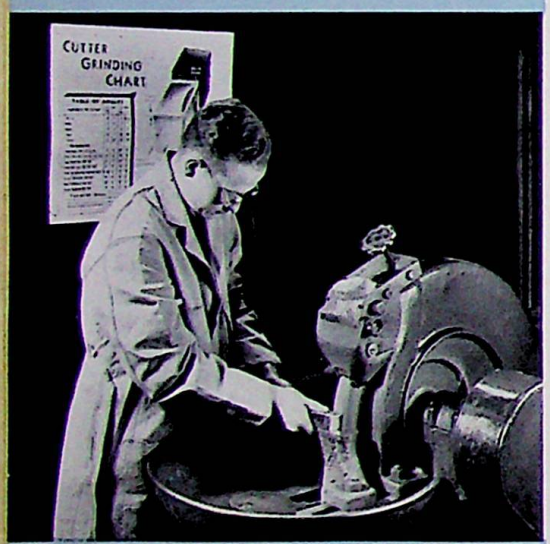
Chucking Work—Jobs produced from castings and forgings of large diameter and short overhang, require extended tooling that overhangs the hexagon turret.

2 Analyze the basic machining operations required

From the details of the work piece as shown in the blueprint, separate the machining operations into the two basic types—Internal and External Work.

Internal Work—Internal operations are usually set up before external cuts are arranged. Determine first what operations are necessary to machine the parts to required sizes and limits.

External Work—Determine what turning cuts should be taken from the hexagon turret, and what cuts (turning and facing) should be handled from the square turret. After turning cuts are set up, arrange the facing cuts. Chamfering, necking, grooving, and cut-off cuts are set up last.



3 Grind and set cutters

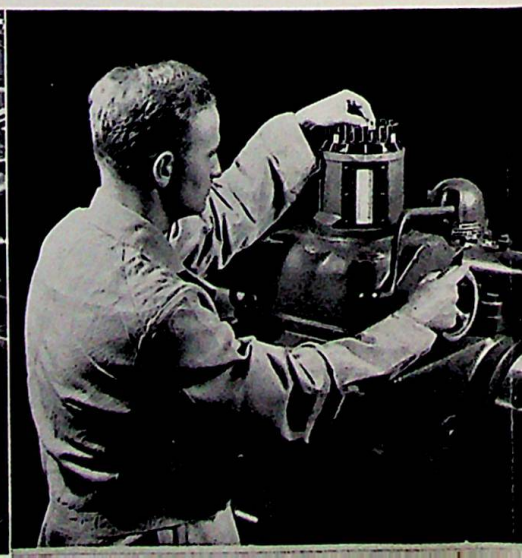
Correct angles of rake and clearance must be ground on each cutter to suit the material being machined. Set cutters with minimum overhang and grip cutters firmly in holders.

4 Set machine stops

Hexagon turret stops are usually set first—cross slide stops last. Set machining stops only as accurately as tolerances require.

5 Select correct cutting speeds and feeds

Cutting speeds and feeds are most important. They affect the finish and accuracy produced as well as the rate metal is removed. Consult charts for suggested speeds and feeds for each material.



HOW TO ANALYZE WHAT BASIC MACHINING OPERATIONS ARE REQUIRED

THE internal and external shape of the work piece and the accuracy specified generally determine the *kind* of machining cuts necessary. The amount of metal to be removed from the rough form governs the *number* of cuts required to produce the finishes required.

Two cuts—one roughing and one finishing—in most instances, are needed to produce the tolerances and finishes called for in general machining practice. In cases where the work piece is of unusual shape and limits are extremely close, three or more cuts may be needed.

Roughing or "hogging" cuts are taken primarily to remove larger quantities of metal for shaping the work piece to form. Finishing cuts produce size, concentricity, and smooth finish.

TWO TYPES OF MACHINING OPERATIONS

Internal Work—Simplest of all turret lathe operations is drilling. As the internal shape of the work piece becomes more complicated, other types of internal cuts, such as boring, counterboring, recessing, reaming, and threading become necessary.

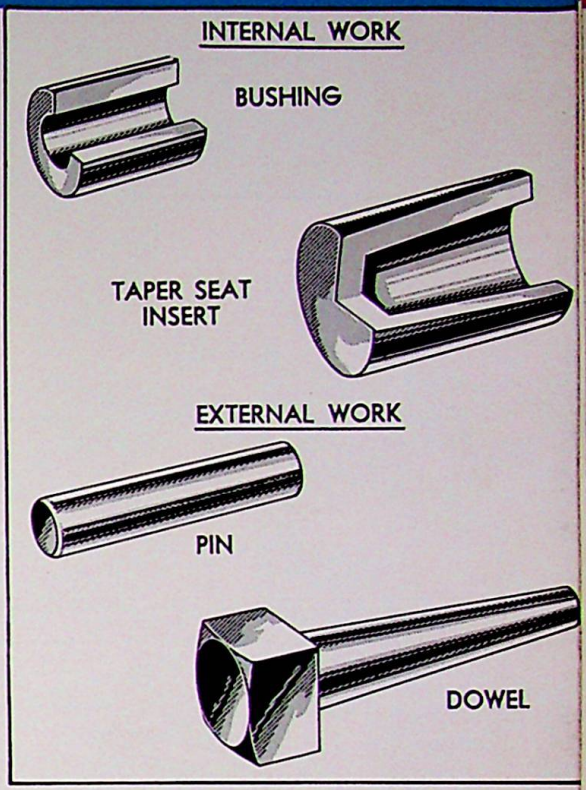
Turret lathe jobs often require many types of internal operations in one set-up. For example, in the machining of the threaded adapter shown at the right, each internal cut is designed to accomplish a specific purpose—drilling to remove metal—boring to obtain concentricity—reaming to produce size—recessing for thread clearance —and tapping.

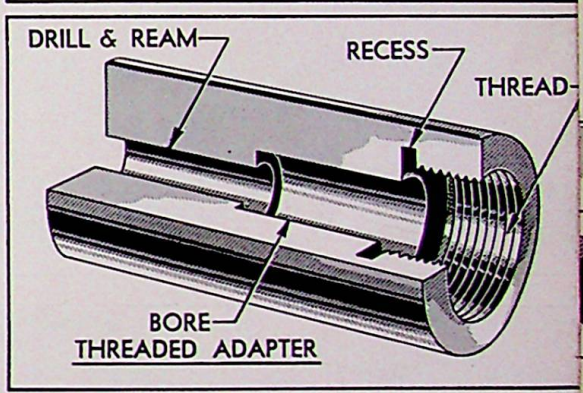
External Work—External operations range from single turning cuts as on simple pins and dowels, to combinations of cuts as required for completely machining threaded shafts or gear blanks. Straight and taper turning cuts, facing cuts, forming, grooving, and threading, are required in proper sequence to machine more complicated shapes.

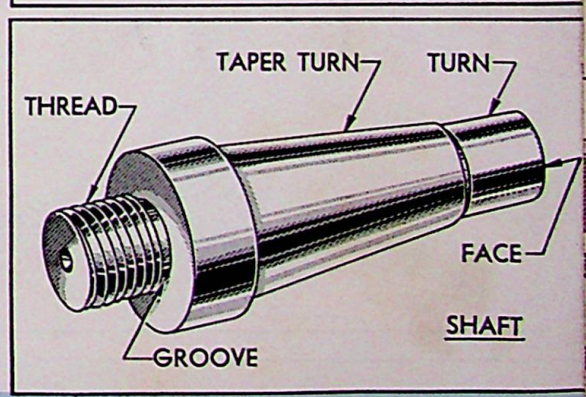
"MULTIPLE CUTS" AND "COMBINED CUTS"

Through proper selection of turret lathe tooling, internal operations may be combined with external cuts. In practical turret lathe set-ups, this is accomplished by *"Multiple Cuts"*—two or more cuts taken at one time from one hexagon turret station. *"Combined Cuts,"* cuts taken from the square turret and hexagon turret at the same time, can also be used.

"Combined Cuts" and *"Multiple Cuts"* are the most effective means for completing all required internal and external operations in one set-up in the shortest possible time.







SEQUENCE OF BASIC TURRET LATHE OPERATIONS

Internal Work

- DRILLING
- BORING
- RECESSING
- REAMING
- TAPPING

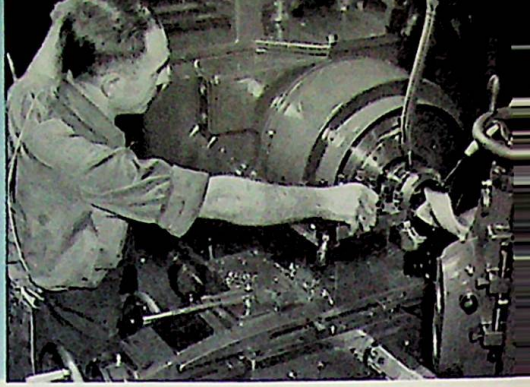
External Work

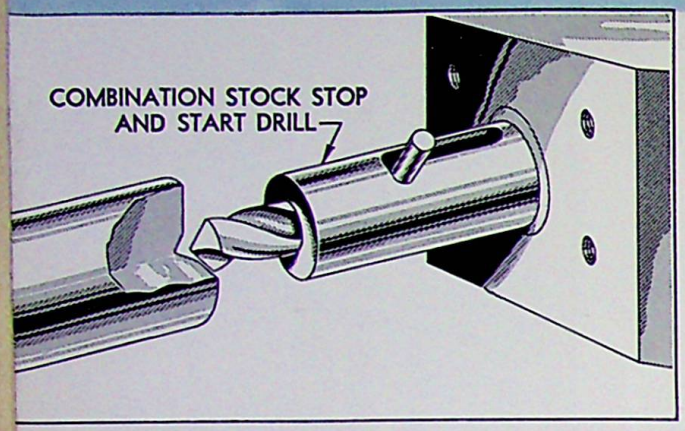
- TURNING
- FACING
- GROOVING
- FORMING
- THREADING

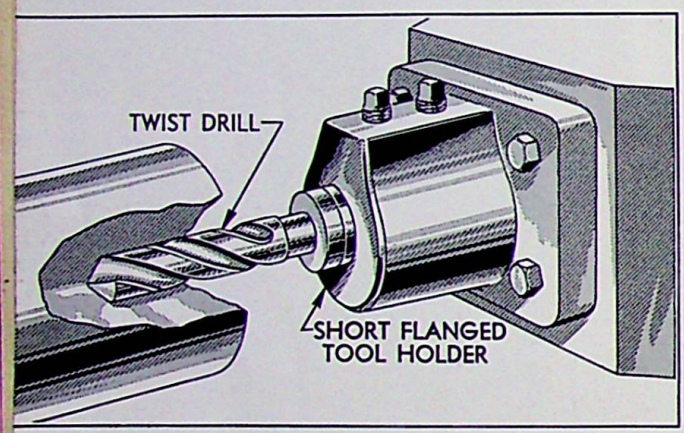
THE FOLLOWING PAGES ILLUSTRATE PRACTICAL APPLICATIONS OF THESE BASIC INTERNAL AND EXTERNAL MACHINING OPERATIONS AS THEY ARE PERFORMED IN ACCEPTED TURRET LATHE PRACTICE

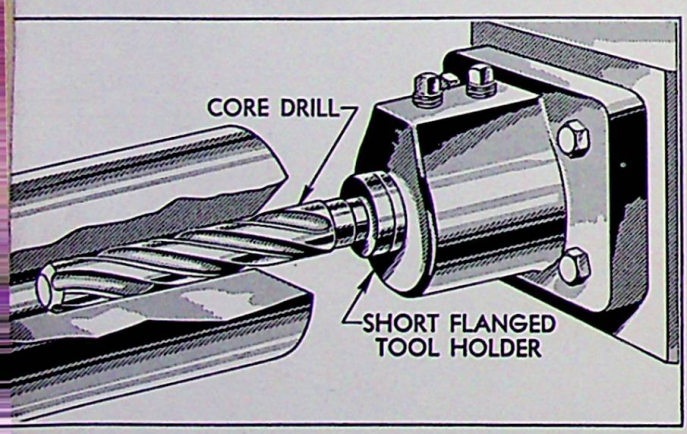
Drilling

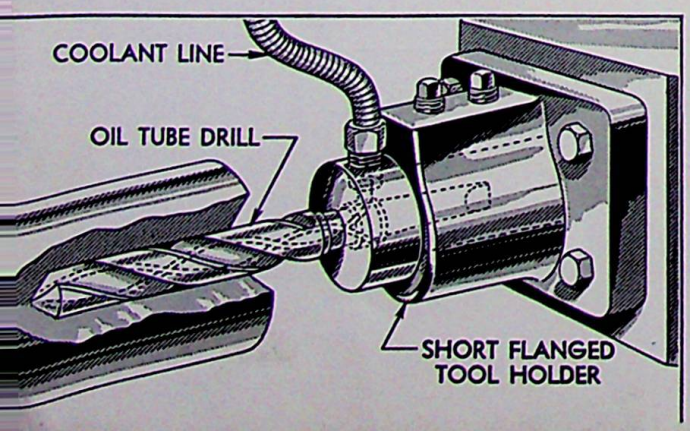
» » » » Drilling Operations Machine Holes in Solid Stock » » » » »











1... Start Drilling

The accuracy of a drilled hole depends upon its start. Rough and uneven surfaces on bar stock, castings, and forgings may cause longer drills to weave at the beginning of drilling operations.

Use a short, rigid, start drill to spot a true cone in the work.

The Combination Stock Stop and Starting Drill is used for start drilling and for positioning the bar stock to length.

2... Drilling

Twist drills, essentially two-bladed cutters, are usually held in Flanged Tool Holders or in Drill and Tool Holders. Keep drills sharp and grind drill lips to correct angles for material being machined.

On extremely large diameter drilling work, two drills are generally used—a smaller drill to pierce the hole, followed by a larger diameter drill to produce the desired size.

3... Core Drilling

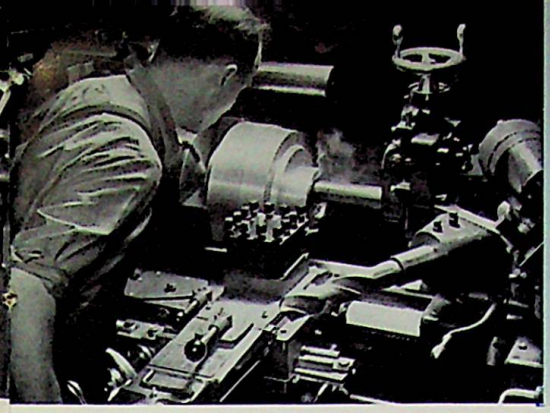
Core drills are three or four fluted cutters used for enlarging cored holes, or previously drilled holes, to larger diameters. As in plain drilling practice, a start drill or start bore is taken first to produce an accurate cone for accurately guiding longer core drills.

4... Deep Hole Drilling

When drilling deep holes, chip removal is a most important factor. To overcome breakage, smaller drills should be withdrawn frequently to allow the chips to escape.

Oil-tube drills, that supply coolant under pressure to the point of the drill, may be used to wash out chips during deep hole drilling operations.

Extremely small diameter holes may be drilled with drill speeders in the hexagon turret set-up. Rotating the drill and the spindle in opposite directions obtains recommended cutting speeds for the drill, and assures more accurate holes when size and straightness must be held to close limits.

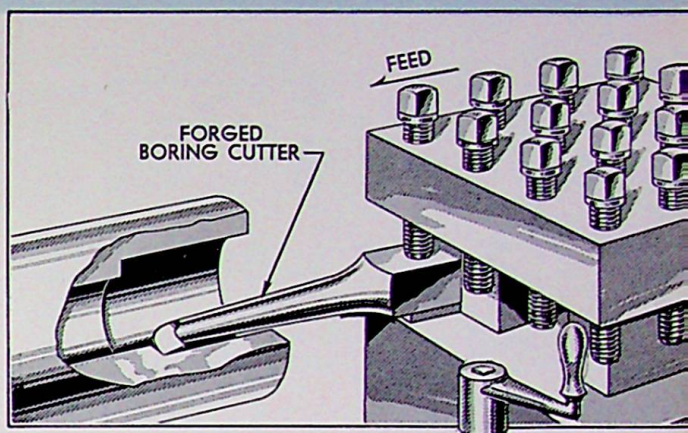


Boring

» » » » Boring Cuts True Up Holes and Produce Accurate Size

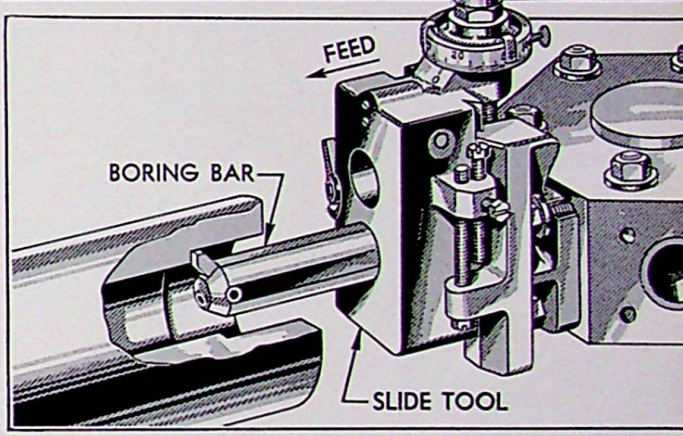
1...Square Turret Boring

Forged boring cutters, held in the square turret, may be used for short boring work. Limited by the rigidity of the forged cutting tool, the square turret method for boring short holes is confined to lower feeds and lighter cuts.



2...Hexagon Turret Boring

Greater rigidity for heavy and more accurate boring is obtained by using Stub Boring Bars held in Vertical Slide Tools. Adjustments for size are made by using the micrometer dial on the Slide Tool. Removable cutter bits in the boring bar enable quick tool regrinding and resetting.

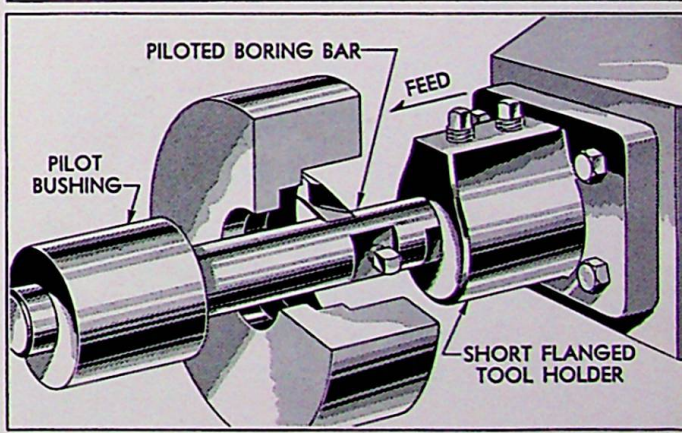


3...Piloted Boring for Heavy Boring Cuts

Heavier boring cuts may be taken when piloted boring bars are used in the tooling set-up. The additional support for the piloted boring bar in the spindle or chuck increases the rigidity of the boring set-up.

4...Single Point Taper Boring

Taper boring cuts may be taken from the square turret, and from the hexagon turret unit when Cross Sliding Hexagon Turret machines are used.



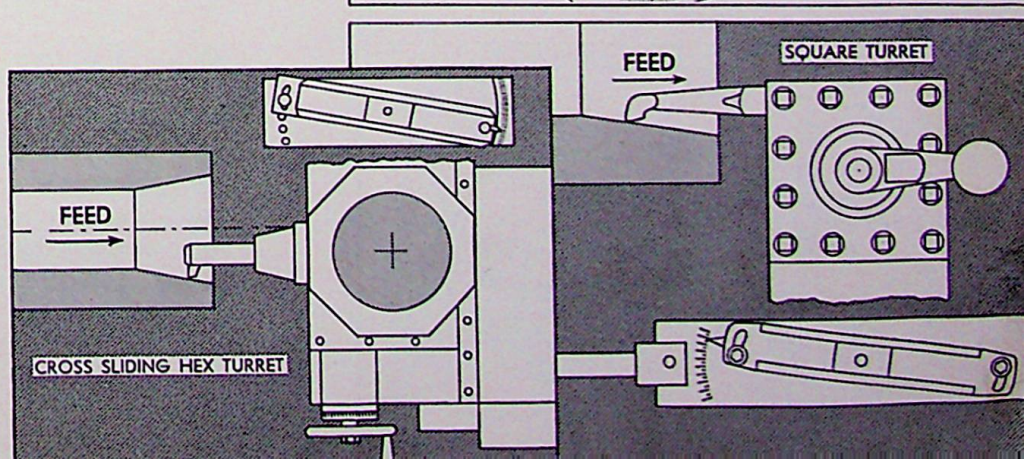
1. Square Turret Taper Boring

Internal taper cuts are taken from the square turret by using the Taper Attachment set to the correct angle.

For accurate taper boring, the cutter should be fed away from the spindle, or in the direction of the greater bore.

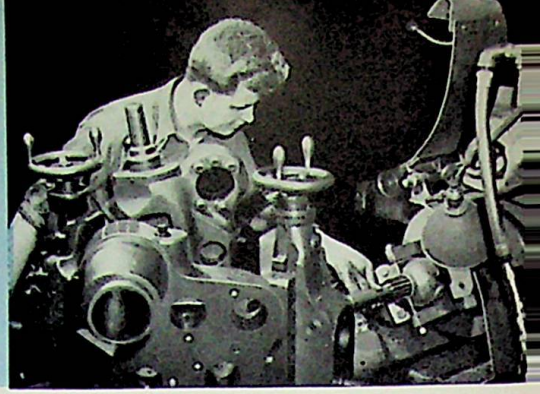
2. Cross Slide Hexagon Turret Taper Boring

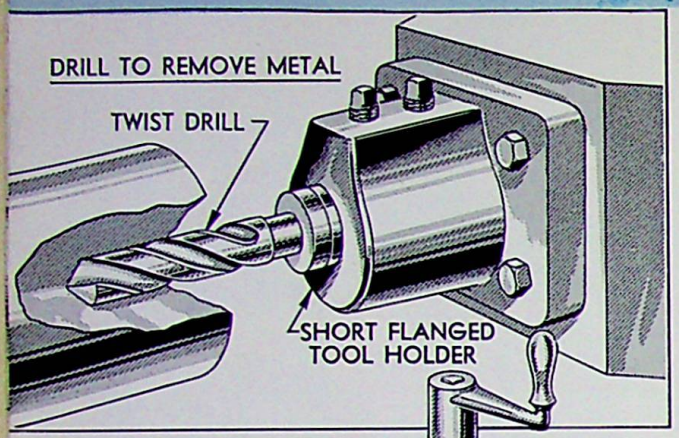
A Cross Sliding Hexagon Turret provides cross as well as longitudinal motion to the hexagon turret. The Taper Attachment is set for the desired angle of taper boring required. The micrometer dial on the hexagon turret cross slide handwheel sets the boring cutter to size.

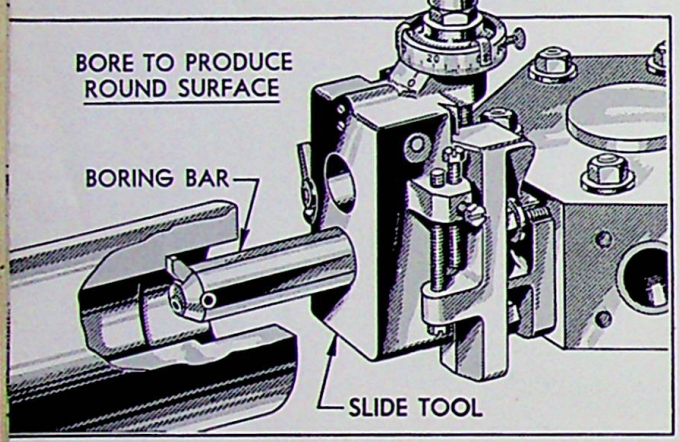


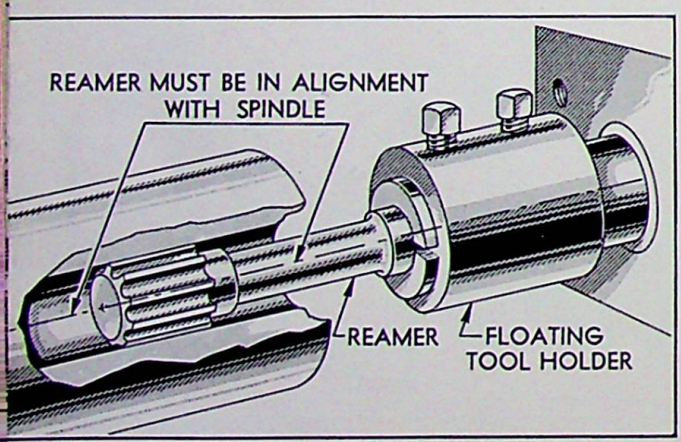
Reaming

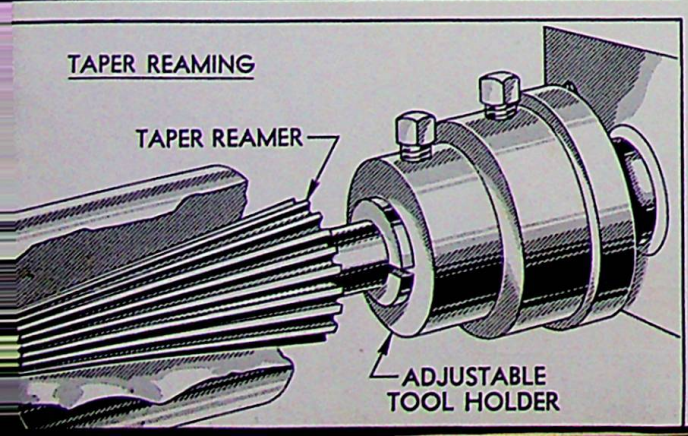
» » » » Reamers Machine Accurate Sizes and Produce Smooth Finishes











1... Drill to Rough Out Metal

A drilling cut is taken first to rough out the bore. Where size, concentricity, and finish are not very important, drilling alone may be sufficient.

Mount drills in drill sockets and Flanged Tool Holders or directly in Drill and Tool holders. Select the correct size of drill. Drills should be as large as possible and yet allow sufficient stock for true boring and for reaming.

2... Bore to Remove Runout and Obtain Roundness

Single point boring cuts are used to true up holes produced in drilling operations.

Concentricity and roundness, held to extremely close limits, may require two or more boring cuts.

When boring prior to reaming, the bore should be left .003" to .005" under reaming size.

For accurate boring prior to reaming, set the boring cutters in a vertical position to insure accurate duplication of size and to avoid chip interference. Obtain size desired with the micrometer dial adjustment on the Vertical Slide Tool.

3... Reaming for Size and Finish

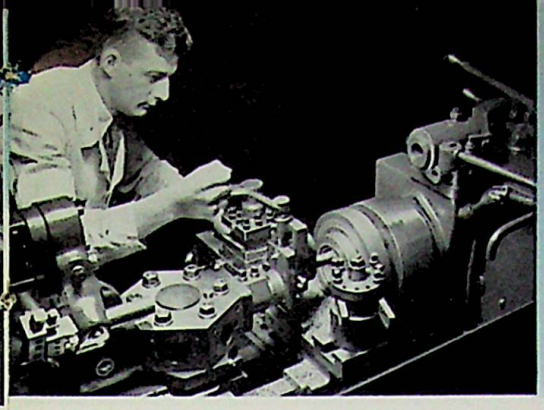
Accurate alignment of reamer and spindle is necessary to obtain straight reamed holes. Adjustable or Floating Tool Holders are used to align reamers.

Reamers may be floated for alignment in Flanged Tool Holders held loosely on the face of the hexagon turret and guided by hand into the previously drilled and bored hole. Extremely coarse feeds are generally used for reaming. Smaller reamers are often fed by hand. Slower cutting speeds should be used when reaming.

For smooth finish and accurate size keep reamers sharp. Use coolants on steel jobs.

4... Taper Reaming

Smaller diameter taper bores are generally finished with taper reamers. On steep tapers, roughing and finishing taper reamers may be required to produce smooth finish and accurate size. To assure more accurate alignment, taper reamers may be held in Floating Tool Holders or in Adjustable Tool Holders.

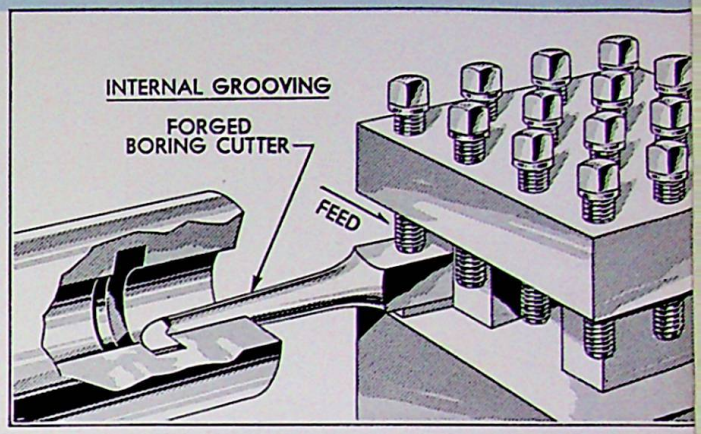


Recessing

» » » » Internal Grooving - - Internal Facing and Back Facing » » » »

1 . . . Square Turret Recessing

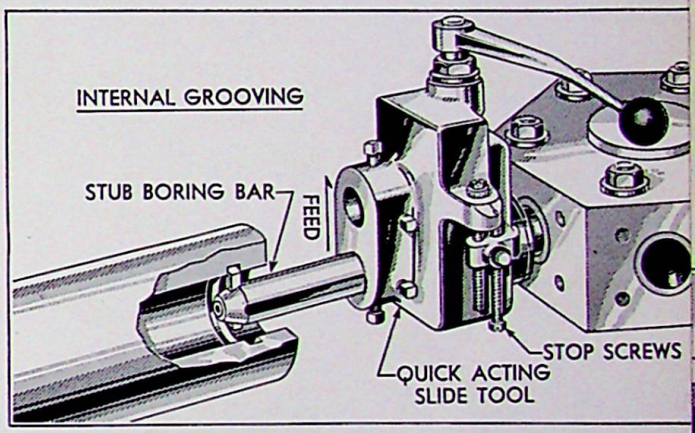
Internal grooves for grinding clearance or thread clearance may be recessed with forged cutters ground to correct shape and held in the Square Turret. Since rigidity is limited by the cross section of the tool and the overhang of the cutter, lighter cuts and hand feeds are used.



2 . . . Hexagon Turret Grooving

The Quick Acting Slide Tool, supporting a boring bar with a recessing cutter ground to shape, allows heavier recessing cuts to be taken. Sensitive feed to the cut is provided through the hand operating lever.

The Hexagon Turret Unit is brought quickly into position. The depth of cut is accurately determined by stop screws on the slide tool.

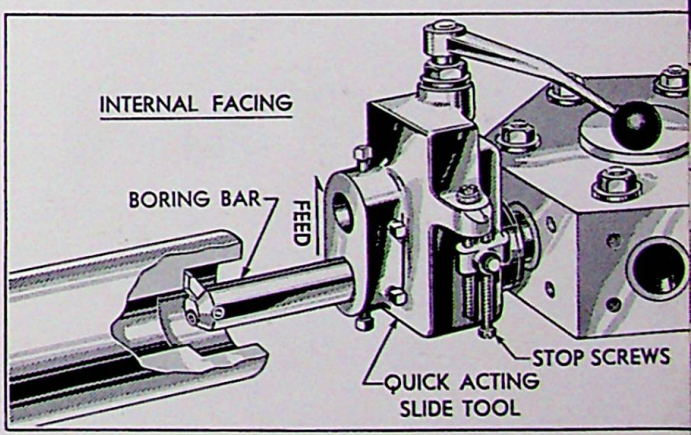


3 . . . Internal Facing

Short internal facing cuts may be taken with a Quick Acting Slide Tool from the Hexagon Turret.

A boring bar, with cutter bit ground as a facing tool, provides the means for machining internal faces and shoulders square with previously bored diameters.

To reduce machine handling time, use Quick Acting Slide Tools for internal facing cuts.

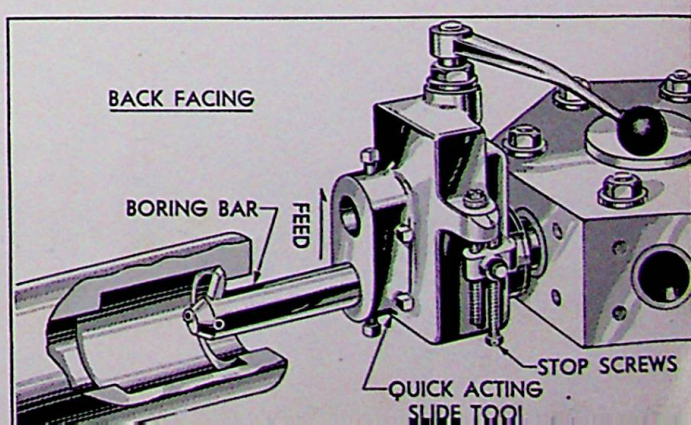


4 . . . Back Facing and Chamfering

The cutter, reversed in an Angle Cutter Stub Boring Bar and held in a Quick Acting Slide Tool, permits short *back facing* operations to be completed from the Hexagon Turret station, eliminating additional chuckings otherwise necessary to complete the job.

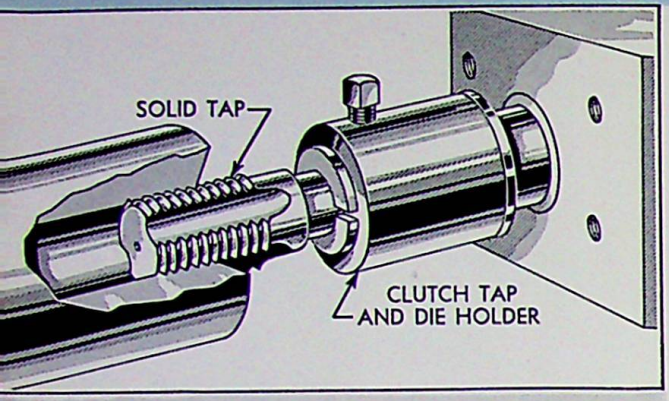
Cutter bits, ground for *inside chamfering and back chamfering* and mounted in Stub Boring Bars, enable accurate chamfering cuts to be taken with Quick Acting Slide Tools.

As a shank type tool, the Quick Acting Slide Tool is quickly adapted to any turret lathe set-up for handling chamfering operations in preference to files or hand scrapers.



Internal Threading

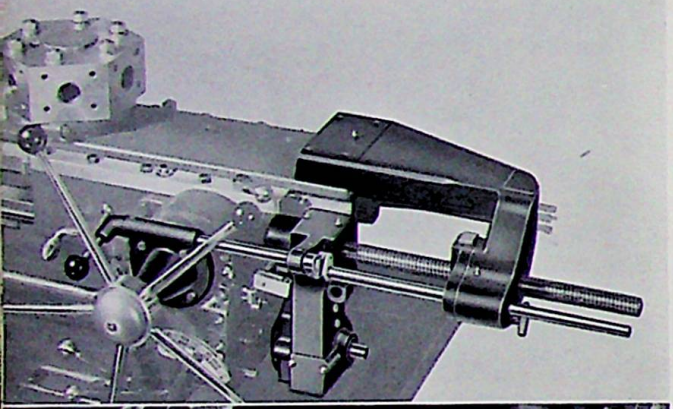
» » » » Cutting Internal Threads from the Square and Hexagon Turrets



1... Tapping

Solid taps, held in the Clutch Tap and Die holders, are most commonly used for cutting small diameter internal threads. By pre-setting hexagon turret stops, the Clutch Tap and Die Holder trips off at any predetermined point, for tapping threads to any desired depth.

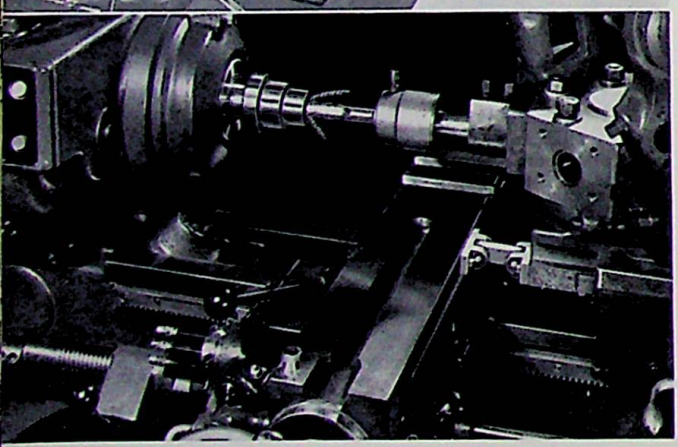
Provision is made in the Clutch Tap and Die Holder for cutting right-hand or left-hand threads with solid taps.



2... Accurate Thread Lead

Accurate thread specifications require positive means for leading on taps during thread cutting. The Leading-on Attachment for the hexagon turret is used to feed the turret slide by means of leaders and half nuts to the correct pitch of thread to be cut. Automatic Knockoff of Lead is provided to maintain accurate depths of tapping cuts to shoulders or blind holes.

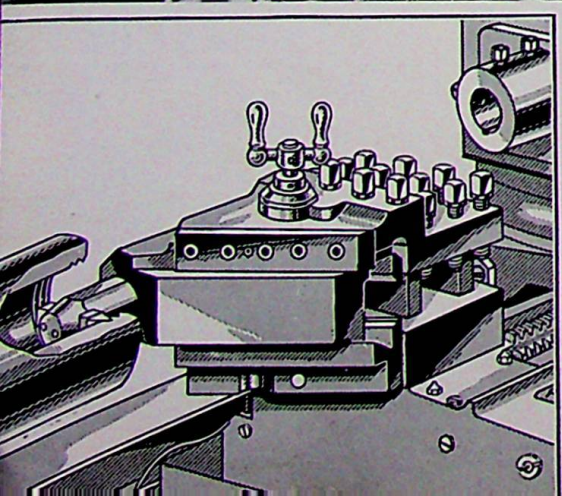
Leading-on taps from the Hexagon Turret on ram type turret lathes may also be done by linking the Hexagon Turret slide to the Cross Slide. The Cross Slide in turn is led on with a Leader and Follower Thread Chasing Attachment for the thread chasing operation.



3... Single Point Threading

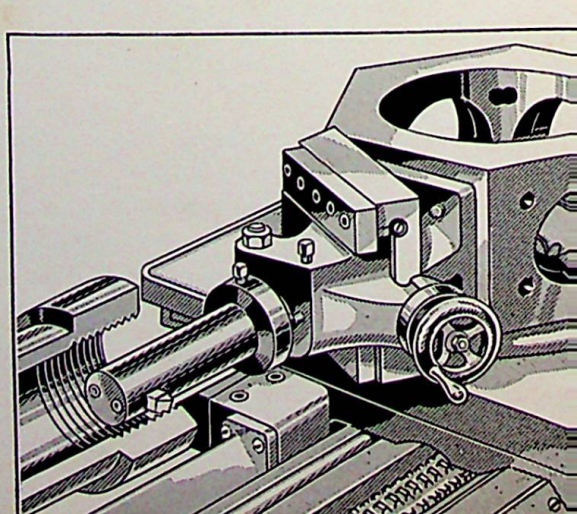
Where thread concentricity must be maintained with other machined diameters, single point threading may be used. The threading cutter is held in an Adjustable Threading Tool Holder and is fed into the work at the angle of 29° commonly used in single point threading practice.

A Leader and Follower or Lead-Screw Attachment leads the Cross Slide or the Hexagon Turret at the desired pitch to be cut.



Internal Single Point Threading with Square Turret Adjustable Threading Tool Holder.

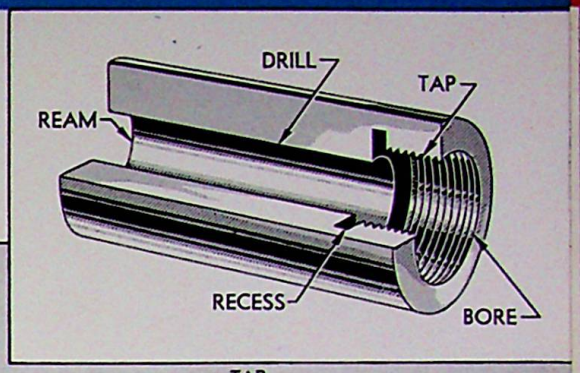
Internal Single Point Threading with Hexagon Turret Adjustable Threading Tool Holder.

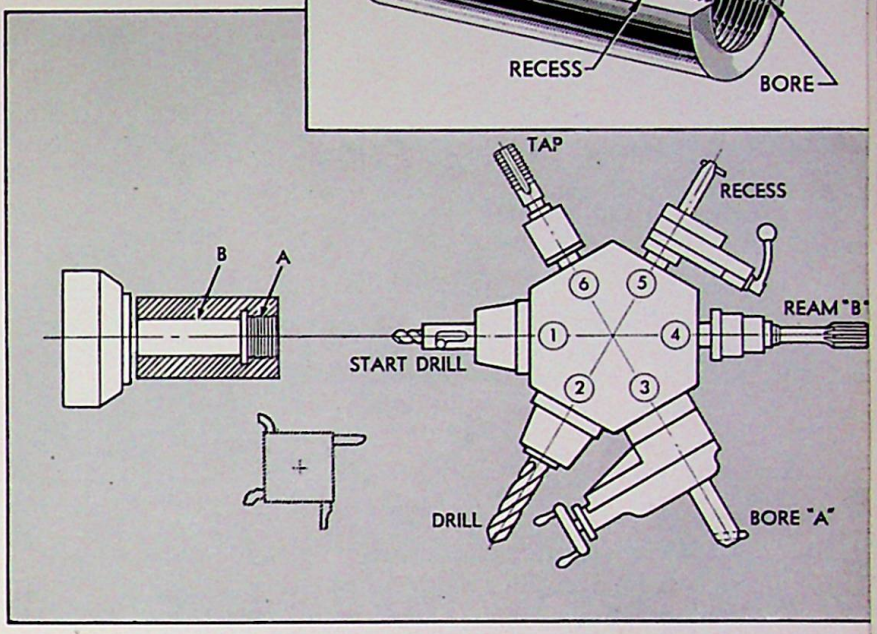


COMBINED INTERNAL OPERATIONS

INTERNAL operations should be combined in proper succession because the performance of each basic machining operation depends upon the form and accuracy produced by a previous cut. As an example, the operations of start drilling, drilling, boring, reaming, recessing, and tapping should be taken in proper order for machining the Threaded Adapter shown.

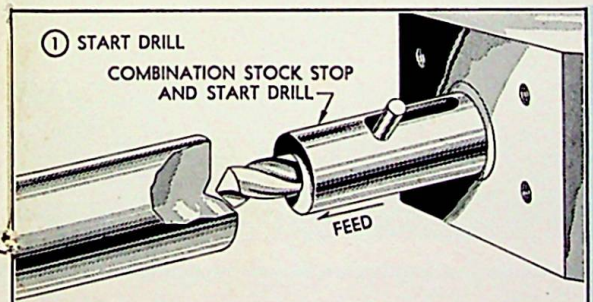
In most instances, specifications required on internal work are for standard sizes of bores and threads. As a result, standard drills, reamers, and taps can be incorporated quickly into the hexagon turret set-up. When odd size bores or threads are required, special drills, reamers or taps may be necessary or the internal work may be completed by single-point boring cuts and single-point threading operations.

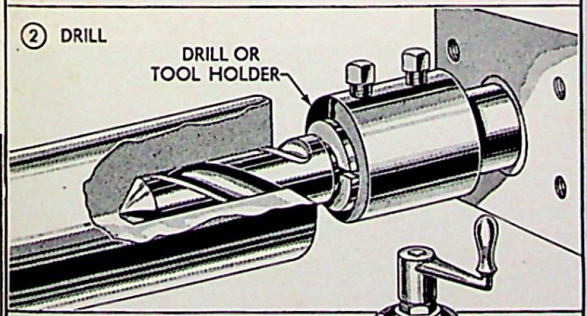


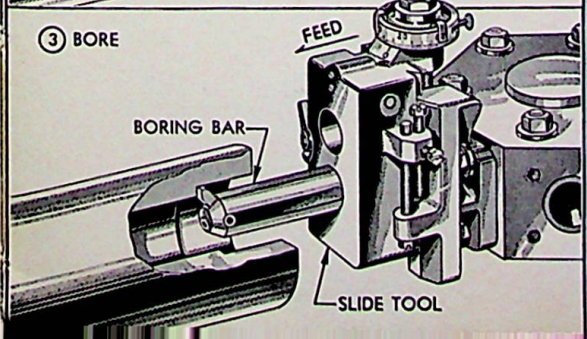


Basic Hexagon Turret set-up illustrating the correct sequence of internal operations to handle required internal machining cuts.

SET-UP FOR MACHINING INTERNAL OPERATIONS ON THREADED ADAPTER







The following illustrations show the details of the basic internal cuts required to machine the Threaded Adapter.

1. Start drill the work piece with a short stud drill or with a Combination Stock Stop and Start Drill.

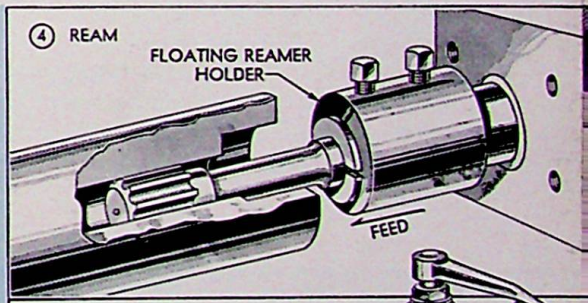
2. Drill hole through Solid Stock.

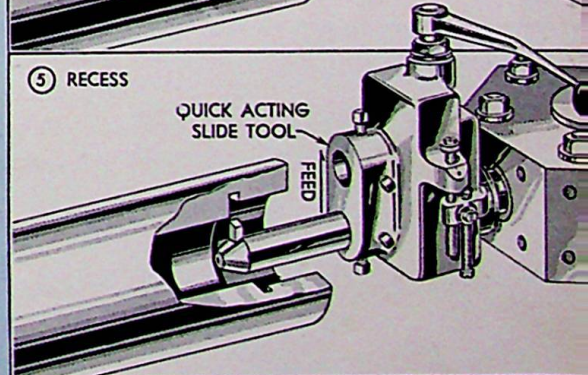
3. Bore the thread diameter to correct size for threads specified. *A Stub Boring Bar in a Slide Tool is used.*

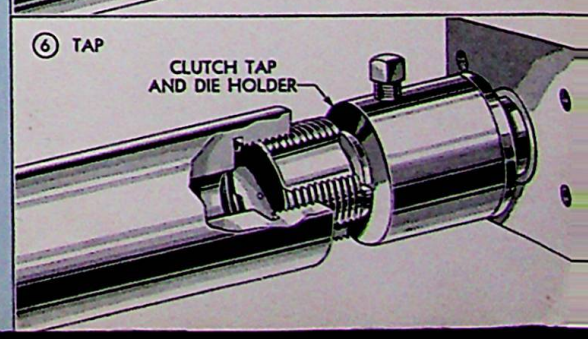
4. Ream hole to size. *Support reamer in an Adjustable Tool Holder or in a Floating Tool Holder.*

5. Recess groove for thread clearance. *Use the Quick Acting Slide Tool with a recessing cutter in a boring bar.*

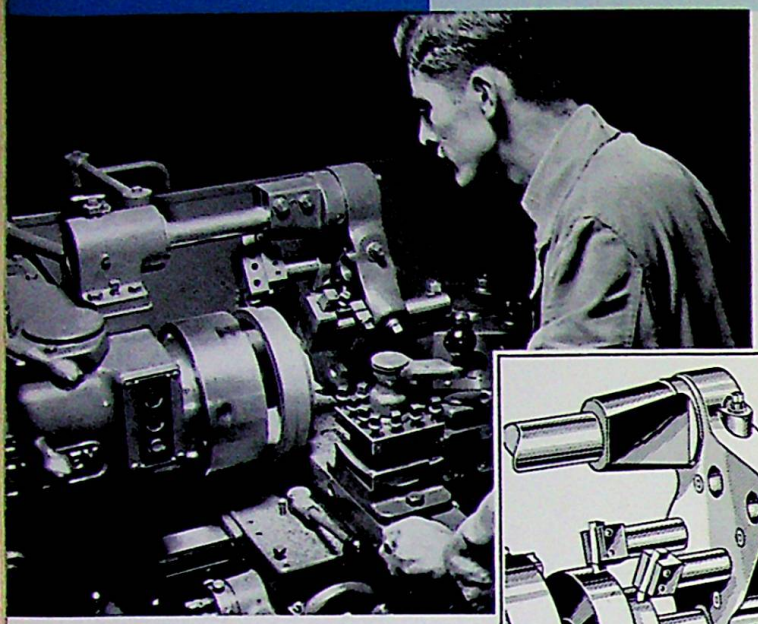
6. Cut thread with a tap held in a Clutch Tap and Die Holder. *For odd size threads, single point the thread from the square turret or hexagon turret.*







Turning



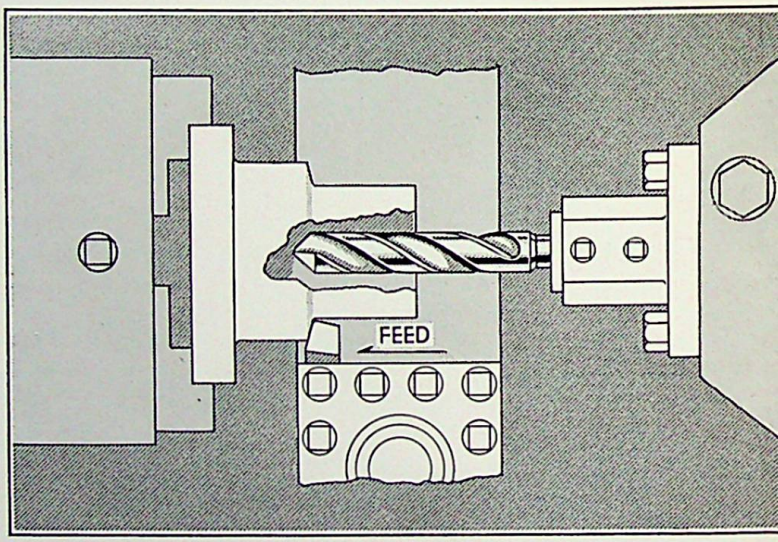
CHUCKING WORK

Turning, facing, grooving, forming, threading, and cut-off operations are the basic external machining cuts taken with turret lathes. The sequence in which external operations are done depends largely upon the shape of the work piece, the material, the accuracies required, and the number of pieces to be machined in the lot.

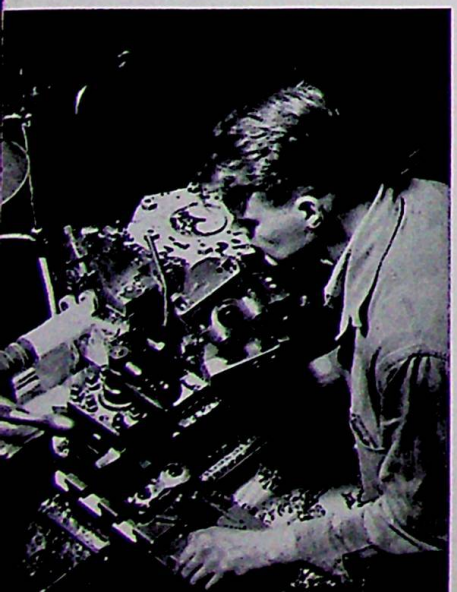
Overhead Turning—Multiple Turning Heads and Single Adjustable Turning Heads mounted on the hexagon turret are set up with one or more cutters for overhead turning. Turning cuts taken from the hexagon turret assure closer tolerances in the finished size and allow the square turret to be used for facing cuts.

Side Turning operations may be done with cutters held in the square turret. When combining machine operations, turning cuts from the square turret can be performed at the same time drilling or boring work is being done from the hexagon turret station.

To duplicate accurate sizes when side turning with the cross slide, the square turret should be indexed consistently in one direction during any one job. When setting the cross slide for turning cuts, remove all backlash between the cross slide screw and the cross slide nut and then bind the cross slide screw firmly.

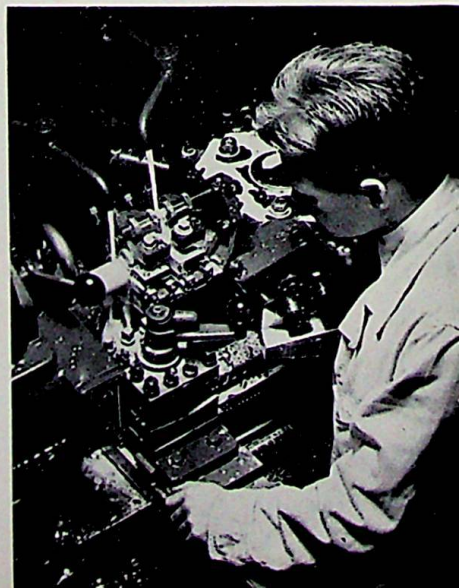


BAR WORK



Small Quantity Lots—Long bar work that overhangs the Collet Chuck is turned with Single Cutter Bar Turners from the hexagon turret. Roller rests on the bar turner support the bar stock against the cutter and heavier cuts can be taken at greater machining speeds. During the turning operation, the rolls burnish the turned diameter to a smooth finish.

Large Quantity Lots—The Multiple Cutter Turner is used where two or more diameters are to be machined and where a larger number of pieces is to be produced with each turret lathe set-up.



Facing

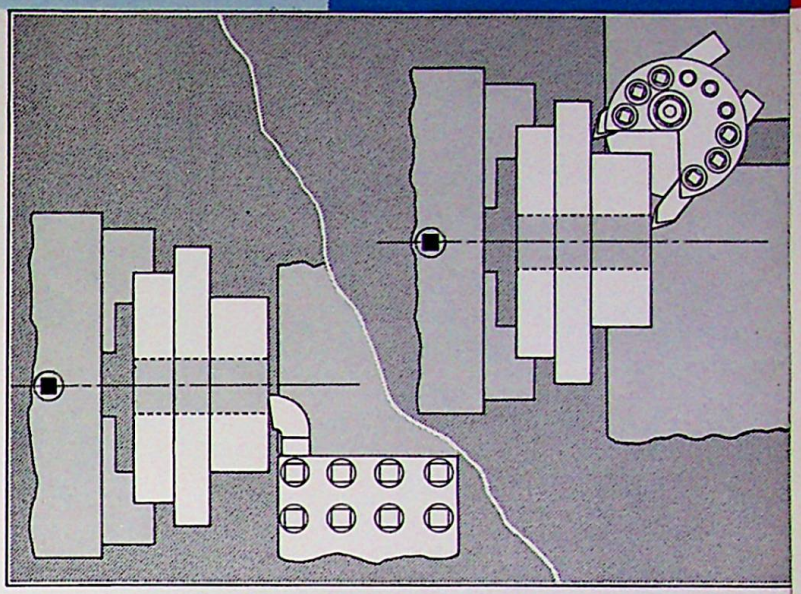
CHUCKING WORK

Cross Slide Facing

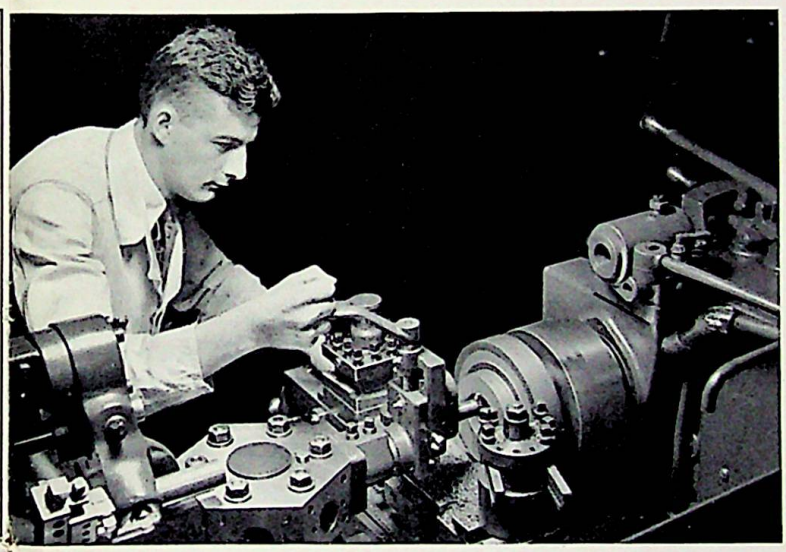
To produce flat surfaces at right angles to turned diameters, a forged facing cutter, held in the Square Turret or in a Rear Tool Post, is fed by means of the Cross Slide.

Most facing work on turret lathes is done with single point cutters from the Cross Slide unit. Wherever possible, the cross feed cuts are taken at the same time the Hexagon Turret cutting operations, like drilling, boring and turning are being performed.

Two or more surfaces may be faced at one time by mounting multiple cutters (two or more) in an Open Type Square Turret or in a Two Cutter Rear Facing Block to handle both facing operations at one pass of the cross slide.



The Cross Slide, used for longer facing operations, is fed by power to or from the spindle for smoother finish.



Hexagon Turret Facing

Short facing cuts may be taken also from the Hexagon Turret by using the Quick Acting Slide Tool. The cutter is fed at right angles to the spindle by the hand operating lever.

The Quick Acting Slide Tool is preferable for handling short facing cuts since it is generally easier and quicker to bring the Hexagon Turret into position for short facing cuts than to use the Cross Slide.

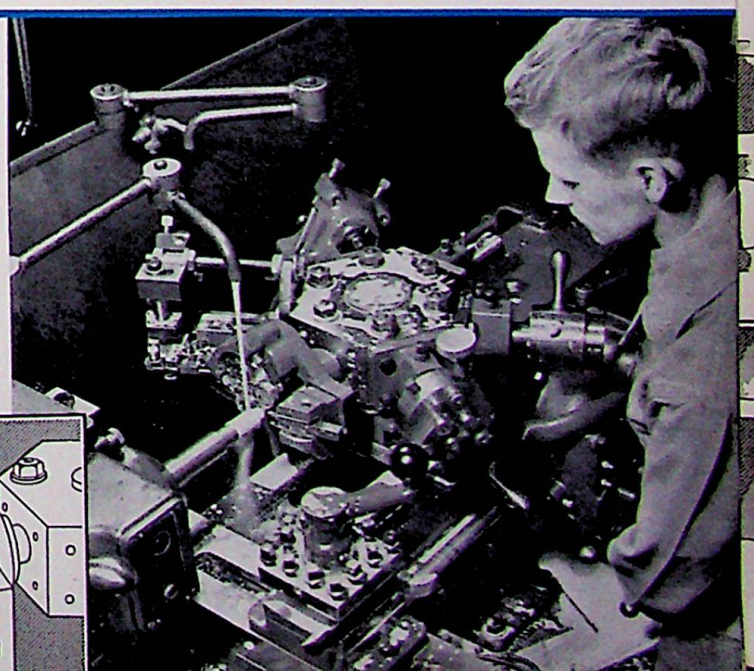
Stop screws on the Quick Acting Slide Tool limit the travel of the cutter to any set point.

BAR WORK

End Facing Bar Work

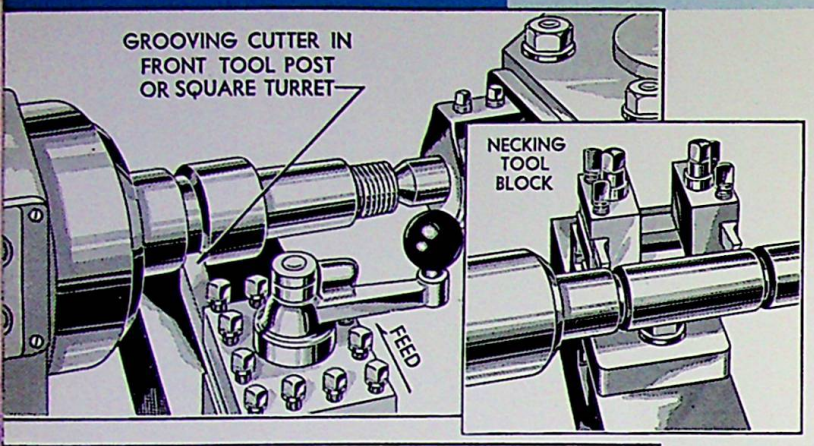
Longer bar work is faced with the Combination End Facer and Turner. Roller rests, provided with this tool, support the work against the cutter, avoiding spring and chatter.

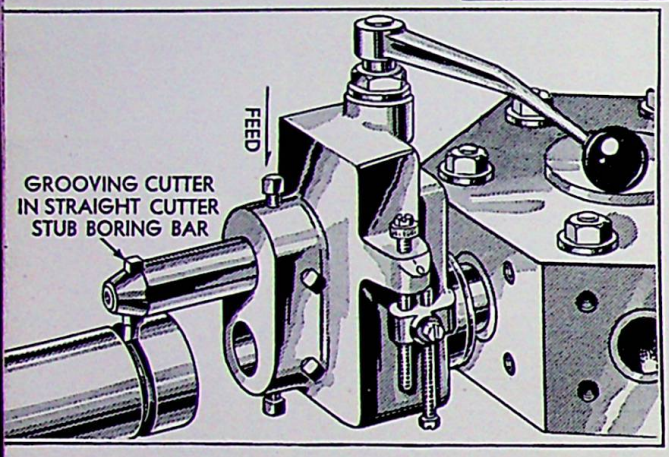
The cutter is ground and set to the desired form to be faced. The tool in the hexagon turret is fed by hand. Slower cutting speeds and coolants are generally required for smooth finishes when facing the end of bars.

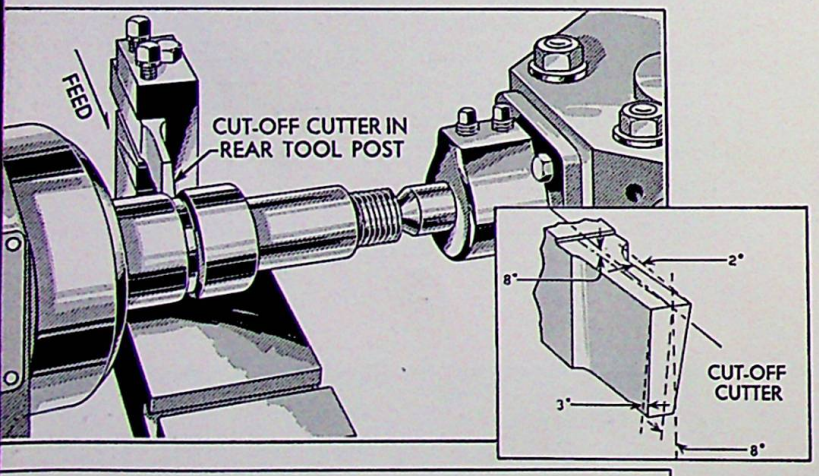


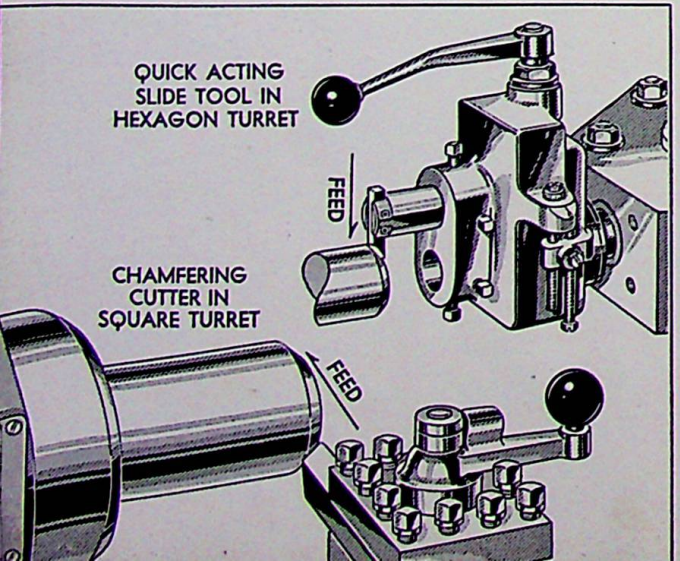
Roller rests set ahead of cutter for end facing bar work.

Grooving









Square Turret Grooving

External grooving and cut-off work are generally done with forged cutters held in the Square Turret, or in Cutter Blocks on the Cross Slide. Single grooving cuts are taken from the Square Turret. For multiple grooving, several grooving or necking cutters are mounted in an Open Type Square Turret or in a Necking Tool Block.

For most grooving work, the bar stock is supported on a center in the hexagon turret or against roller rests of bar tools. Work springing away from the cutter, causing chatter and poor finish, is thus avoided.

Hexagon Turret Grooving

Short grooving cuts are taken also from the Hexagon Turret with the Quick Acting Slide Tool. A grooving cutter bit, held in the boring bar, is fed rapidly into the work by means of the hand operating lever. The stop screws limit the travel of the cutter to the correct groove depth.

Cut-off

Cut-off work is done with forged parting tools held in the Square Turret, or in a Cross Slide Tool Post. Since the rigidity of cut-off tools is limited by the width of the cutter, the correct grinding and setting of the cutter is important. Use correct angles of rake and clearance and support cut-off cutters firmly in cutter blocks.

Cut-off Cutters may be provided with chamfers to bevel the edge of the bar stock after the work has been parted to provide a starting surface for bar turners on the next piece.

Chamfering

Chamfering cuts are usually taken from the Square Turret. A cutter, ground with the correct angle of chamfer, machines the desired bevel on the work piece.

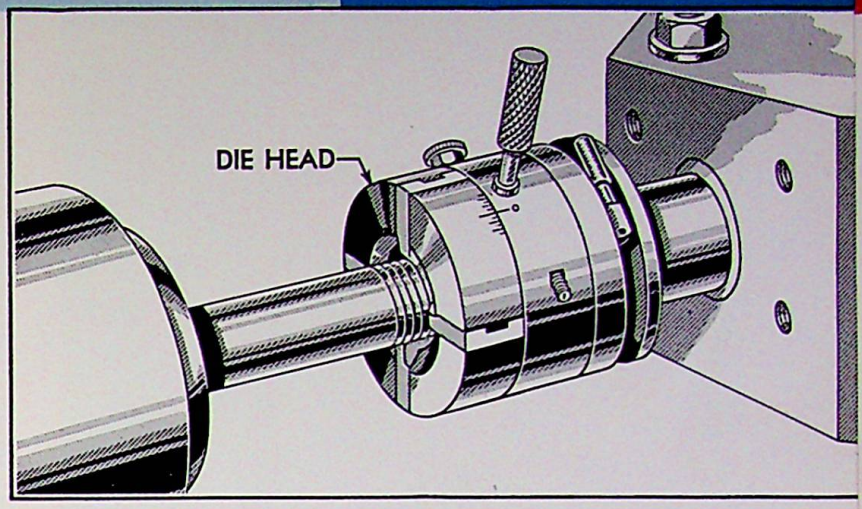
Short chamfering cuts may be machined with Quick Acting Slide Tools from the Hexagon Turret. Using the Hexagon Turret for such chamfering requires less machine handling time to bring the chamfering cutter into position.

Threading

Almost every type of external thread can be produced on a turret lathe. Several methods may be used for machining threads, depending upon the type of thread to be produced and the tolerances that must be maintained.

Die Heads

Die Heads are commonly used for machining standard threads. Chasers of the proper size and pitch are held in Die Heads for cutting threads. Most Die Heads spring open and release automatically when the desired length of thread has been machined.

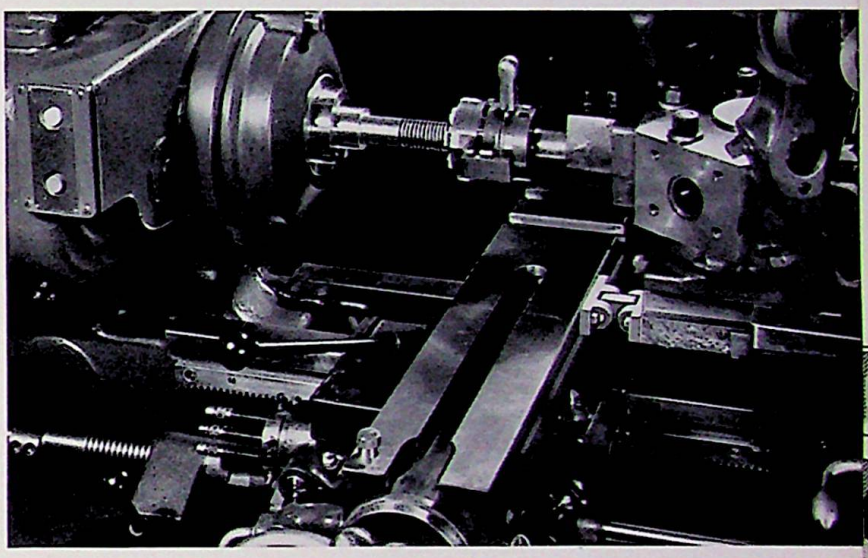


Accurate Threading with Die Heads

For general purpose threading Die Heads are led on by hand. For highly accurate lead the Die Head is led on more positively with Leader and Follower Thread Chasing Attachments.

On Ram Type machines, the Hexagon Turret may be led forward by means of a link connecting the turret slide with the Square Turret unit. Accurate threading with Ram Type turret lathes is also done with Leading-on-Attachments built directly into the turret slide and saddle units.

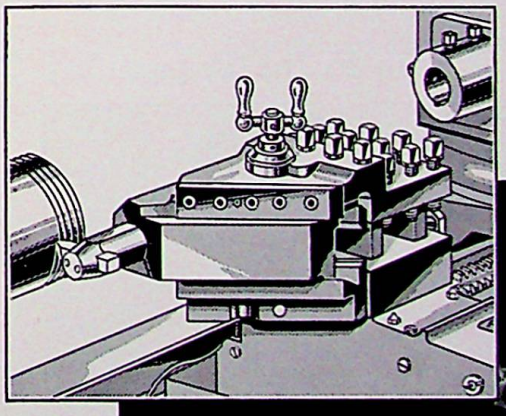
On Saddle Type machines, the hexagon turret is led on directly with Leader and Follower Thread Chasing Attachments.



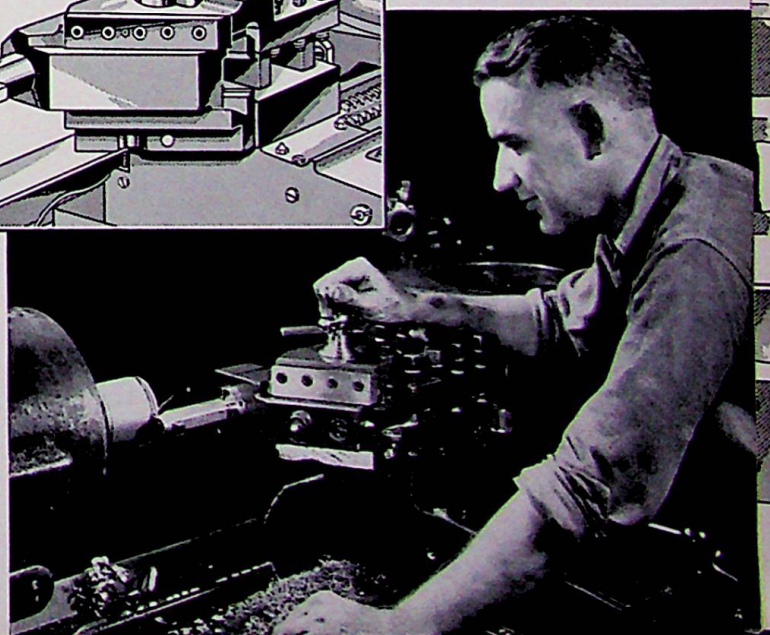
Single Point Threading

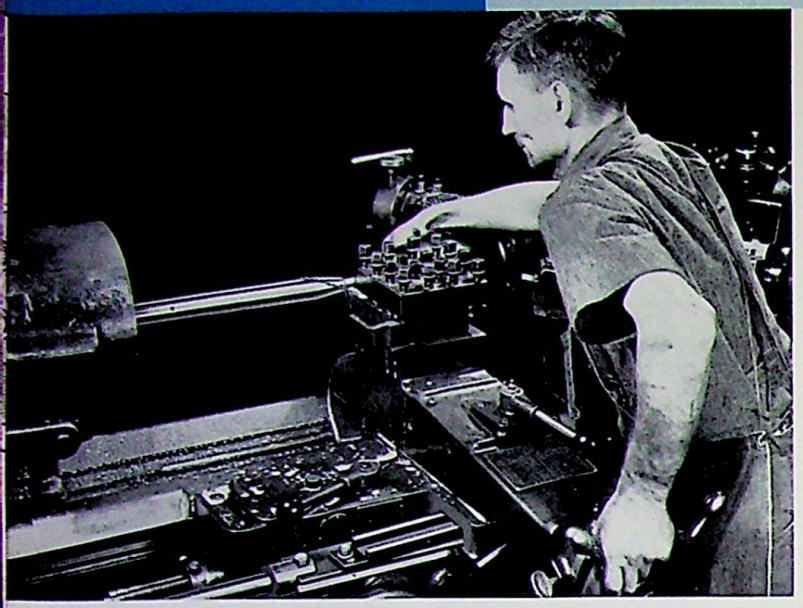
Where true round threads must be produced, and where concentricity must be maintained between thread diameters and previously turned or bored surfaces, or where unusual thread specifications are encountered, the lathe method of single point threading can be followed on turret lathes.

A Leader and Follower Chasing Attachment is set up on the Cross Slide Carriage to lead on the Square Turret at the desired rate for each revolution of the Spindle. A threading tool, held in a Square Turret Adjustable Threading Tool Holder, feeds the cutter at a 29 degree angle for thread cutting. For thread finishing, the Square Turret is fed at 90 degrees to the spindle for the final pass with the V-shape cutter.



Single pointing external threads with the Square Turret Adjustable Threading Tool Holder.





Single Point Taper Turning

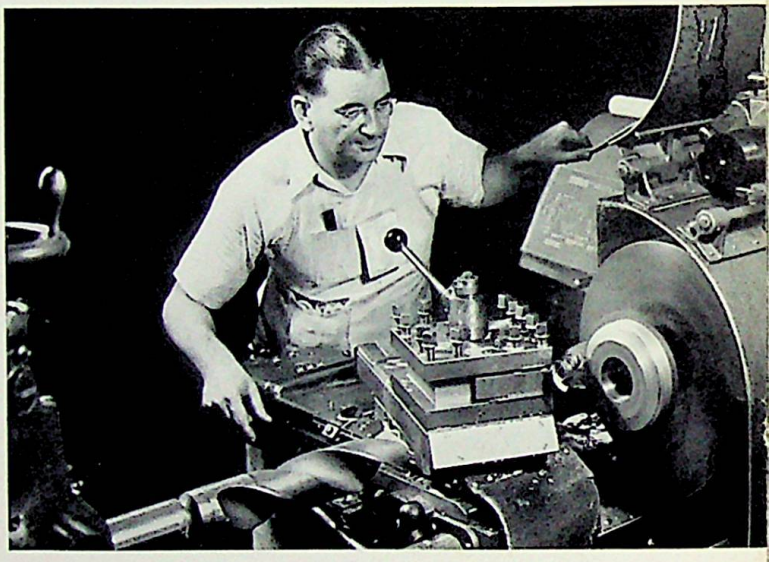
The Cross Slide of a Universal Turret Lathe may be provided with a Taper Attachment for taper work. The Guide Plate of the Taper Attachment, set to the desired angle of taper to be cut, controls the travel of the cutter to generate the taper on the work piece. Feeding the cutter in the direction of the smaller diameter of taper, results in better finish and closer tolerances.

For accurate taper turning work, begin the taper cut well in advance of the starting position of the tool on the work to remove all clearance between the taper attachment guide parts.

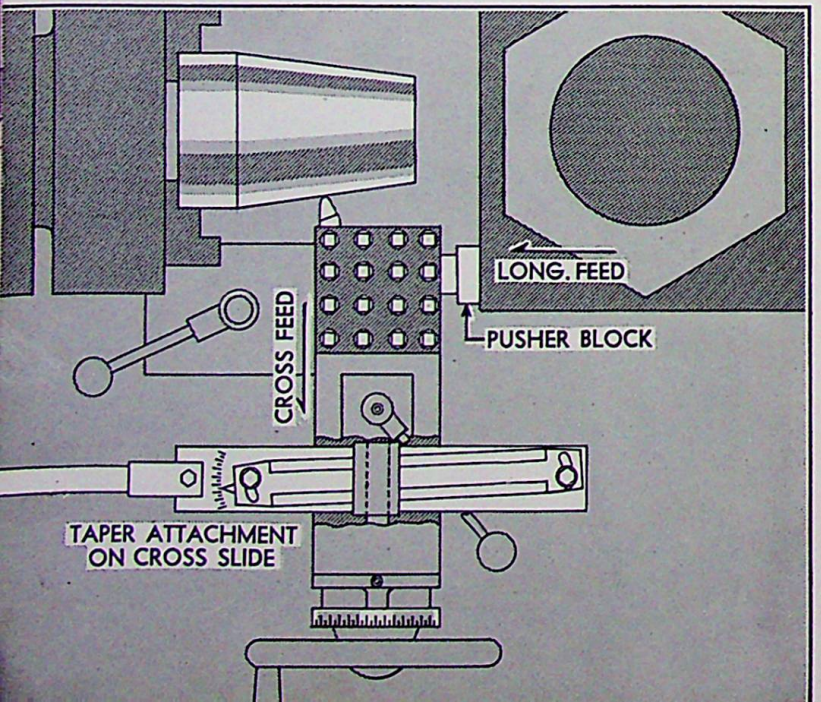
Taper Facing

Tapered surfaces beyond the angle that can be cut with standard Taper Attachments, may be machined with Compound Cross Slides that can be swiveled to any desired angle. Both Power Feed and Hand Feed compounds may be provided on machines where considerable steep taper facing and taper turning work is required.

Compounds on turret lathes are used also for standard thread cutting by setting the compound slide at 29° for roughing the threads.



Single Point Tapers by Combined Feed Method



Machining steep tapered surfaces may be done by combining the Square Turret Cross Feeds with the Hexagon Turret Longitudinal Feeds. By means of a Block, a Hexagon Turret Unit moves the Square Turret forward as the Cross Slide itself is fed by power at right angles to the spindle.

Selecting a combination of Hexagon Turret Longitudinal and Cross Slide Cross Feeds enables the operator to rough out any taper.

The Taper Attachment can be set to compensate for any difference between the angle formed by combining the feeds and the desired angle to be cut, allowing the operator to obtain more accurate tapered surfaces. A table on page 63 shows the approximate angles that can be cut by combining feeds.

Taper Turning

Cross Slide Taper Forming

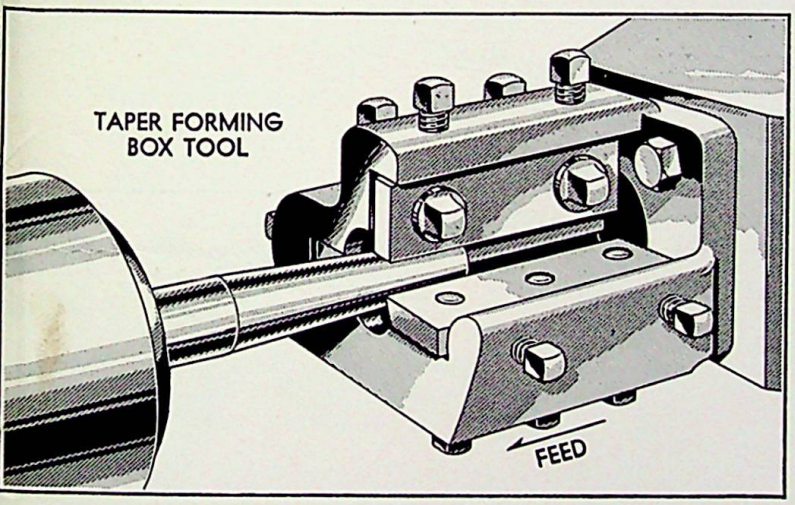
A cutter ground flat across the front and held in the Square Turret can be fed at right angles to the spindle to form short tapered surfaces.

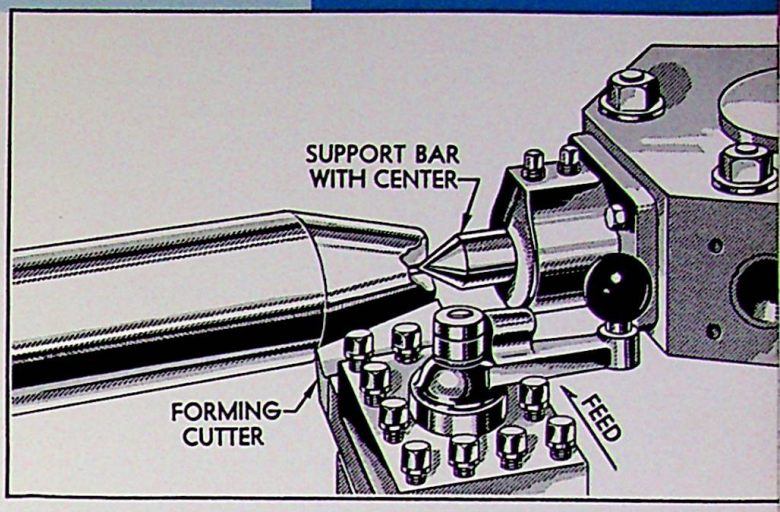
Since greater quantities of metal are removed at each revolution of the spindle on forming cuts, smoother finishes can be obtained when slower cutting speeds and feeds are used.

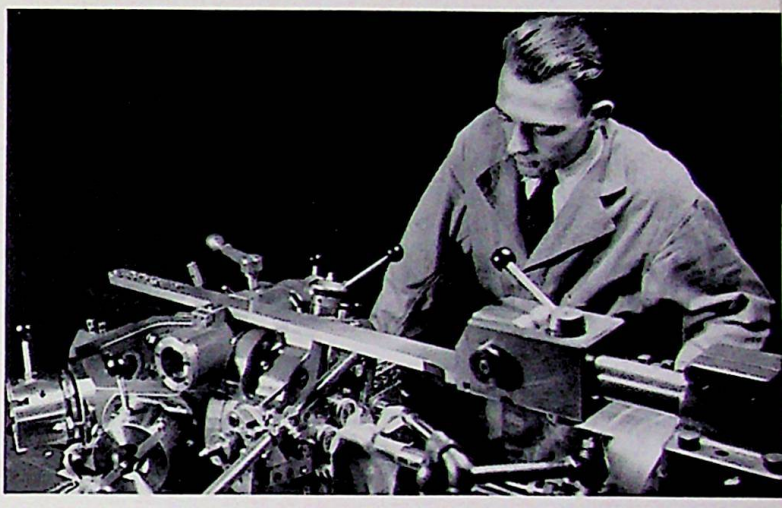
Chucking work generally has sufficient rigidity within the work piece to withstand most forming cuts. Bar jobs, on the other hand, must usually be supported with a center from the Hexagon Turret for taper forming work. Where extremely accurate tapers must be maintained with regard to straightness and size, the single point taper turning method should be used.

Hexagon Turret Taper Forming

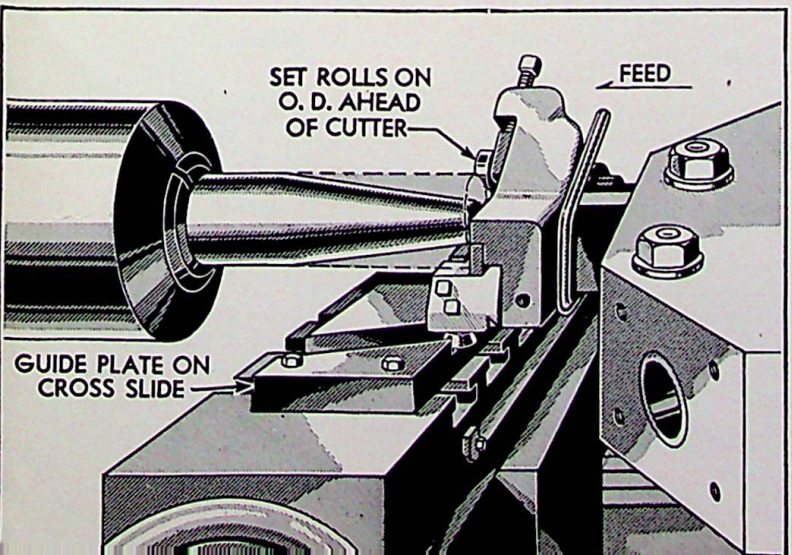
Short tapered pins can be formed with Hexagon Turret Taper Forming Box Tools. Solid "Vee" rests within the Taper Forming Box Tool support the work firmly against the cutter.







Taper turners with roller back rests are used where considerable taper turning work is done on bar stock. These turners are equipped with a cam arrangement that controls the motion of the rolls and cutter as the cut progresses, generating tapered surfaces directly from solid bar stock.



Single Cutter Bar Turners can be arranged to machine short tapered surfaces. The Cutter Adjustment Screw is replaced by a Spring. A Guide Roll is assembled to the Cutter Slide Block. A guide plate with a groove machined to the angle to be cut is mounted on the cross slide in place of the square turret.

With roller rest set ahead of the cutter and to bear against the outside diameter of the bar stock, the longitudinal feed of the Hexagon Turret is engaged. As the cut progresses, the guide on the Cross Slide controls the movement of the cutter, duplicating the taper of the guide onto the work piece.

COMBINED EXTERNAL OPERATIONS

The combined basic external machining operations shown in the example, illustrate how hexagon and square turret tooling may be arranged for the machining of a Threaded Shaft.

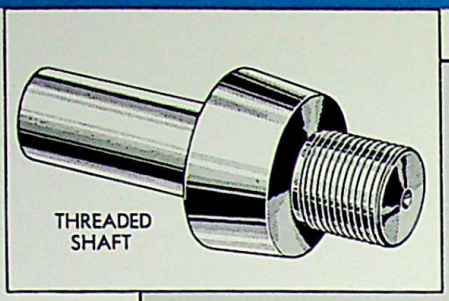
Since the work is to be done from bar stock, roller rest type bar tools are selected.

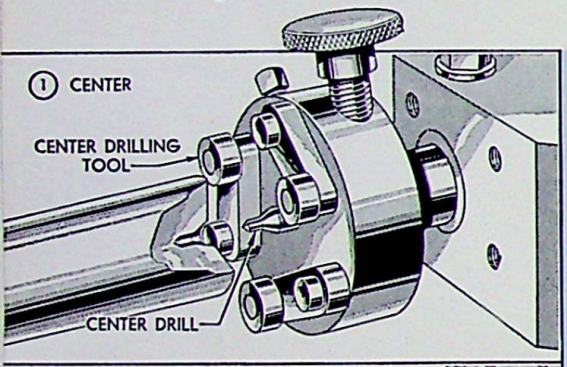
A Combination Stock Stop and Center in the hexagon turret positions the bar stock to correct length as the bar is fed through the Collet.

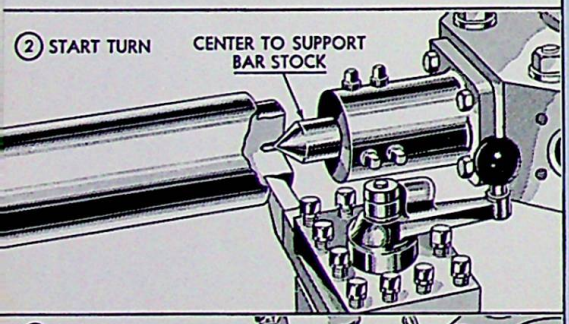
On small lot work, the Single Cutter Turner is used to machine the thread diameter. The outside diameter (later taper turned) is roughed out with the Multiple Cutter Turner set up with one turning cutter only.

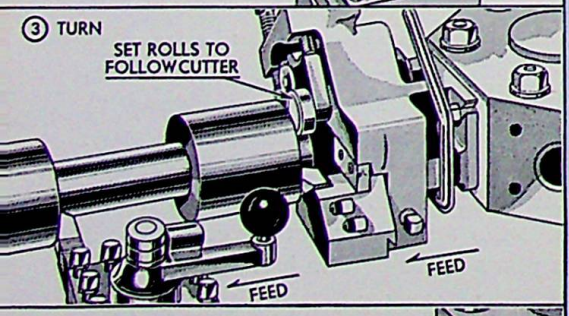
On larger quantity lots, the Multiple Cutter Turner is set to turn both the thread diameter and outside diameter with one pass of the tool.

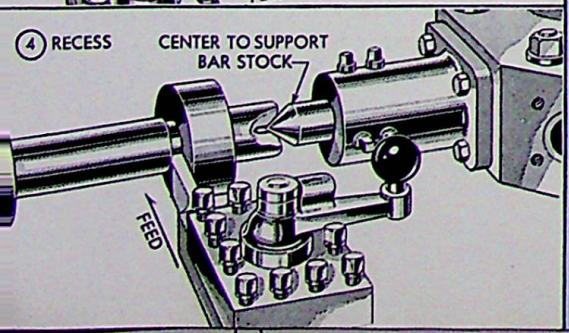
The following sequence is used for machining the external operations on the Threaded Shaft.











SEQUENCE OF OPERATIONS FOR MACHINING THREADED SHAFT

1. Center—Center the bar stock with the Center Drilling Tool. The roller rests support the end of the bar as the center drilling cut is taken.

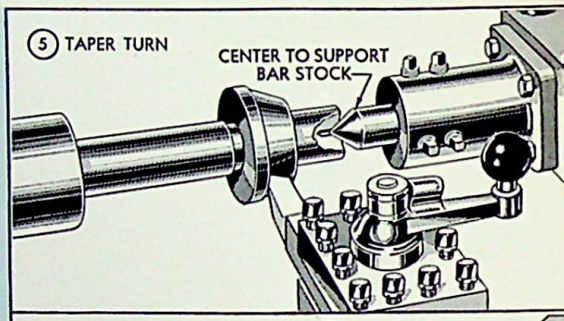
2. Start Turn—Start turn the work piece with the bar stock supported in the Center to provide a true round diameter on which to begin the turning cuts with the bar turner.

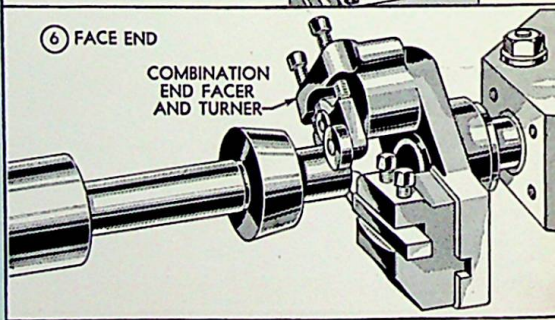
3. Turn—Turn the thread diameter with the Single Cutter Bar Turner. At the same time the shaft diameter is undercut with a tool in the square turret.

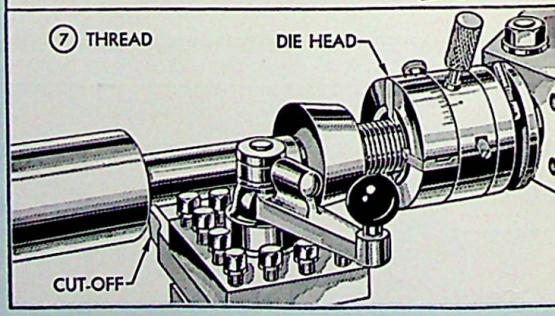
4. Recess Grooves. With the end of the bar supported from the hexagon turret station, a forged cutter in the square turret machines the grooves.

5. Taper Turn—With the work piece supported in a Center from the hexagon turret, the taper turning cut is machined with the cross slide. The taper attachment on the cross slide is set at the angle of taper required.

6. End Facing—The end of the bar is faced to length and chamfered for the threading operation. The roller rests of the Combination End Facer and Turner are set to bear against the thread diameter for supporting the work firmly against the cutter.







7. Threading. A Die Head, with Chasers having the correct specifications for the thread to be cut is led onto the work. After threading, the sharp corners of the work piece may be burred with a file.
The completed job is cut off with a parting tool in the Square Turret or Rear Tool Post.

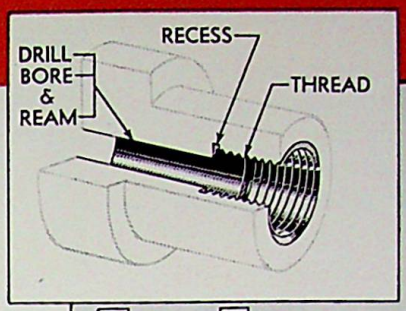
HOW TO COMBINE INTERNAL AND EXTERNAL OPERATIONS

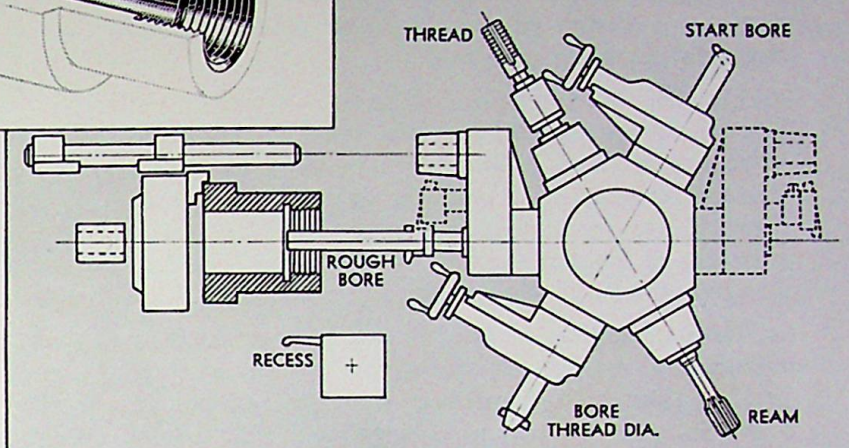
ANALYZE BASIC INTERNAL OPERATIONS

Use the minimum number of tools to obtain the accuracies and tolerances required on internal diameters. Set the internal tools—boring bars, taps and reamers—in the Multiple Turning Heads, Adjustable Single Turning Heads, Vertical Slide Tools and Flanged Tool Holders.

Set the Hexagon Turret Stops to disengage the Power Feeds at the proper points. After set-up adjustments are completed, tighten all cutters and tool holding screws securely.

For drilling, boring, and reaming—select a drill that will allow $\frac{1}{16}$" on the diameter for a true concentric boring cut and bore the hole .004" undersize for reaming to size and finish.



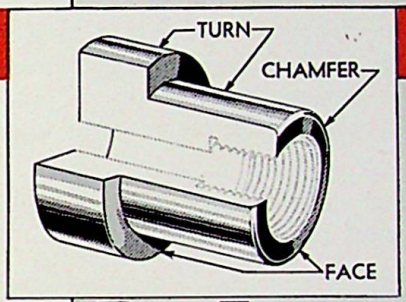


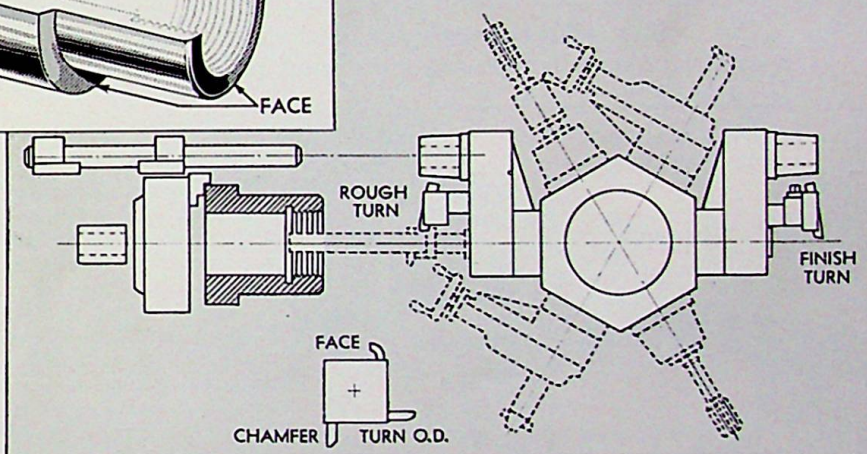
ANALYZE BASIC EXTERNAL OPERATIONS

Position the overhead turning cutters in the Multiple Turning Heads or Adjustable Single Turning Heads on the hexagon turret, to turn the outside diameters while the boring cuts are taken.

Set up the square turret tools for facing and turning cuts and other supplementary square turret operations like chamfering and grooving. Adjust the cross slide carriage stops to knock off the power longitudinal and power cross feeds and to position the square turret station accurately for all cuts.

Outside rough turning cuts are set up in Plain Angle Cutter Holders. On finish turning cuts, Reversible Straight and Angle Cutter Holders are used.



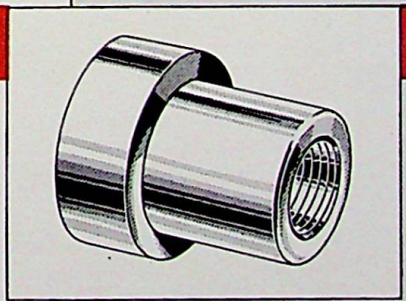


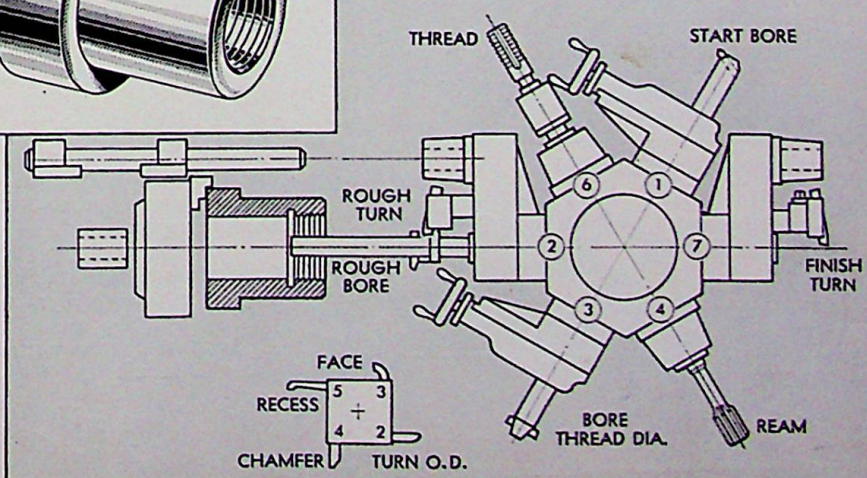
COMBINE SQUARE & HEXAGON TURRET CUTS

To use the turret lathe to its fullest advantage, square and hexagon turret cuts should be combined wherever possible.

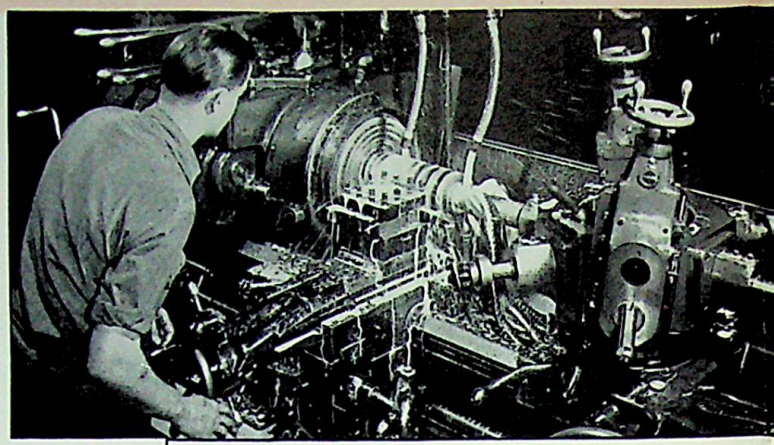
While the hexagon turret is performing turning and boring operations, the square turret should be facing, grooving or chamfering.

If the opposite face is to be finished, the work is gripped in soft jaws of a Geared Scroll Chuck and the second operation facing cuts taken from the cross slide. Overhead turning cuts required to match the size produced in the first operation may be taken with the same setting of the overhead turning cutters in the Hexagon Turret Turning Heads.





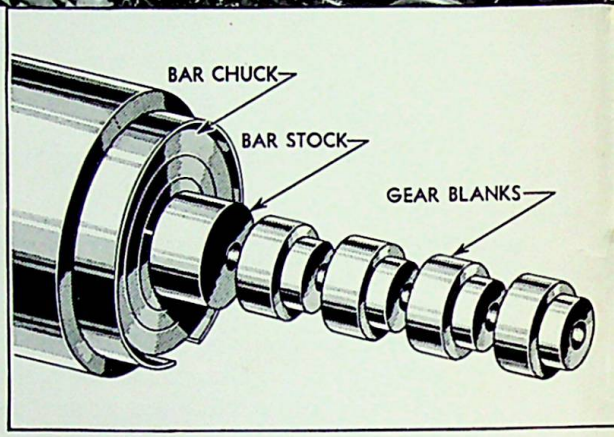
Bar Method



Many parts can be produced either from bar stock or from forgings and castings. Parts formed from bar stock must be shaped completely from the original bar stock. Forgings and castings approximate the shape of the finished piece and less material must be removed.

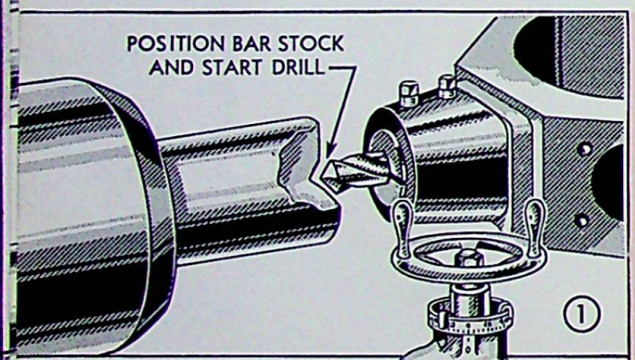
Machining Parts From Bar Stock—Common parts like collars, spacers and gear blanks are often machined in groups or "nests." The internal operations (drilling, boring, reaming) and external cuts (turning, facing, forming) are completed for a number of pieces at one gripping of the bar stock. The parts are then faced and cut off from the bar stock to correct length.

When machining parts in "nests," the external operations (turning, facing, and cut-off) are done from the square turret—internal cuts (drilling, boring, and reaming) from the hexagon turret. The square turret turning cuts should be combined with drilling operations from the hexagon turret.

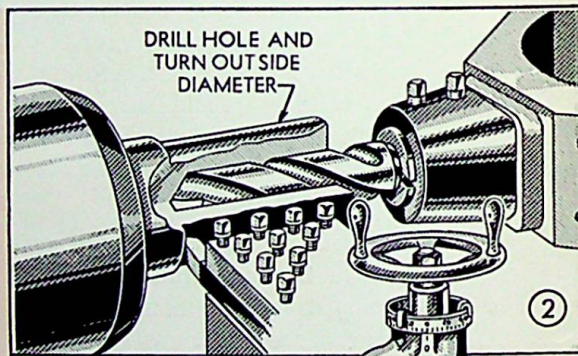


Second Operations on Bar Work—Where a cut-off face must be finished, the piece is gripped in a Collet Chuck or held in soft jaws of a Scroll Chuck. The opposite face is finished with a cutter held in the square turret—the hole chamfered and the corners rounded where required.

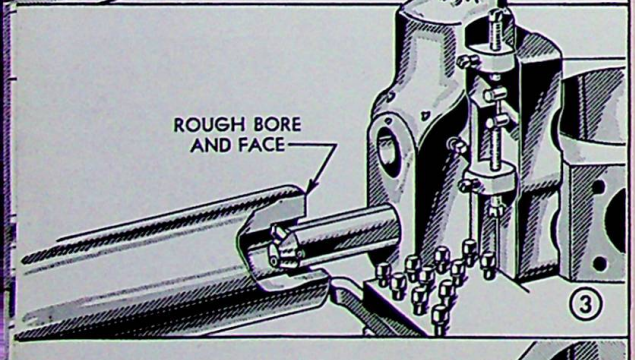
The tooling set-ups shown here illustrate a sequence of bar tooling operations generally followed when machining parts in "nests."



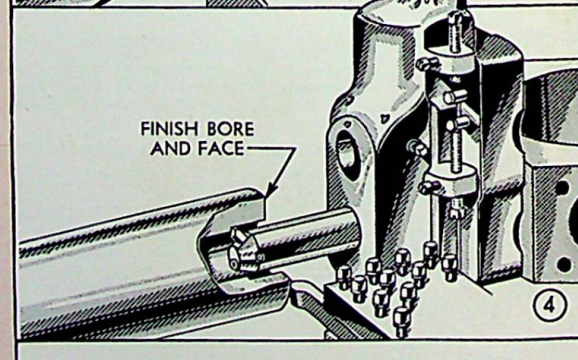
1. Start Drill—Grip the bar stock in a Collet Chuck or Bar Chuck allowing the bar to extend sufficiently to produce several pieces. Start drill the end of the bar to produce a true cone for piloting longer drills.



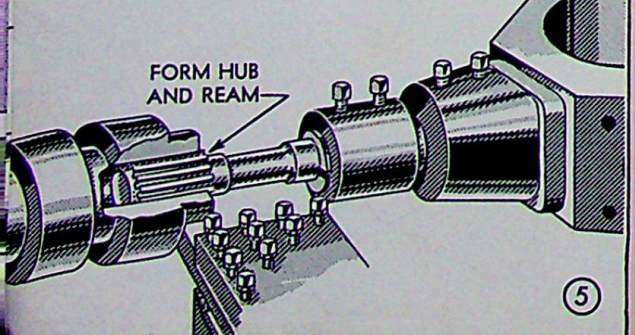
2. Drill and Turn—Combine the drilling operation from the hexagon turret with the turning cuts from the square turret. The same feed can be used for both cuts allowing the cuts to be finished at the same time.



3. Bore and Face—Bore to remove any runout resulting from the drilling cut. Facing work may be done while rough boring is in process.

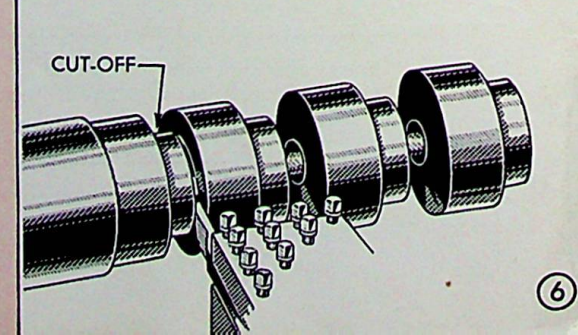


4. If close tolerances are specified on the bore, a second or finish boring cut may be necessary. Use a stub boring bar in a Vertical Slide Tool.



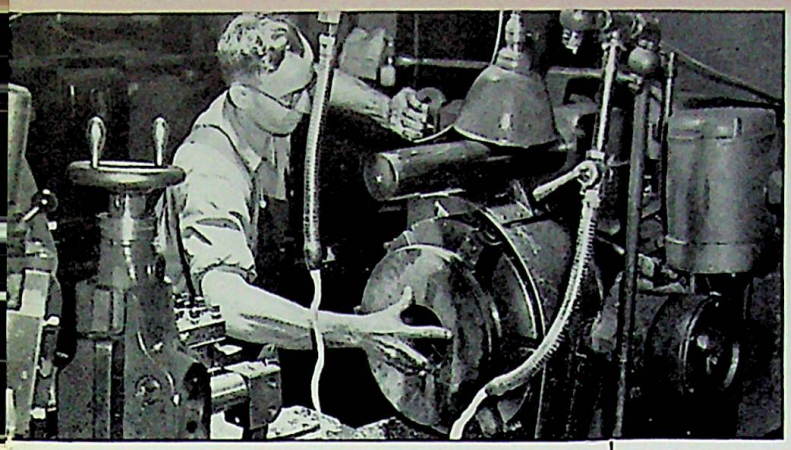
5. Form Hub and Ream—Face the flange of the gear and form the hub to size with a cutter held in the square turret. Use fine cross feeds when forming.

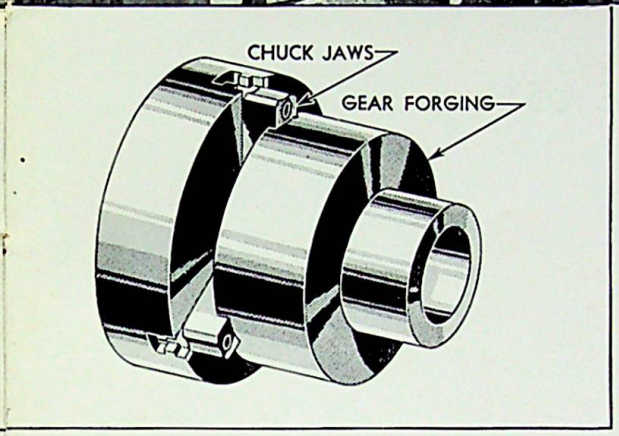
Ream the hole from the hexagon turret where extremely accurate size and smooth finish are specified.



6. Chamfer and Cut off—Chamfer corners to remove sharp edges. Cut off partially from the square turret—chamfer the back face of the work and then complete the cut off.

Chucking Method



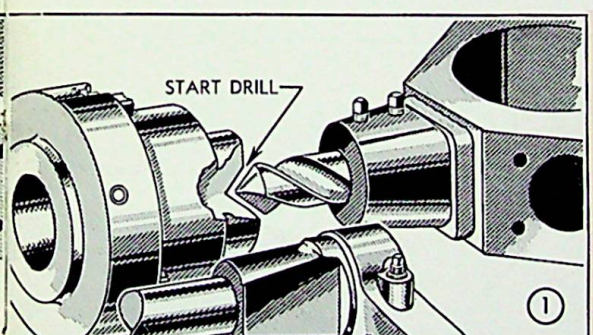


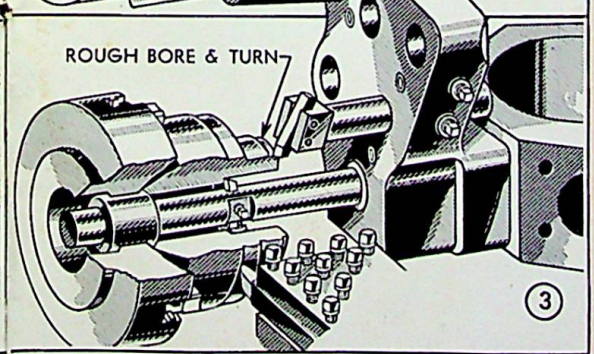
Machining Parts from Castings and Forgings
Since less material is generally removed from forgings and castings, parts can be machined faster by the chucking method than by the bar method where the entire piece is shaped from bar stock. As the cost of forgings is greater than the cost of bar stock, small quantity lots are generally produced from bar stock. In larger quantity lots, however, forgings are more practical because less time is required in the actual machining.

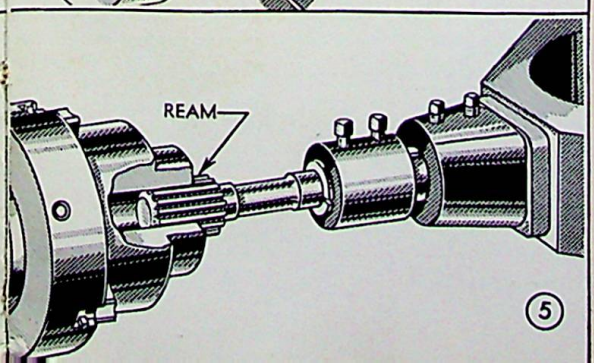
Forgings and castings are gripped one at a time in jaws of scroll chucks. Smaller machines can be used for producing parts from forgings and castings. A machine of large spindle bore is necessary to produce larger diameter gears and sleeves from bar stock. The machining operations involved in the chucking method illustrated here are similar to the bar method.

With the chucking method it becomes possible to combine the hexagon overhead turning and boring with the square turret turning and facing operations.

Second Operation Work—Accurately bored soft jaws are required in second operation work to hold the piece concentric with surfaces machined in the first chucking. To bore the soft jaws accurately, grip the jaws on a metal piece and bore the locating surfaces with a rough and finishing cut from the square turret. Then grip the work in the soft jaws and face and chamfer the opposite side.







1. Start Drill—Grip the casting or forging firmly in hardened jaws of a scroll chuck. Start drill to produce a true pilot cone to guide the drill. If the forging or casting has a pierced or cored hole, a start boring cut should be taken.

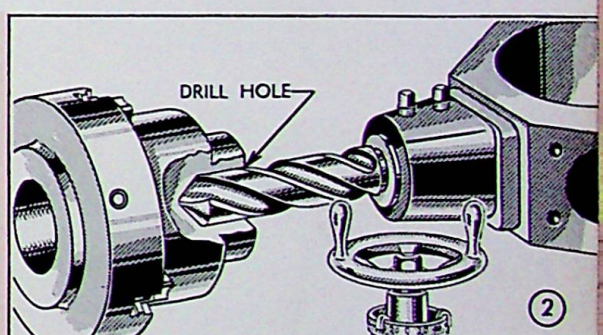
2. Drilling—Drill the hole from the hexagon turret. When the drill is of small diameter, the drilling is done separately because an outside turning operation usually limits the cutting speed of the drill.

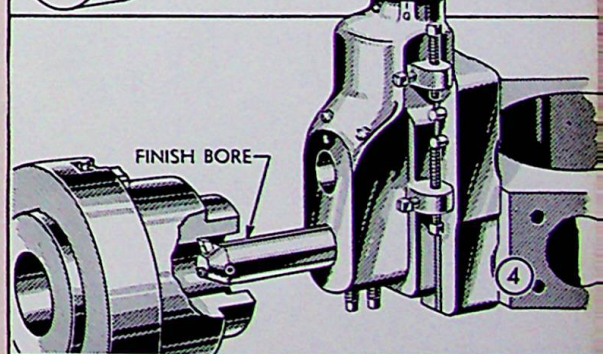
3. Turning and Boring—Set up the turning and boring operation in the Multiple Turning Head. The overhead and center pilots strengthen the tooling set-up to withstand heavier cuts. As the turning and boring is being done from the hexagon turret, secondary side turning cuts can be completed from the square turret.

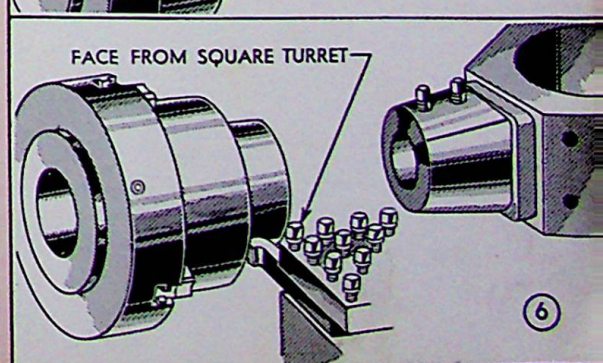
4. Finish Boring—Any runout from the rough boring operation may be removed with a stub boring bar held in a Vertical Slide Tool. Higher spindle speeds are used to obtain smooth finish and accurate size.

5. Reaming—Smooth finish and close tolerances generally call for a reaming operation. The reamer is held in a Floating Tool Holder on the hex turret, thus allowing the reamer to establish its own center.

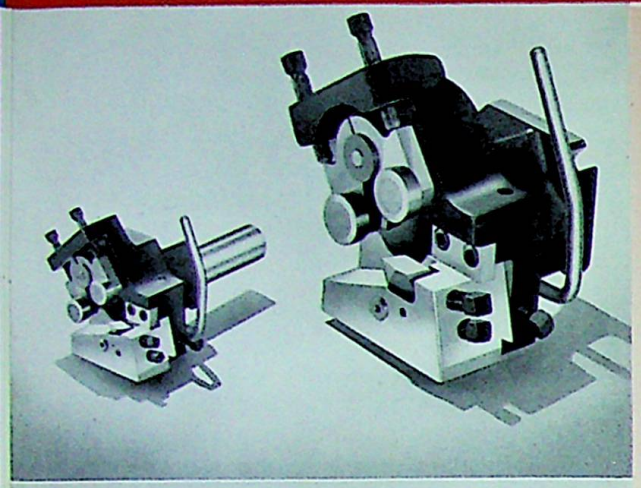
6. Face and Chamfer—Finish face and chamfer sharp corners with cutters held in the square turret. Burr the hole before removing the piece from the chuck.



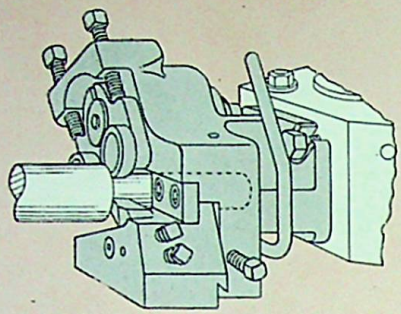




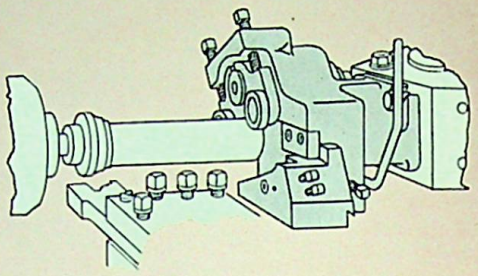
GENERAL PURPOSE HEXAGON



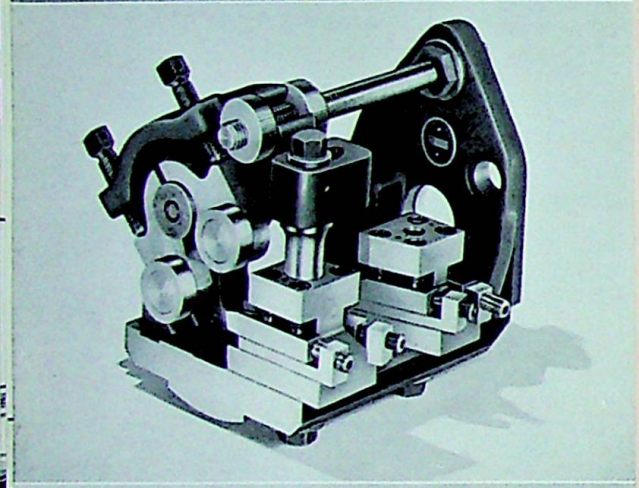
SINGLE CUTTER TURNER



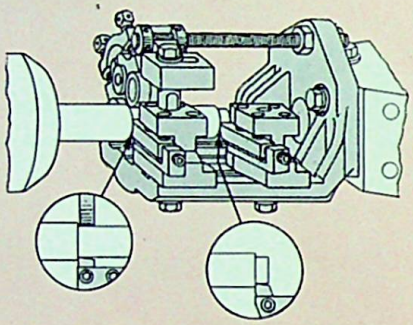
To turn bar stock



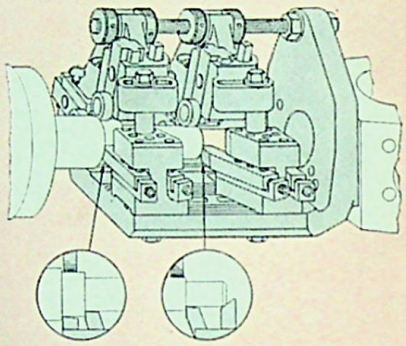
To act as a steady rest



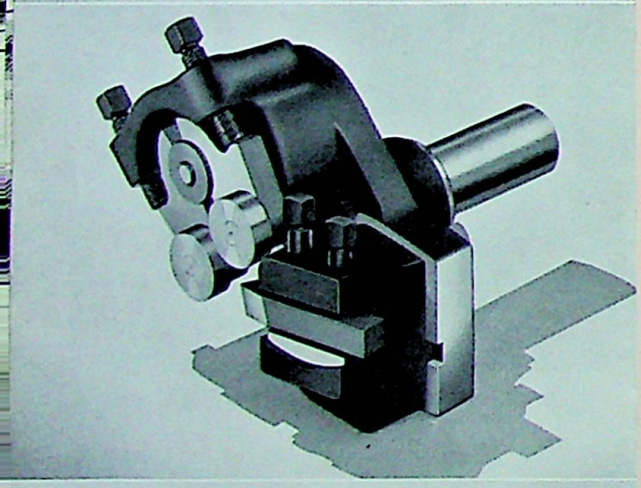
MULTIPLE CUTTER TURNER



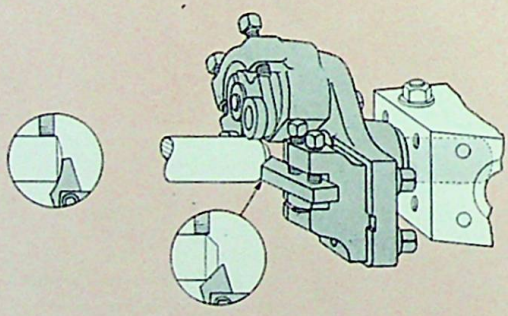
To turn two diameters at one time



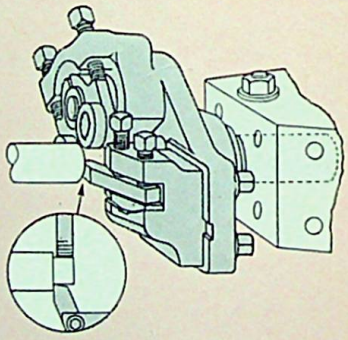
To turn four diameters at one time



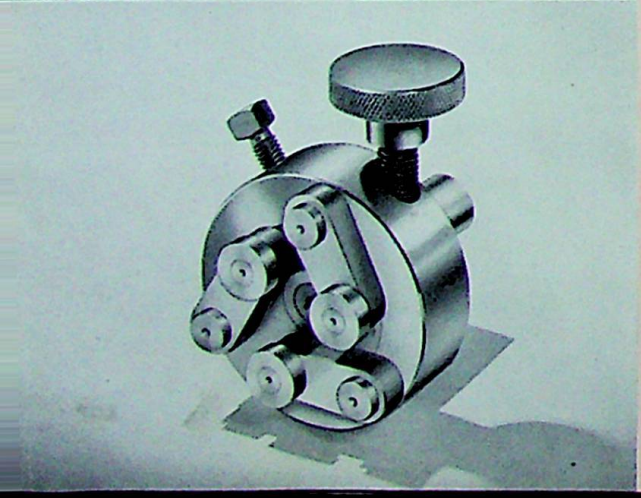
COMBINATION END FACER AND TURNER



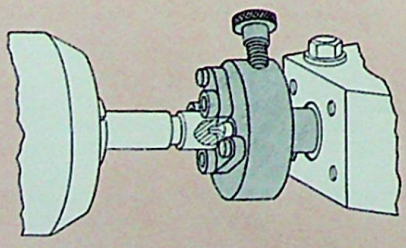
To face ends of bar stock



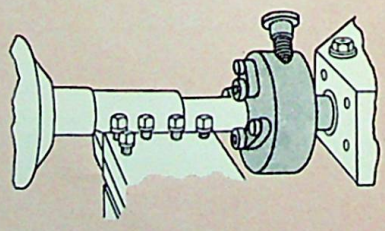
To turn short diameters



CENTER DRILLING TOOL



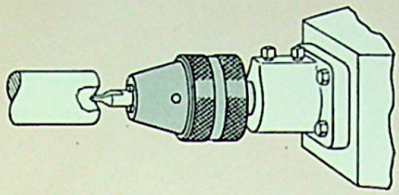
To center work for grinding



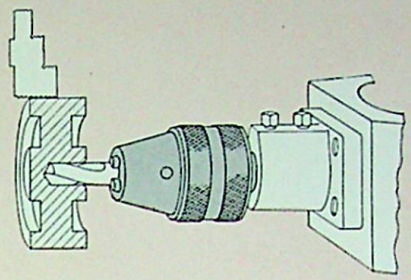
To act as a steady rest

TURRET TOOLS FOR BAR WORK

DRILL CHUCK

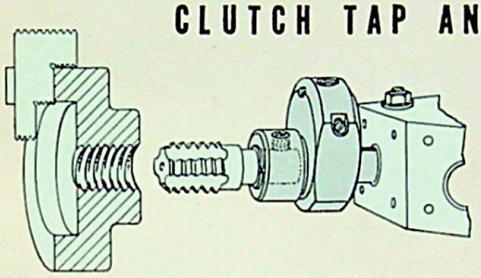


To hold center drills

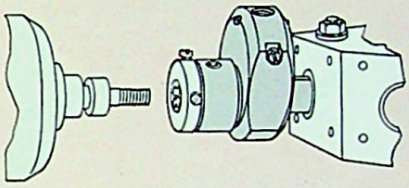


To hold small diameter drills

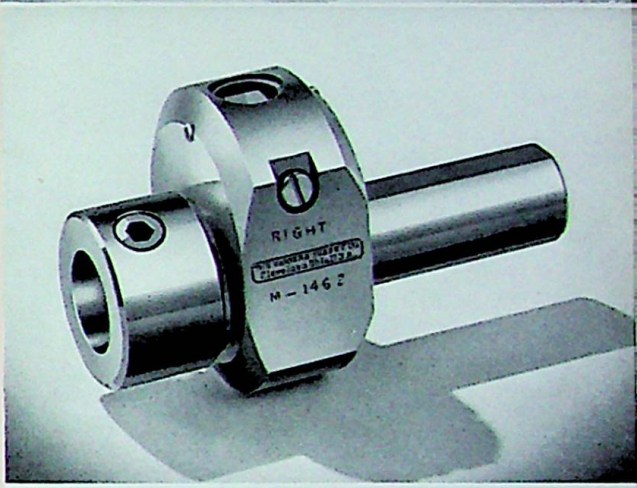
CLUTCH TAP AND DIE HOLDER



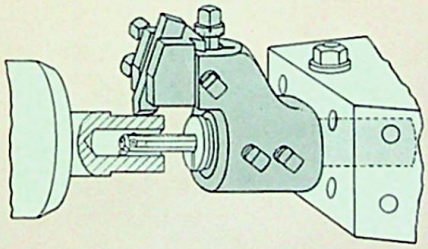
To tap small diameter threads



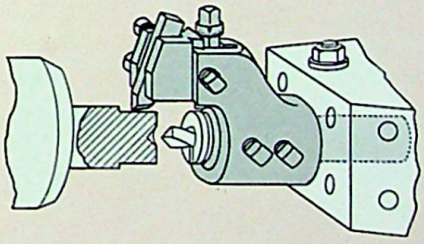
To hold solid dies when threading small diameter work



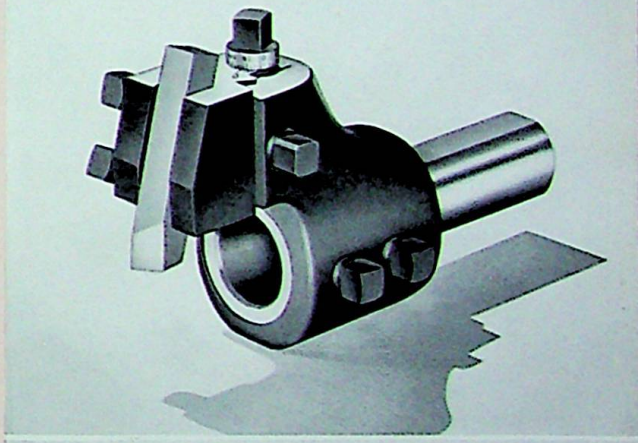
ADJUSTABLE KNEE TOOL



To turn and bore short work



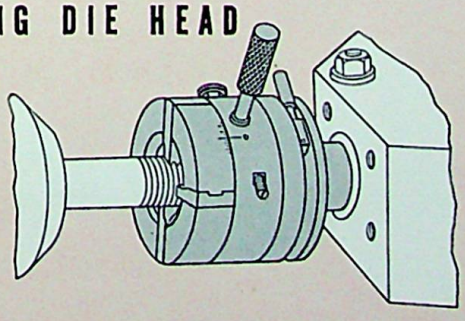
To turn and drill short work



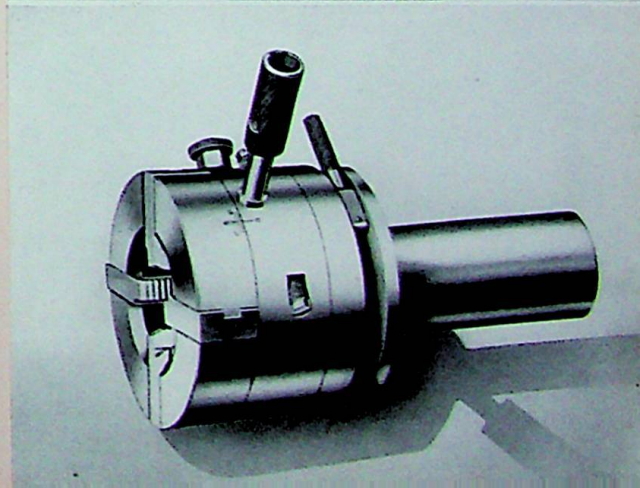
SELF-OPENING DIE HEAD

There is a bar tool for each bar machining operation. Most bar turning tools are equipped with roller rests to support the work firmly against the cutter. By preventing the work springing away from the cutter, heavier cuts and closer tolerances are possible, and better finish assured.

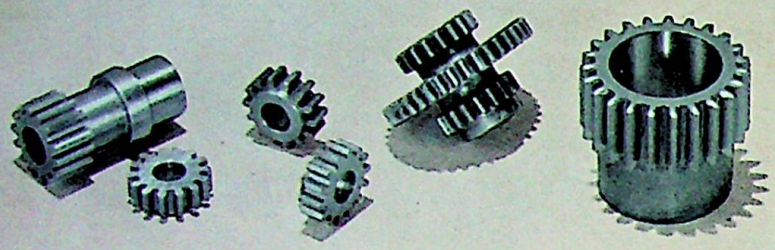
Other bar tools hold drills, taps, boring bars and reamers for internal work.



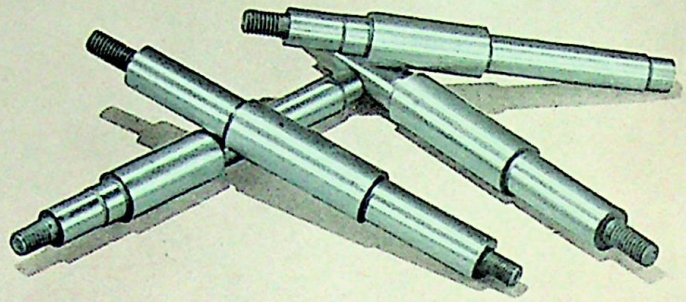
To cut longer threads



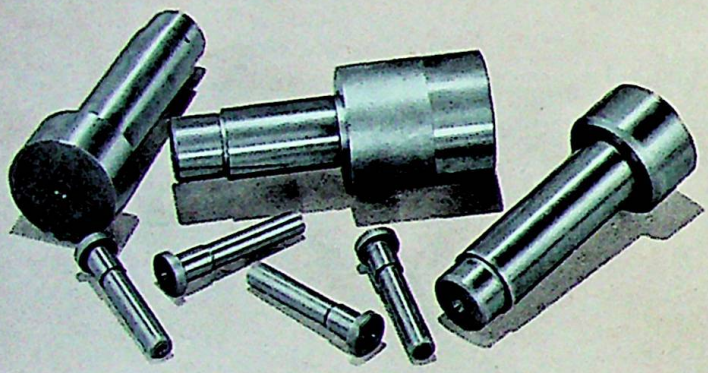
REPRESENTATIVE BAR WORK



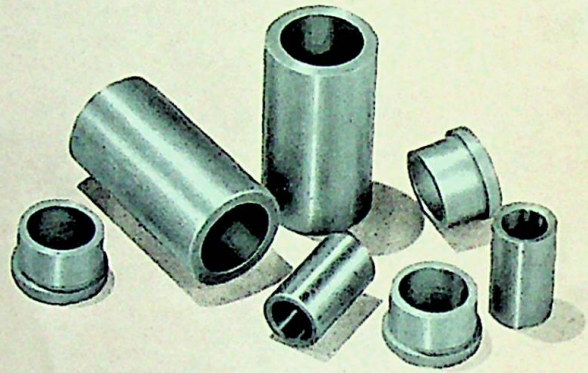
Gear Blanks . . . Page 31



Threaded Shafts . . . Page 29



Plain Studs . . . Page 25



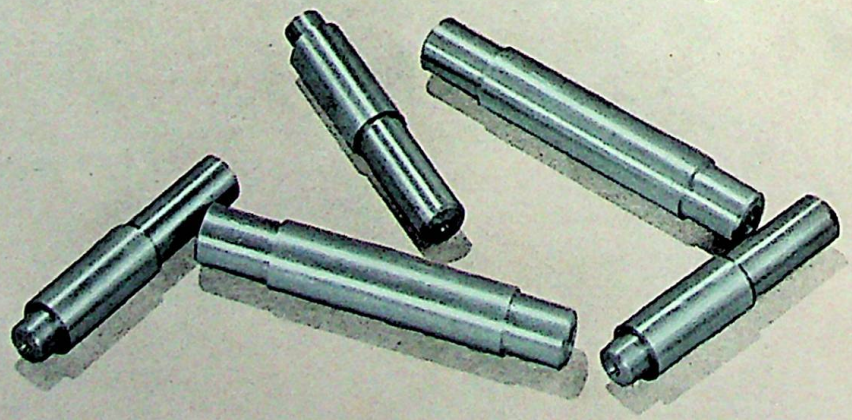
Bushings . . . Page 32

Screws and Bolts . . . Page 26

Threaded Studs . . . Page 27

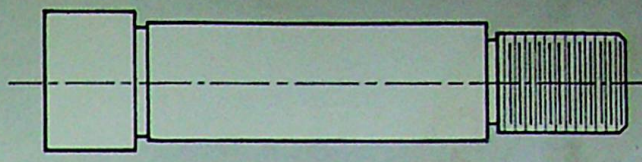
Washers, Spacers and Collars . . . Page 30

Pins and Shoes . . . Page 24



Plain Shafts . . . Page 28

HOW TO SET UP UNIVERSAL BAR TOOLING



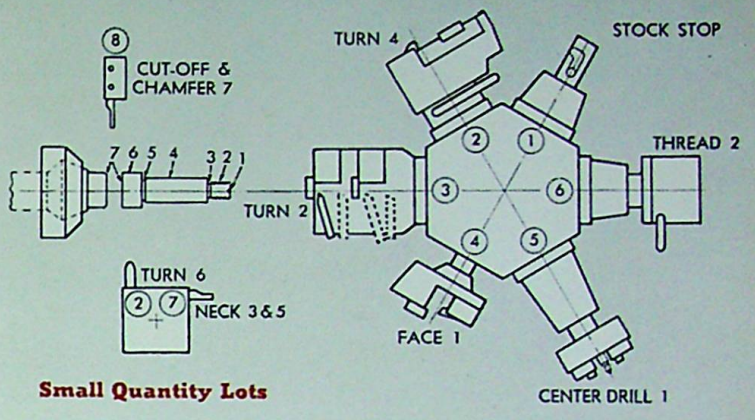
The most effective hexagon turret tooling set-up is one that will produce the required cuts with minimum machine handling.

Since most bar work involves the taking of similar cuts—turning, facing, center drilling—one general tooling set-up may be adapted to the hexagon turret. This set-up is known as the "Universal Bar Set-up."

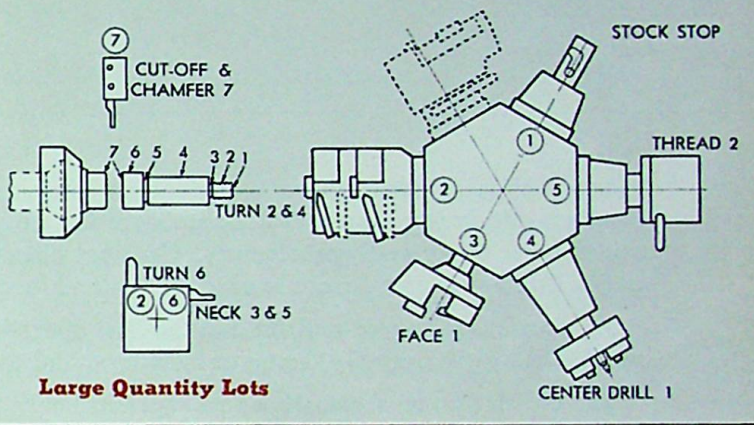
In a Universal Set-up, the heavier tools—the Single Cutter Turner, the Multiple Cutter Turner and Flanged Tool Holders, remain permanently mounted to the hexagon turret. When changing the set-up, the only requirement is to grind and set the cutters and insert drills, reamers, and taps in the Flanged Tool Holders.

As illustrated here in the set-up for producing studs in small and large quantity lots, the flexibility of tooling set-up is the key to efficient operation. The Single and Multiple Cutter Turners are set up to take single cuts on small quantity lots. The Multiple Cutter Turner is set up to take two or more cuts on larger quantity lots.

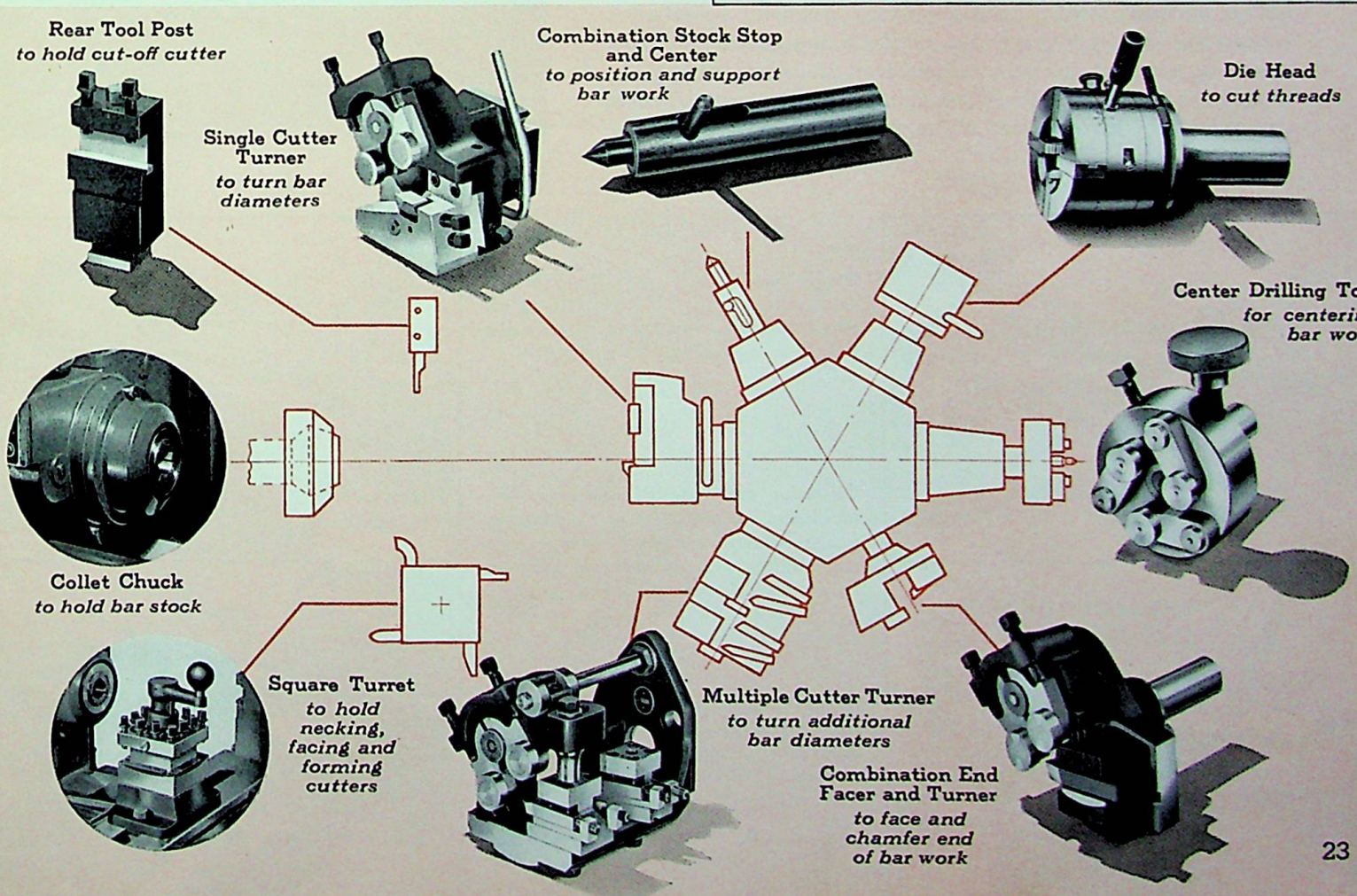
Most bar work may be classified into nine representative groups. The following pages suggest "Universal Bar Set-ups" for machining each of these groups and illustrate in detail the more important operations.



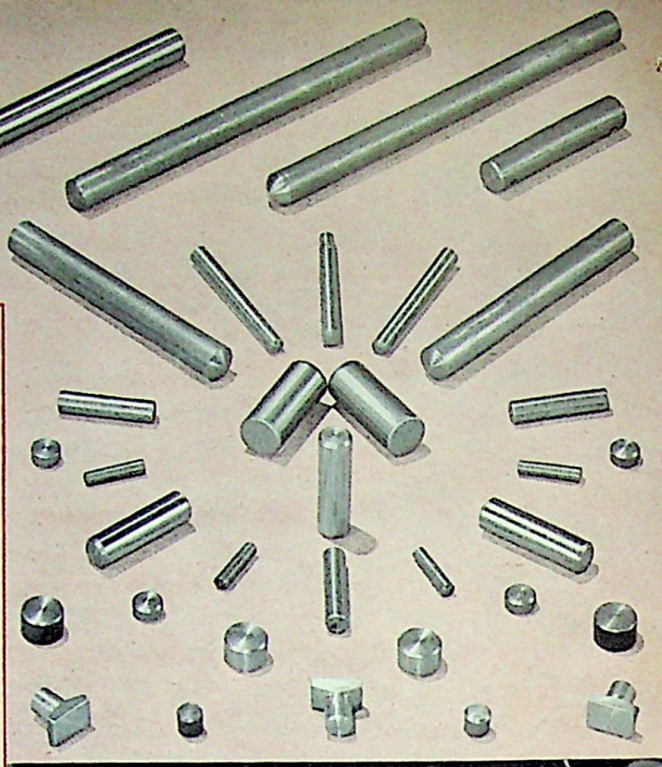
Small Quantity Lots

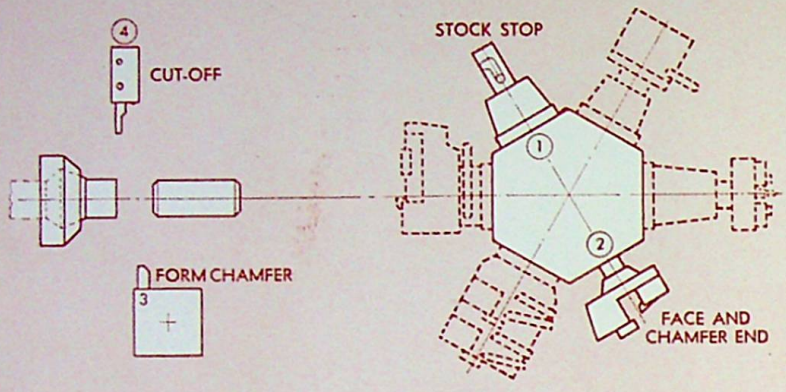


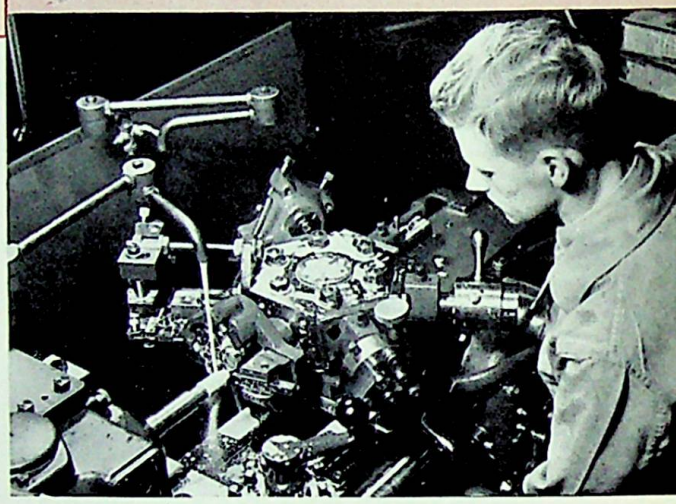
Large Quantity Lots



Pins and Shoes



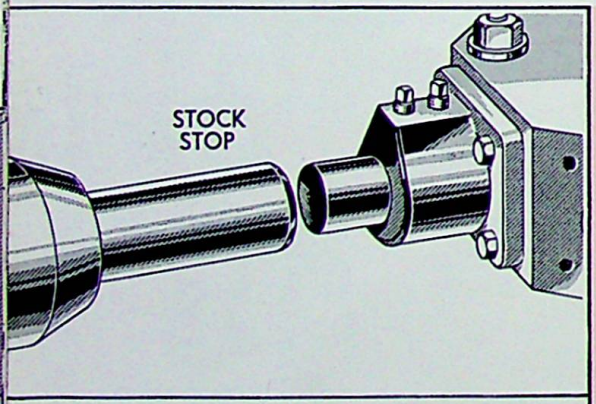




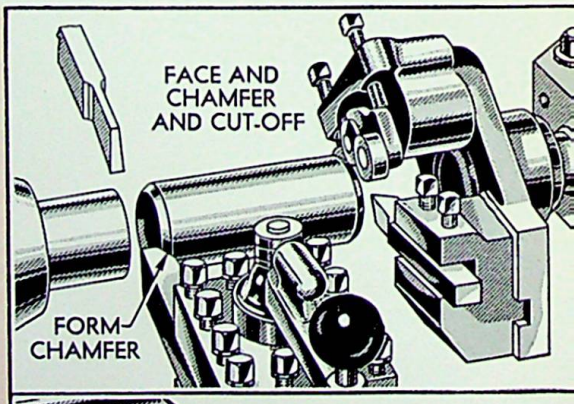
Pins and shoes, made from brass or steel bar stock, require only forming, end facing, and cut-off operations. On brass pins, the cut-off finish is generally satisfactory. On steel pins, the Combination End Facer and Turner is used for the end facing work.

A chamfer, radius or end form in the first operation can be machined by grinding the facing or forming cutter to suit.

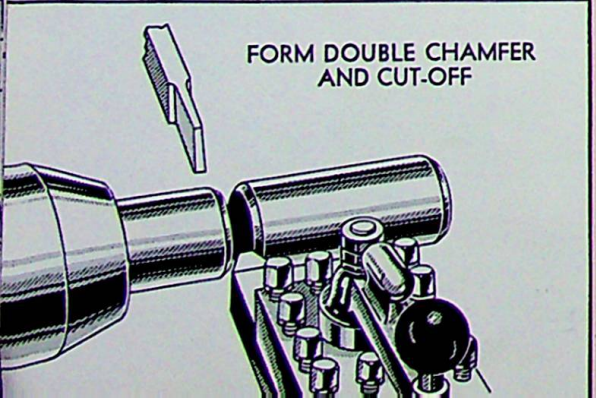
The cut-off face must sometimes be kept extremely smooth and held to accurate length. In this instance, a second operation is necessary. The pin is gripped in a collet using an internal collet stop. The opposite face is finished from the cross slide. If a longer pin is involved, the Combination End Facer and Turner can quickly be incorporated in the set-up.



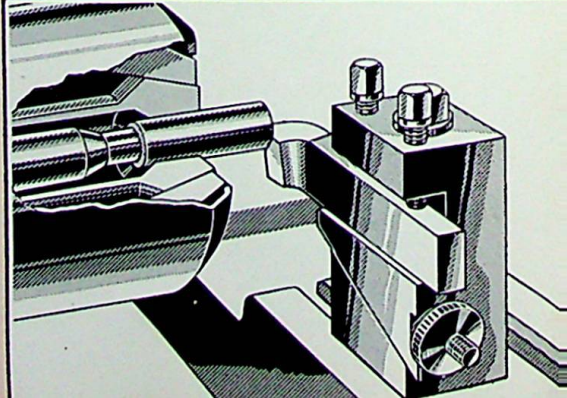
Stock Stop—A solid stock stop positions the bar to length. To provide an extension from the hexagon turret, the stock stop is held in a Flanged Tool Holder.



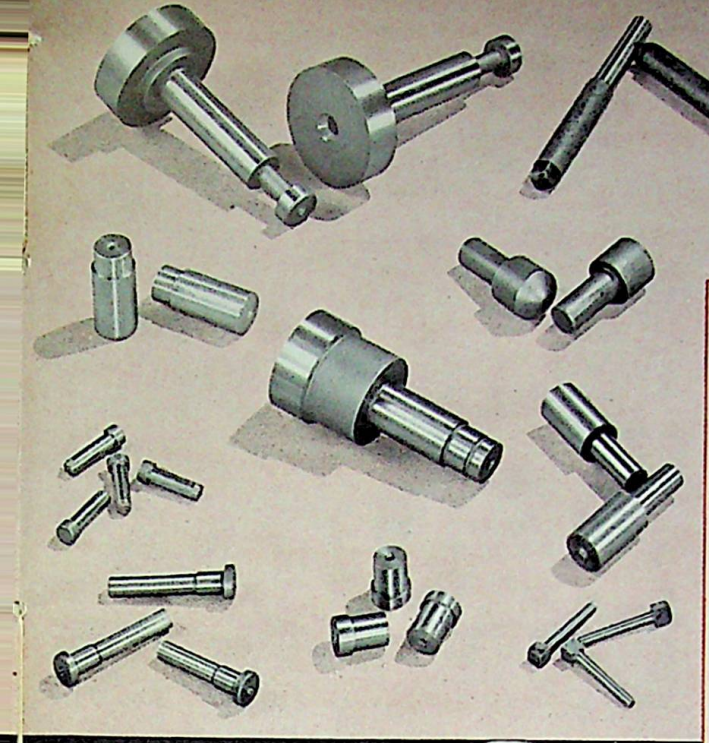
Chamfer and Cut-off—Steel pins are faced and chamfered from the hexagon turret. Chamfers required on brass pins may be done with a chamfering cutter on the cross slide before the cut-off operation.

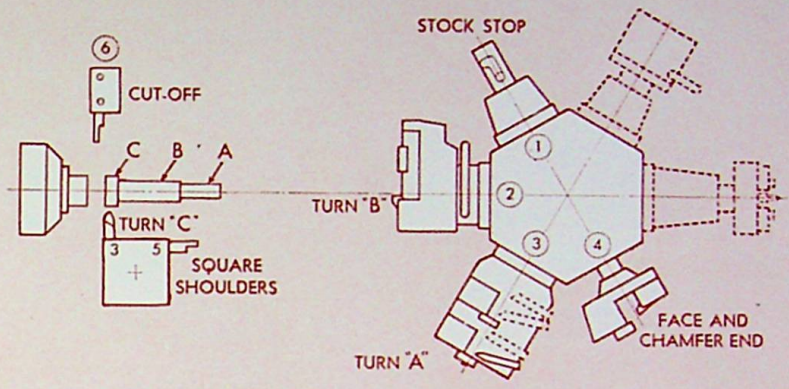


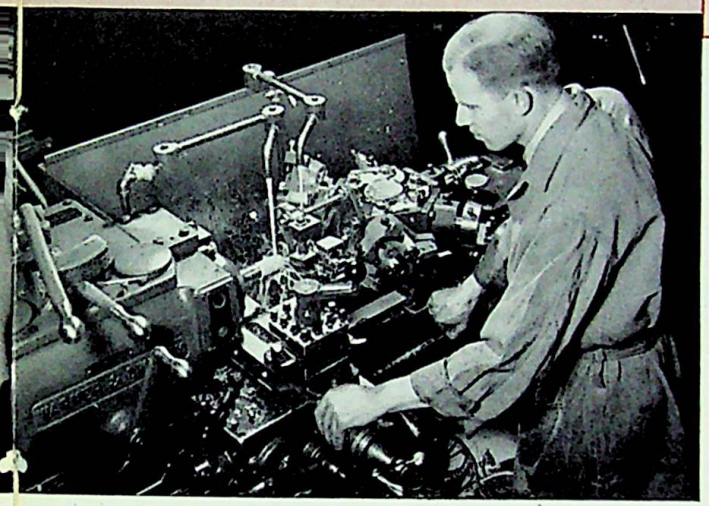
Second Operation (Facing to Length)—An internal collet stop locates the pin accurately within the collet. A cross slide cutter or a Combination End Facer and Turner is used for the end finishing.



Plain Studs





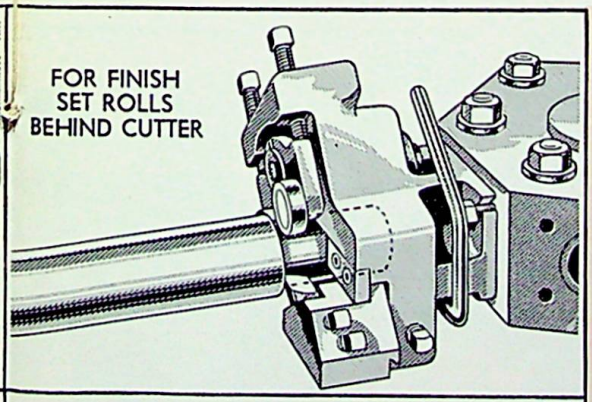


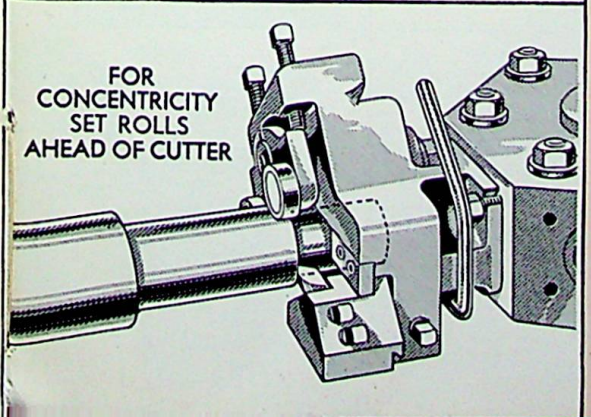
Studs and multiple diameter pins are finished completely from bar stock on turret lathes or they may later be hardened and ground between centers.

Small and Medium Quantity Lots—Universal Bar Tooling is used to machine studs. The Single Cutter Turner is used for turning small quantity lots—the Multiple Cutter Turner for the larger quantity lots.

To obtain a rolled or burnished finish on turned diameters, the rolls of the Single Cutter Turner are set to follow the cutting edge of the tool. Where concentricity between diameters is required, the rolls are set ahead of the cutter to pilot on a previously turned diameter.

Small Quantity Lots





Smooth Finish—For smooth finish on bar turned diameters, set the bar turner rolls slightly behind the cutter nose radius. Use heavy feeds and highest possible cutting speeds.

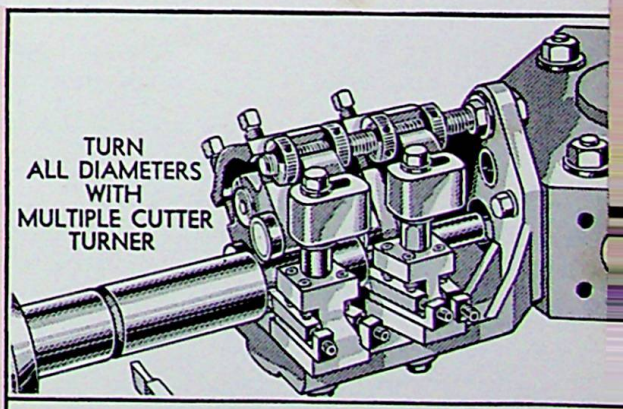
For long studs produced in large lots, the Multiple Cutter Turner is set up to complete all turned diameters in one pass. One cutter may be set to chamfer and end face. One or more sets of rolls may be incorporated in the set-up.

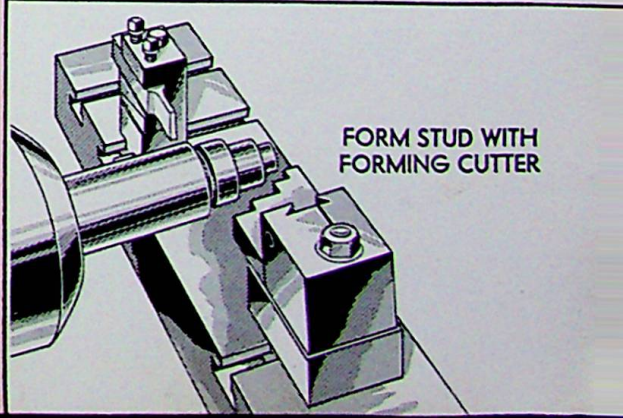
Accurate Concentricity—For minimum runout between turned diameters, set the rolls ahead of the cutter to guide on a previously turned diameter.

Large Quantity Lot Work—Short length steel or brass studs may be shaped with forming cutters in the cross slide. All diameters are finished to size in one pass of a forming tool on the cross slide before the final cut-off operation is completed.

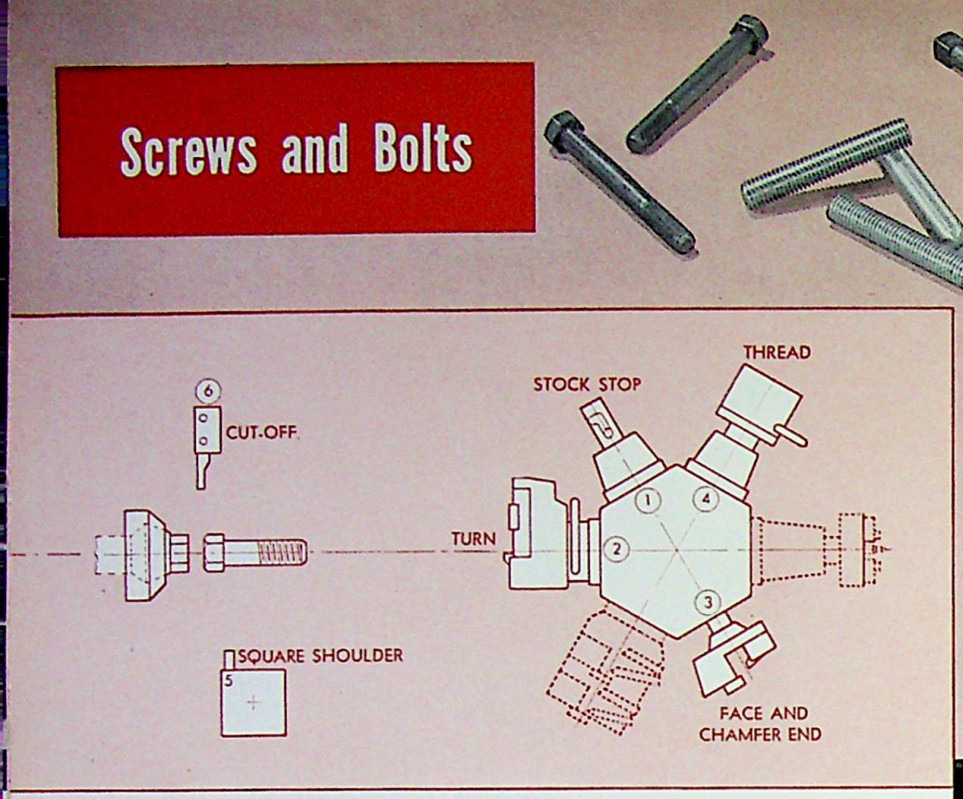
The sizes of the various diameters are established in the tool room when the cutter is made.

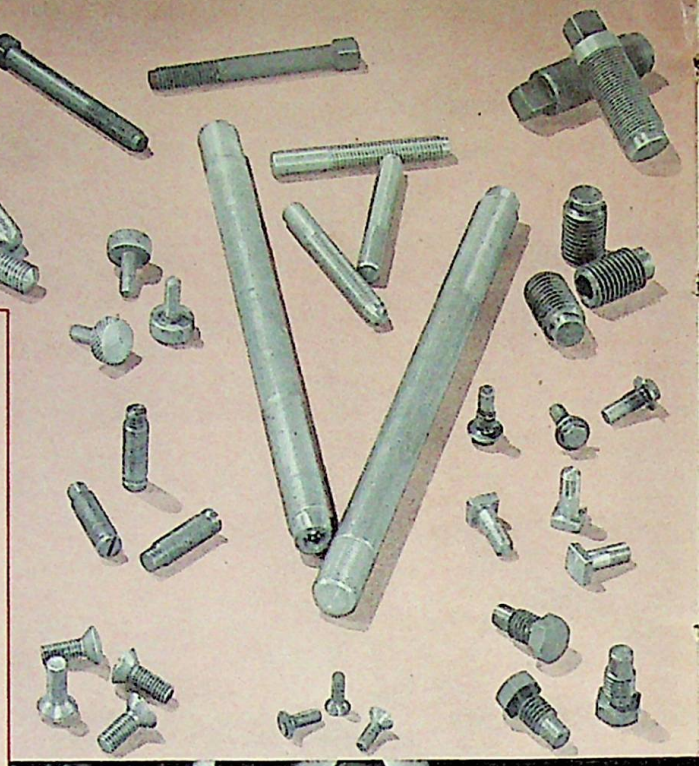
Large Quantity Lots

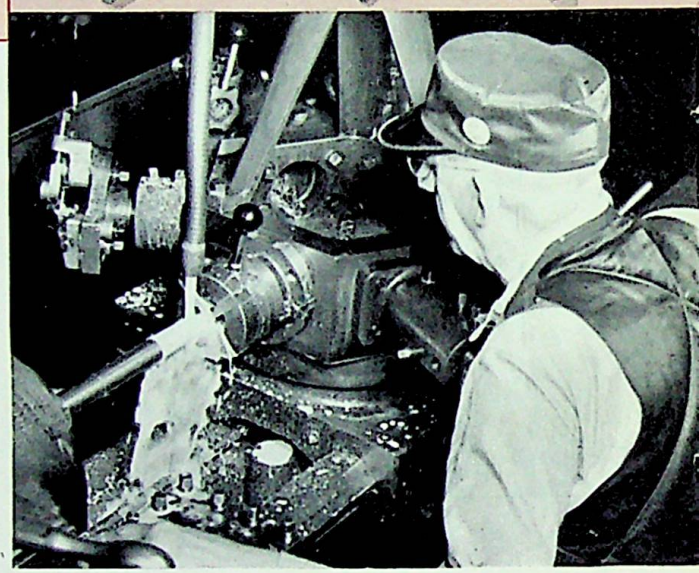




Screws and Bolts







Bar Turning, End Facing and Threading are the basic machining operations required to produce screws and bolts from bar stock.

True round diameters can be cut on hexagon or square bar stock by using a roller rest bar turner. After a start turn cut from the square turret, the bar turner rolls are brought to bear against the turned diameter supporting the work against the impact of cutting across corners of square or hexagon stock.

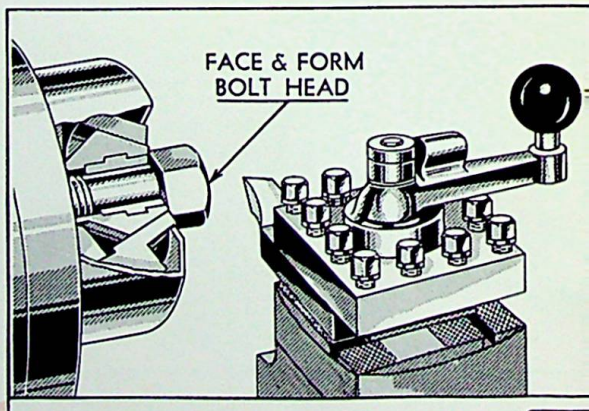
With extreme care, it is possible to grind the bar turner cutter so that the cutting edge is exactly square with the centerline of the work. The cutter will then produce a square shoulder when turning the bar. However, on most average lot bar work, it is simpler and quicker to take a squaring cut from the cross slide after the turning cut has been completed. Threading required on small screws and bolts is done with self-opening die heads.

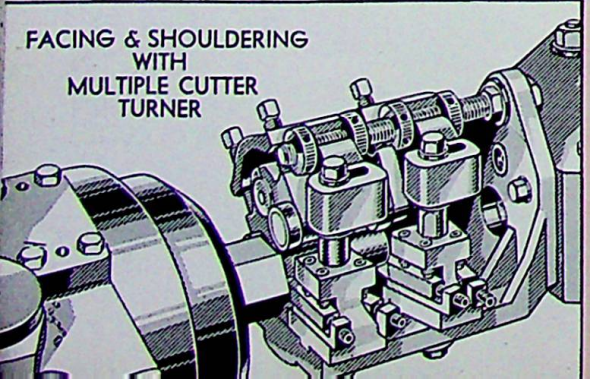
To face and chamfer the head of the bolt, the work piece is held in a collet. The end facing operation may be done from the cross slide or from the hexagon turret.

Where finish on the head of the bolt is not important, the cut-off cutter is provided with a chamfer to form the head.

On small quantity lots—a Single Cutter Turner is set to turn the thread diameter—a Combination End Facer and Turner to end face and chamfer for the first thread.

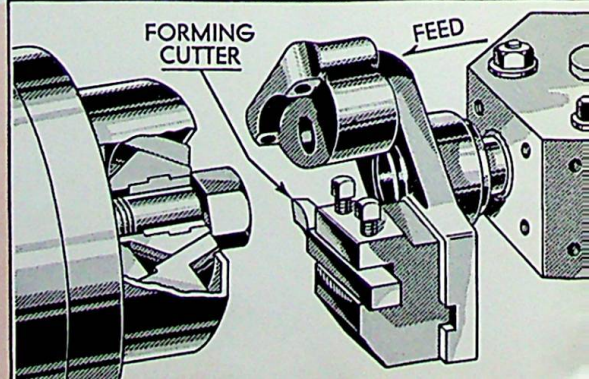
On larger quantity lots—a Multiple Cutter Turner (in place of the Single Cutter Turner) is set with two or more cutters to turn, face and chamfer the end of the bolt in one pass of the tool.



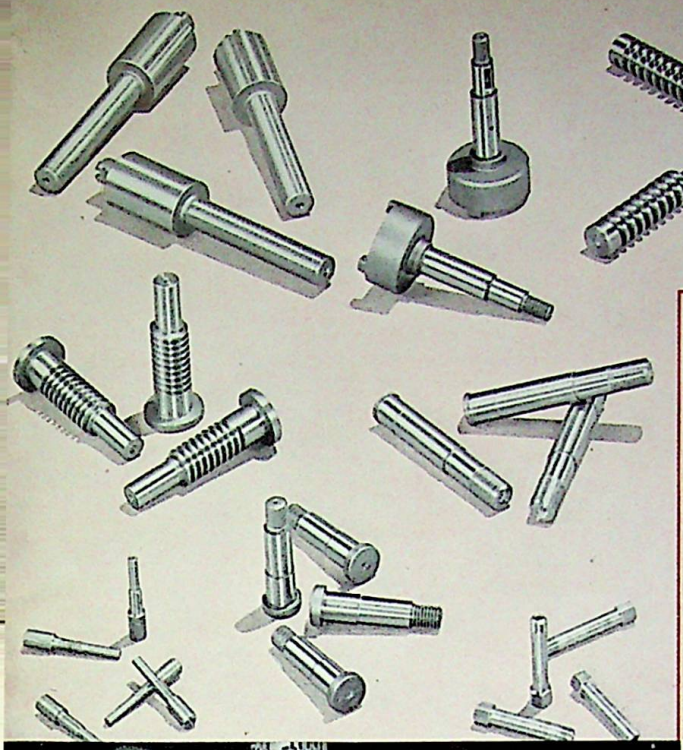


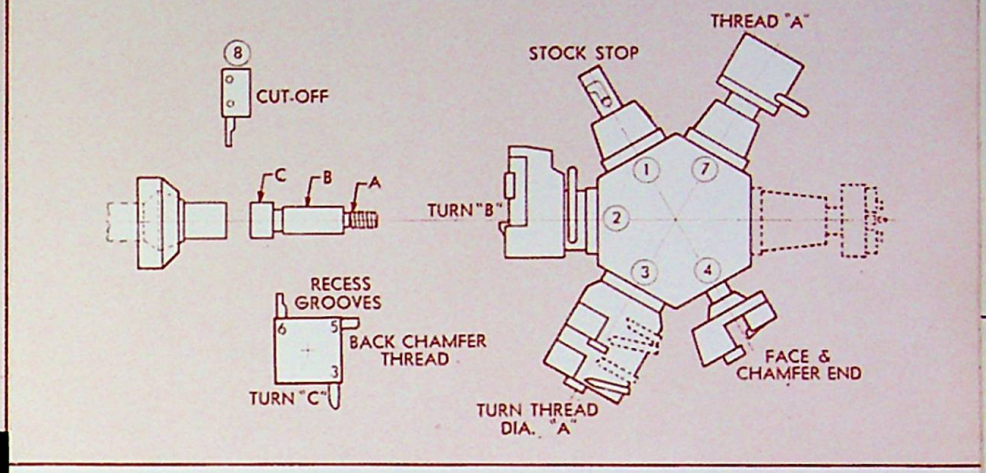
← **Turning** thread and shank diameters, facing and chamfering end with the Multiple Cutter Turner.

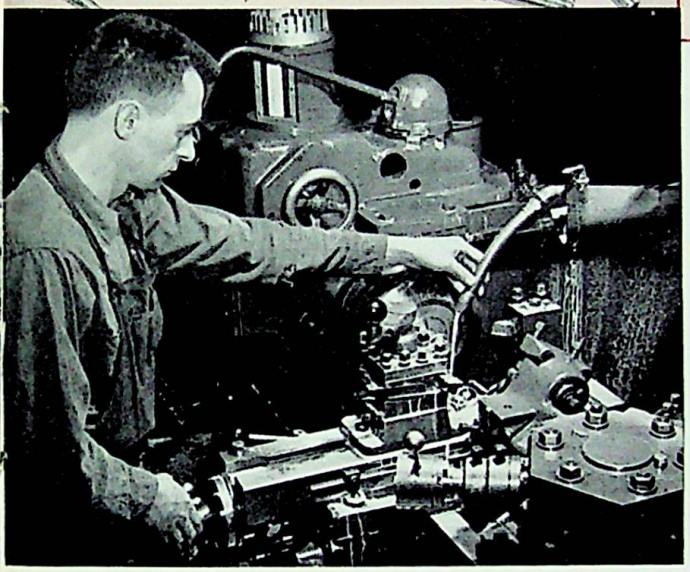
→ **Bolt heads** may be formed from the cross slide or from the hexagon turret using a form cutter in the Combination End Facer and Turner.



Threaded Studs





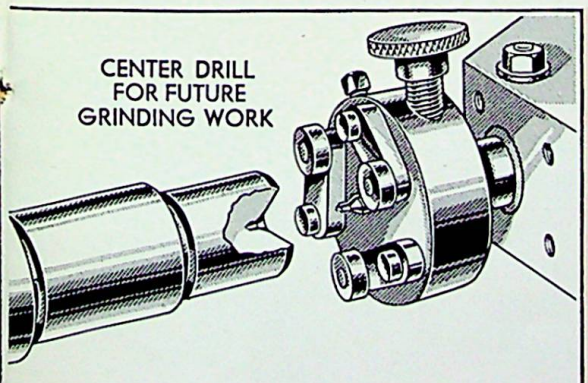


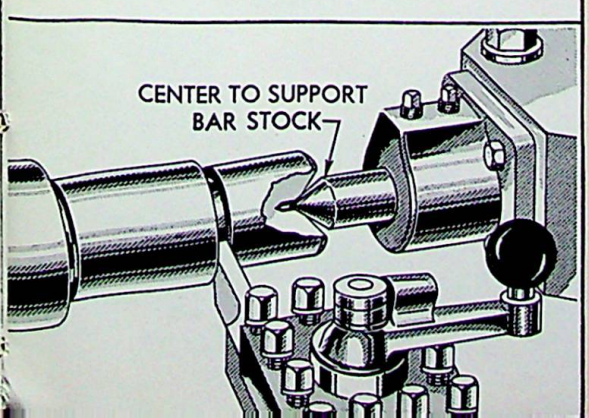
The specified size, pitch and concentricity of threads determines which of several threading methods should be used on studs.

Most studs call for small diameter threads enabling die heads to be used. Extremely fine pitch threads having precision lead tolerances may require a more positive means for leading on the die head. A Leading-On-Attachment for the hex turret may be used, or the hex turret may be linked to the cross slide.

Accurate concentricity between threads and previously turned diameters may require single point threading. The thread is cut with the square turret using a Lead Screw or Thread Chasing Attachment for the cross slide.

To avoid threading into shoulders, a necking cut is taken to provide threading tool clearance. A center drilling operation is required when the stud is to be hardened and ground.



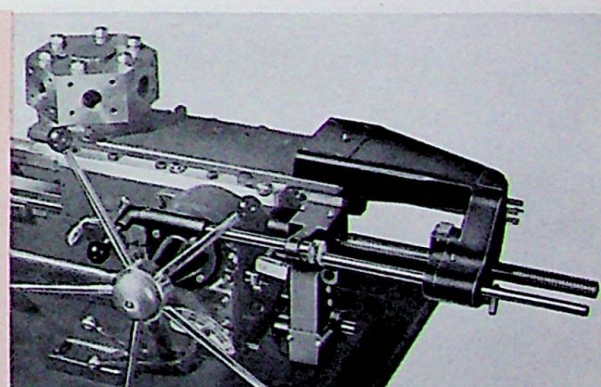


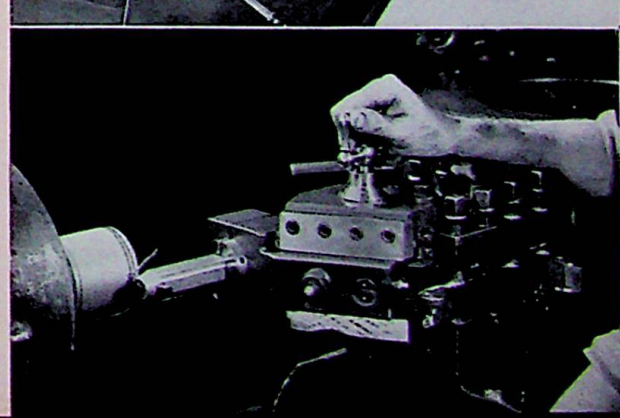
← **Center drilling** for further threading or grinding operations. Roller rests center the piece for the center drilling cut. Center drilling where required is done before any threading.

→ **Precision lead for die heads** to the hexagon turret is obtained with the Leading-On-Attachment incorporating a lead screw and half nuts.

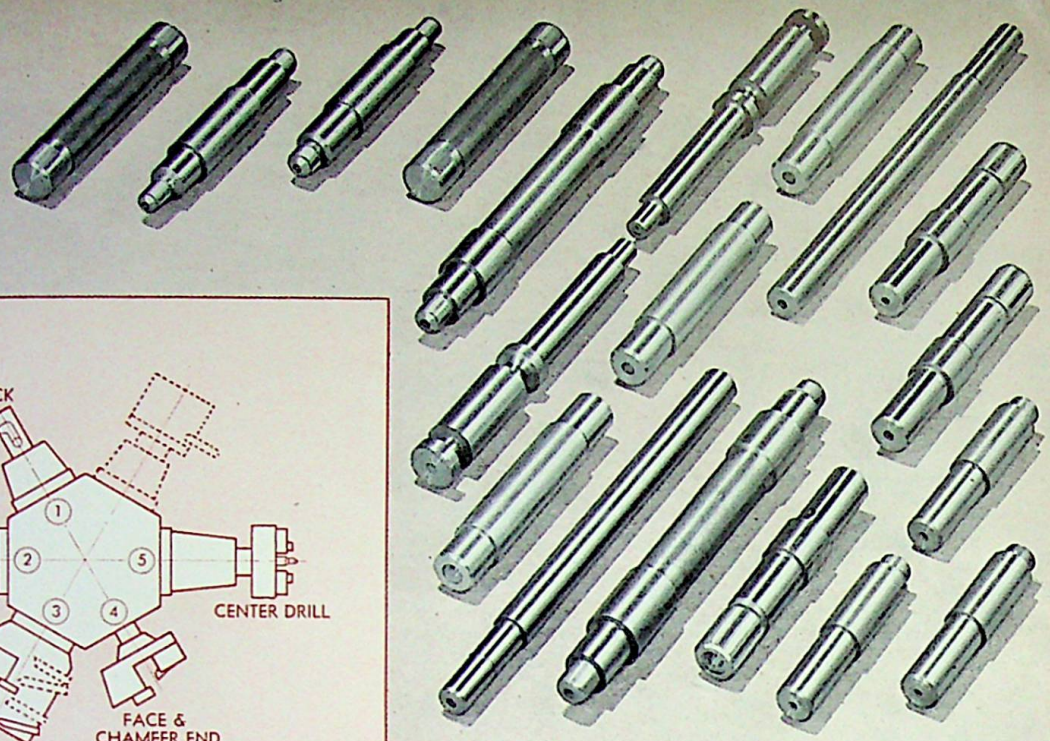
← **Cutting grooves for threading tool clearance.** The end of the stud is supported with a center in the hexagon turret to keep the work from springing.

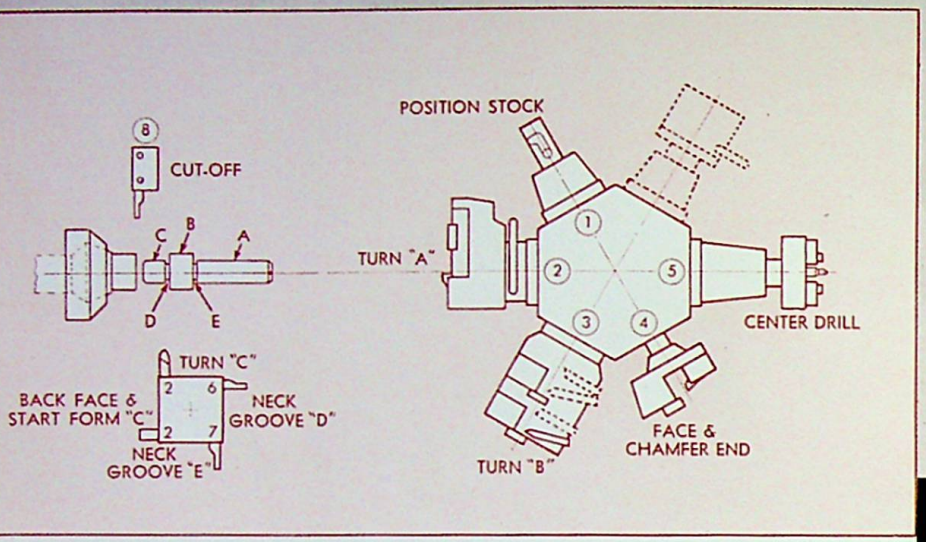
→ **Single point threading** to obtain accurate concentricity of thread with turned diameters.

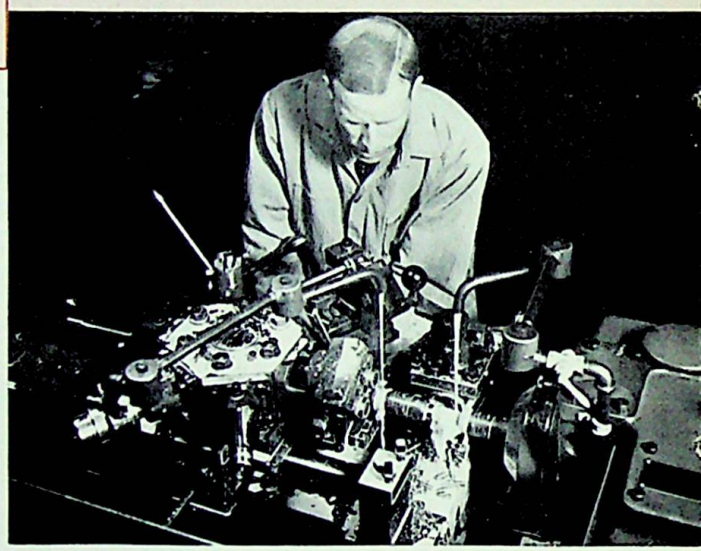




Plain Shafts





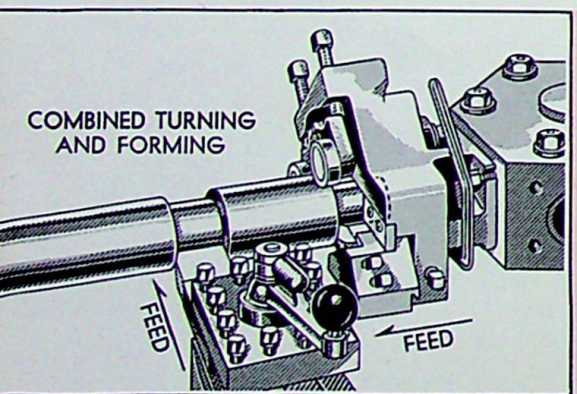


Shafts, similar to studs, require the same basic machining operations. However, in the production of shafts, one additional machining operation is required. It is the turning of back diameters often referred to as undercutting. Undercutting is done from the square turret in two steps:

(1) Form a short diameter through which the square turret turning cutter can enter.

(2) Turn to size with the turning cutter in the square turret.

Combining the Single Cutter Turner operation of the hexagon turret with the square turret undercutting operation enables more metal to be removed at one time. The Single Cutter Turner acts as a steadyrest for the cross slide cuts, and assures a smoother finish free from chatter marks.

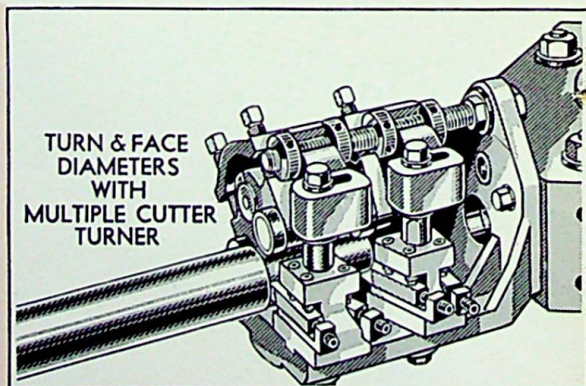


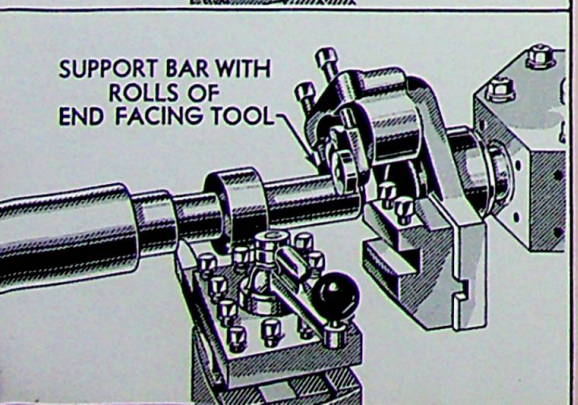
←

The Single Cutter Turner turns the outer end of the shaft and supports the work while the square turret forms the undercut.

→

For Large Quantity Lots—The Multiple Cutter Turner is used in place of the Single Cutter Turner. All machining is combined in the one tool except the undercutting, which is done from the cross slide.



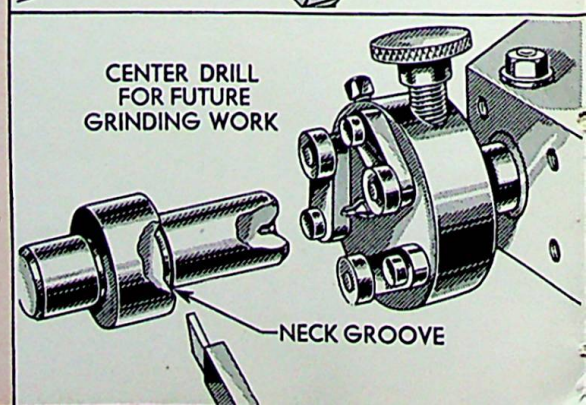


←

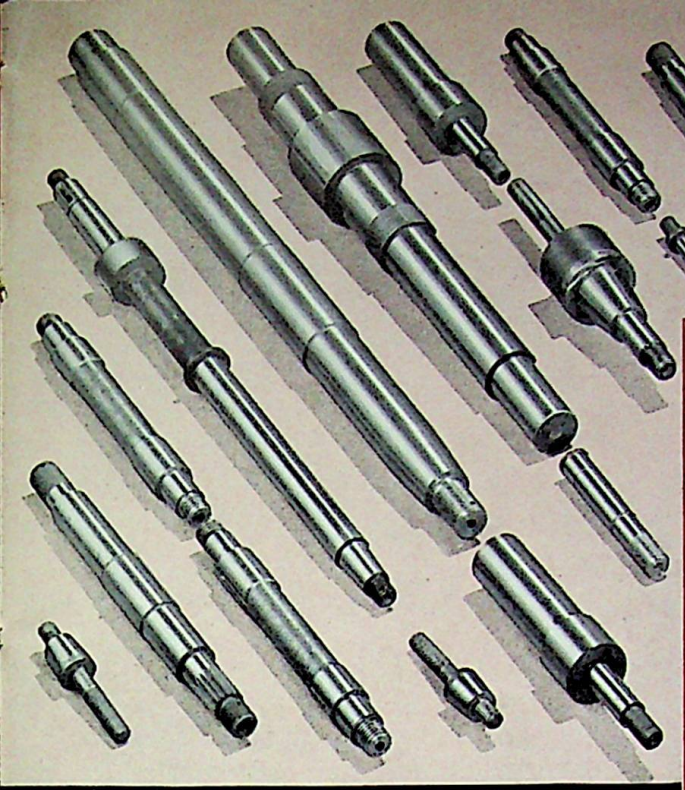
When Undercutting the back diameter from the square turret, the end of the bar stock is supported against the rolls of a Combination End Facer and Turner.

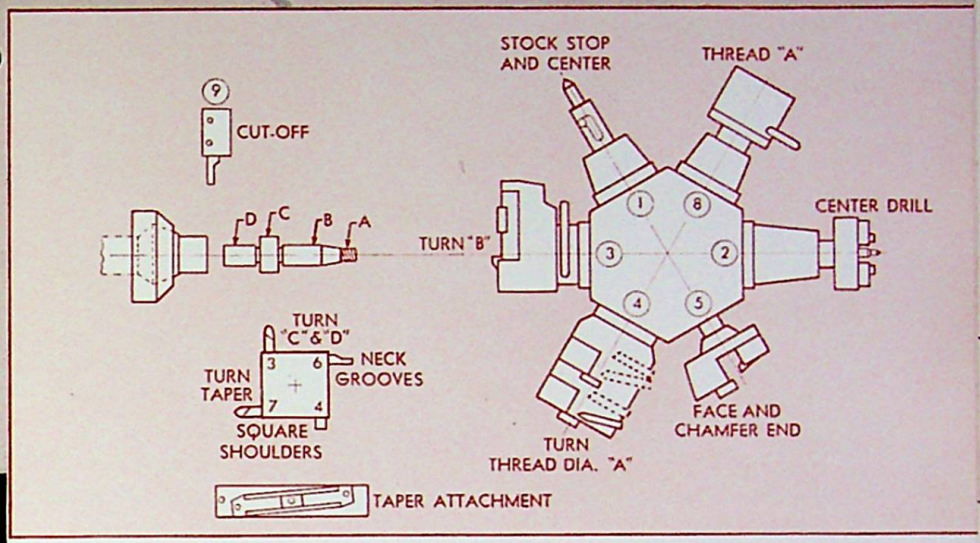
→

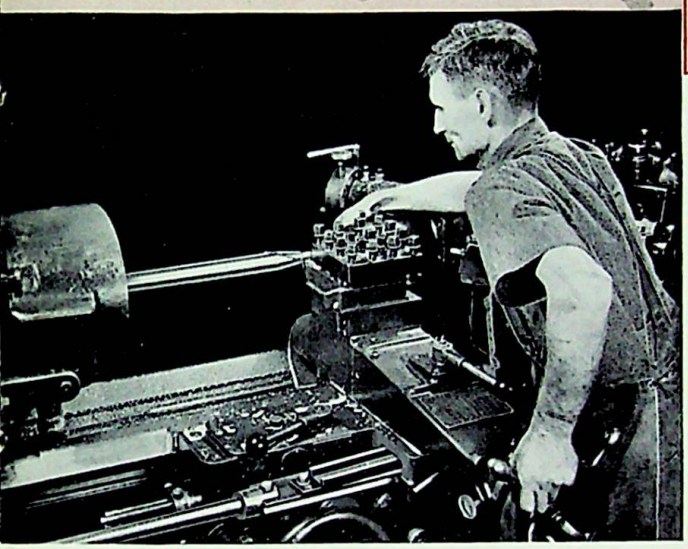
If the Shaft Requires Grinding—A center drilling operation and necking or grooving is done before cut-off.



Threaded Shafts
Tapered Shafts





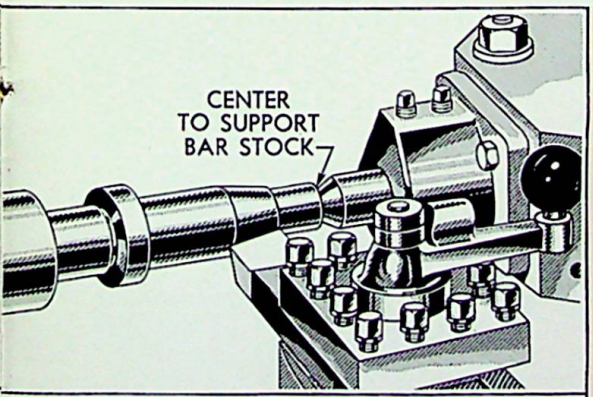


A shaft having a taper and a thread requires operations in addition to those cuts necessary for producing a plain shaft. Taper turning operations on most shaft jobs are usually held to close limits so that mating parts, like hand wheels or pulleys, will fit properly and run true.

Short tapers may be produced with a forming cutter in the square turret. Longer tapers are generally turned from the cross slide using a Taper Attachment.

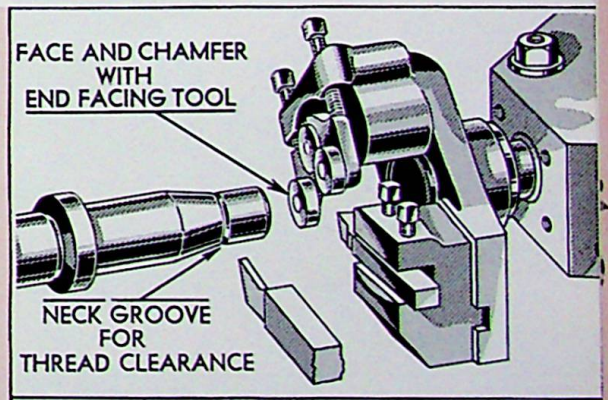
Since shaft work overhangs the collet, a center support is often required to prevent the work from springing away from the cutter and produce a more accurate taper with better finish.

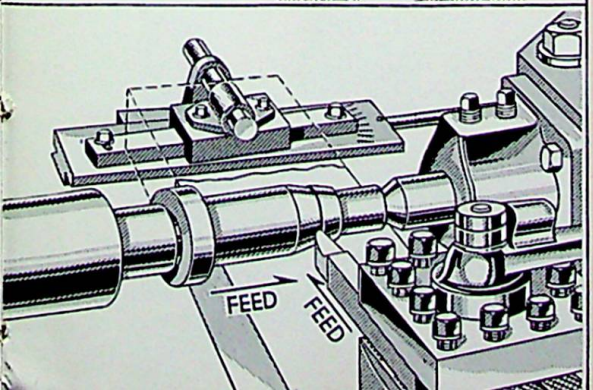
Short threads on shafts are cut with Self Opening Die Heads after chamfering and necking for thread clearance.



Forming Taper—With a forming cutter in the Square Turret, support the shaft with the hexagon turret center to withstand cutting pressure of the forming tool.

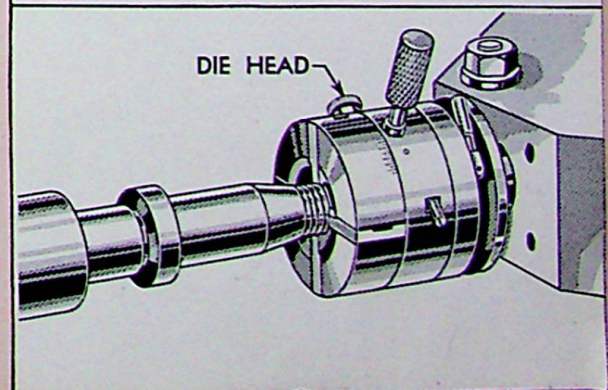
Preparation for Threading—Face and chamfer the end of the piece and neck for die head chaser clearance.



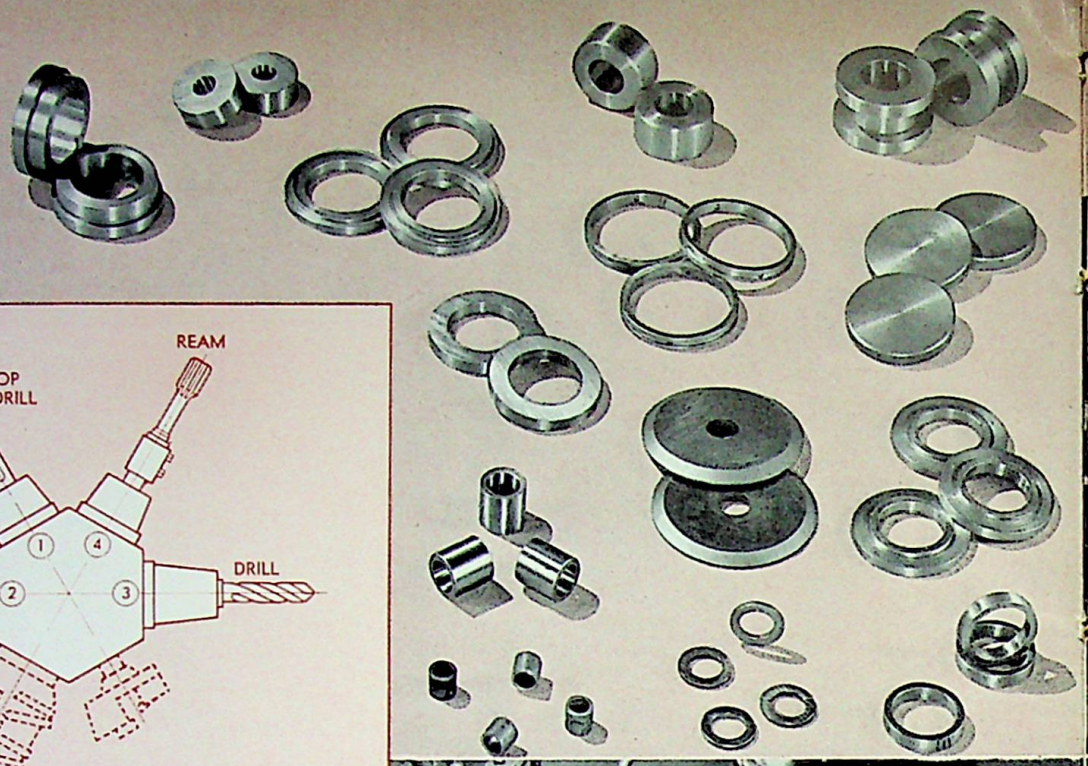


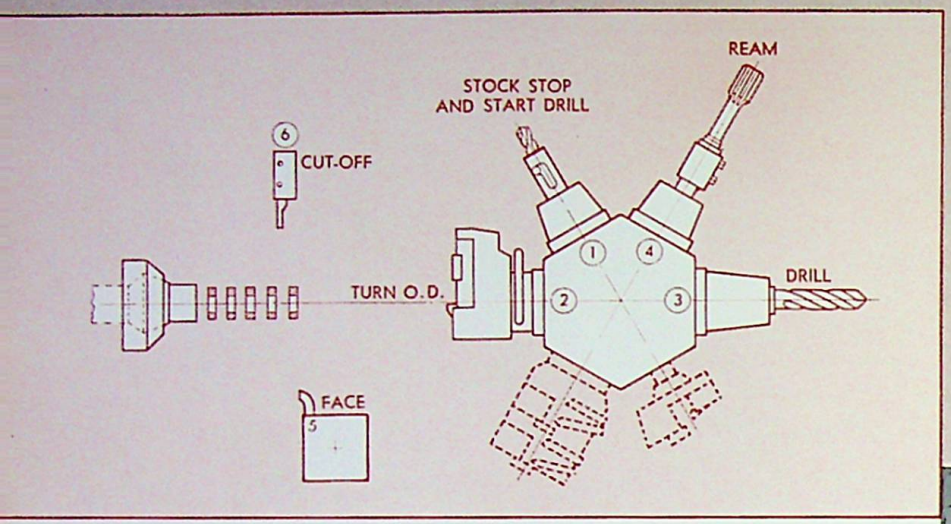
Single Point Taper Turning—Support the end of the shaft from the hexagon turret and feed the cross slide cutter away from the spindle.

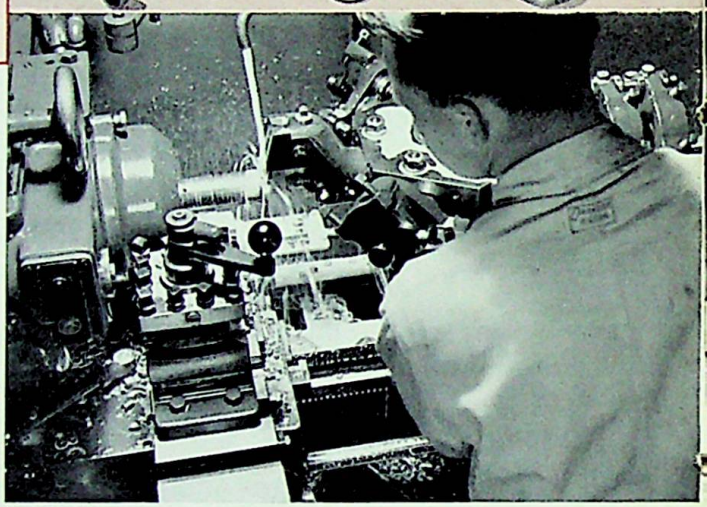
Cutting the Threads—Die heads are used for cutting short threads on shaft work.



Washers, Spacers and Collars



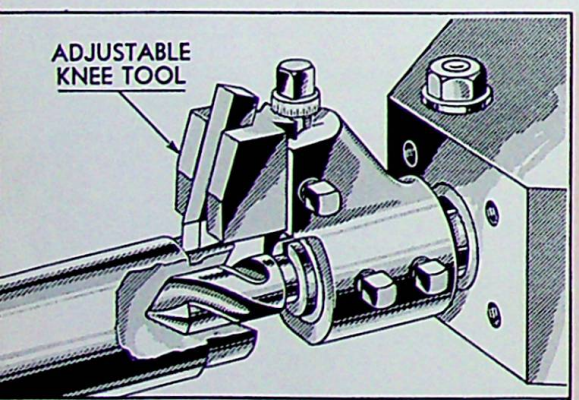




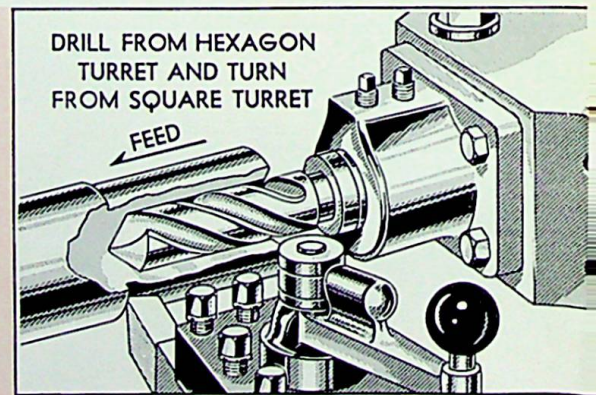
The principal machining operations required for washers, spacers and collars are internal cuts—drilling, boring, reaming, recessing and tapping.

This class of work is often produced in groups or "nests" by drilling and turning a number of parts at one time, before facing and cutting off to width. To maintain accurate limits on width, a fixed position is established between the cut-off tool and the facing cutter. The cut-off tool is placed in the rear tool post and the facing cutter in the square turret or front tool post.

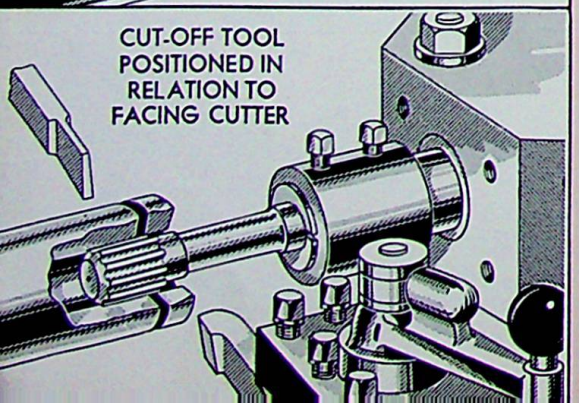
The drilling and turning may be done by either of two methods. As "multiple cuts" using the Adjustable Knee Tool, or as "combined cuts" by turning the outside diameter from the cross slide while the hole is being drilled from the hexagon turret.



"Multiple Cuts"—Drilling the hole and turning the outside diameter with the Adjustable Knee Tool. A similar set-up may be used for finish turning and boring.

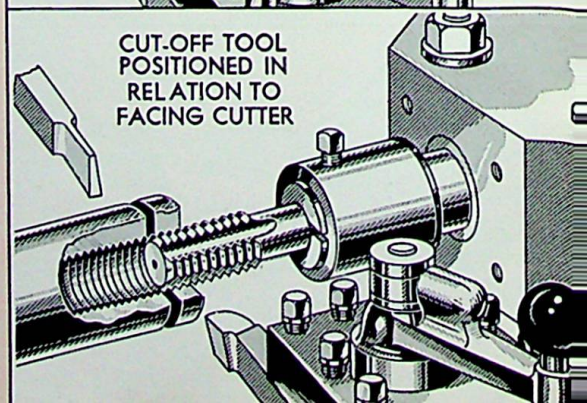


"Combined Cuts"—Turning the outside diameter from the cross slide while the hole is drilled from the hexagon turret. The drilling cut helps to steady the work while the square turret is turning.

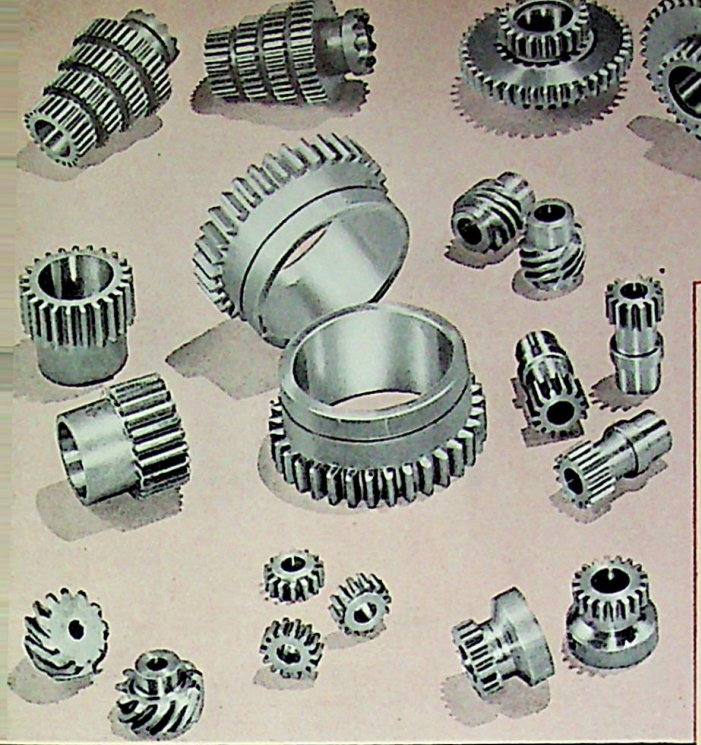


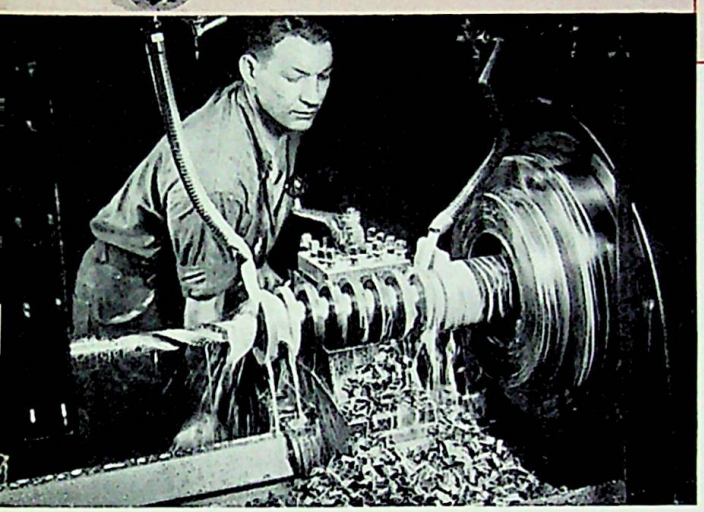
Facing and Cutting Off to Accurate Width—The cut-off tool is positioned in relation to the facing cutter.

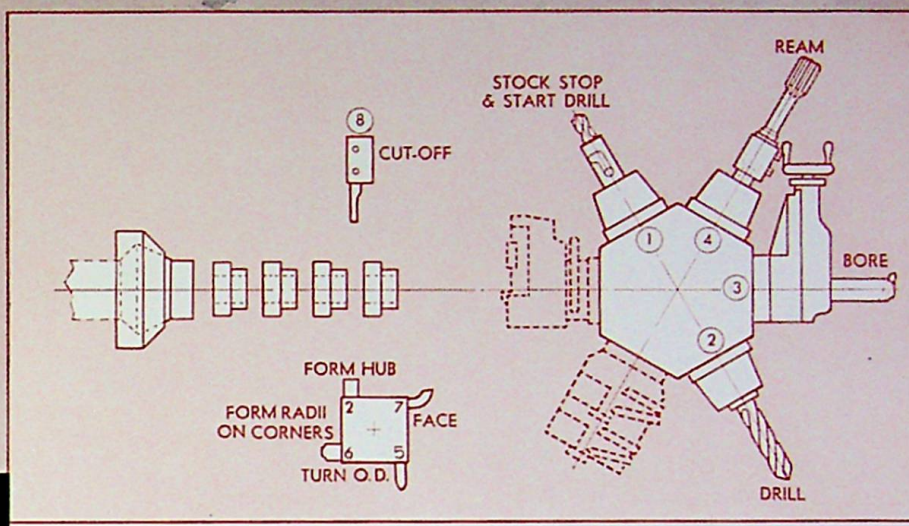
Internal finishing cuts, reaming and tapping, are completed for entire group before final facing and cut-off.



Small Gear Blanks and Clutch Cones



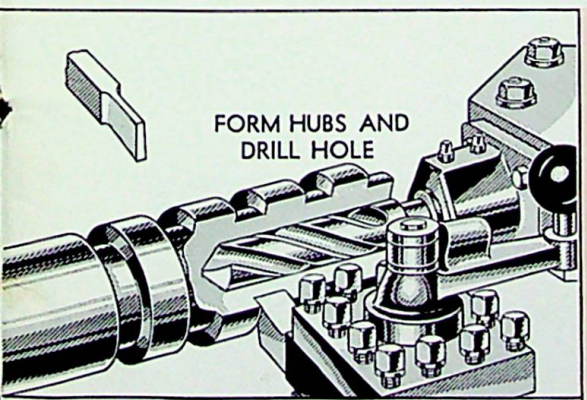




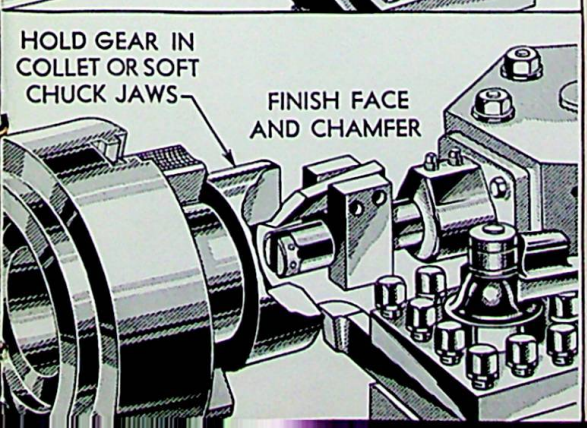
Small gear blanks and clutch cones are often made in "nests." A forming cut from the cross slide forms the short hub to size while the hole is being drilled. The drill also provides additional support for the bar stock to withstand the pressure of the heavy forming cut. Wide hubs, having close limits on diameter, may require an additional turning cut for final size.

For second operation work on small gear blanks, the part is held in soft jaws of a scroll chuck, the opposite face finished, the corner radii formed and the hole chamfered.

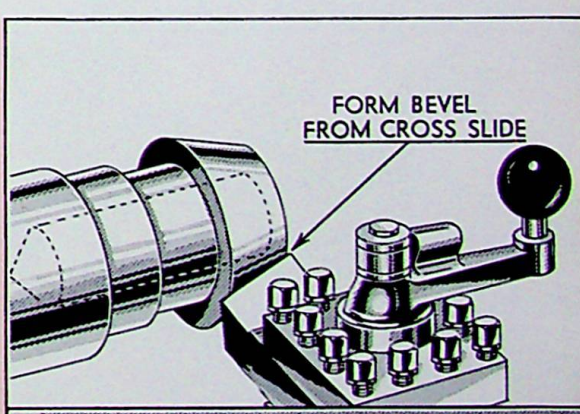
Clutch Cones call for hexagon turret set-ups similar to small gear blank work. The beveled surface is formed with a cutter in the square turret or generated with a Compound Cross Slide swung to the correct angle.



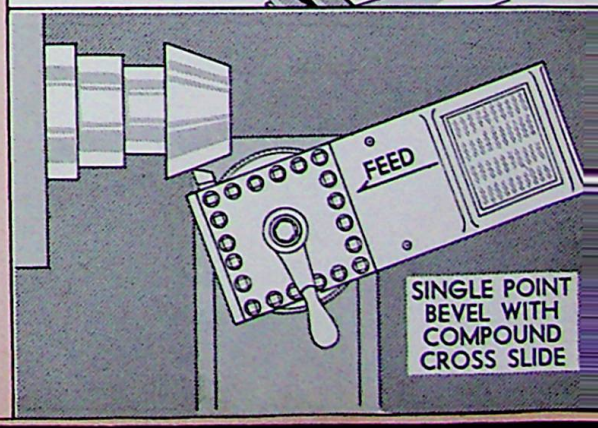
The hub of the gear is formed while the hole is drilled as a combined cutting operation. The part is cut off after all machining work is finished.



Second Operation—Facing the opposite side from the cross slide and chamfering the hole using a Boring Bar Chamfering Head.

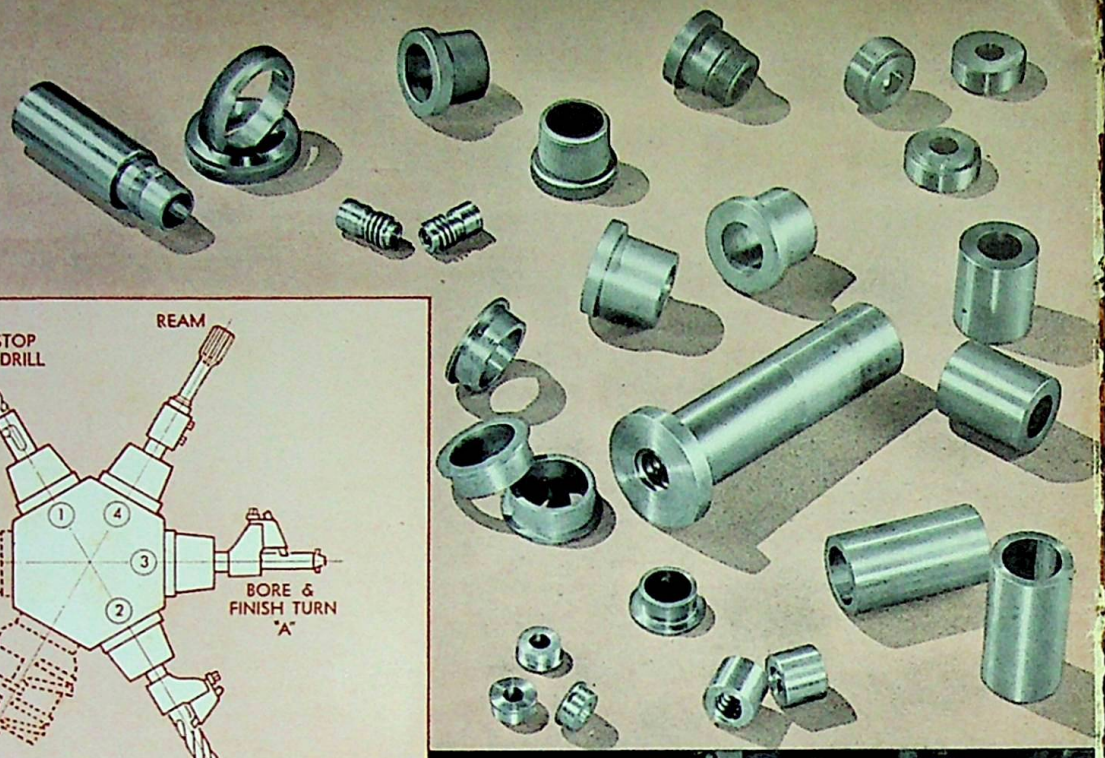


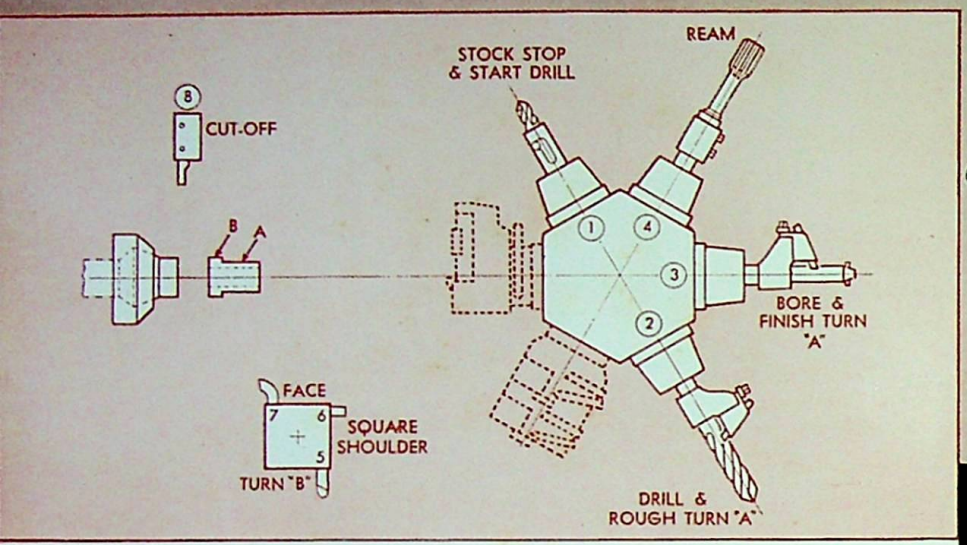
Forming bevels on clutch cones with a forming cutter on the cross slide. For longer work that overhangs the spindle, a hexagon turret support may be necessary.

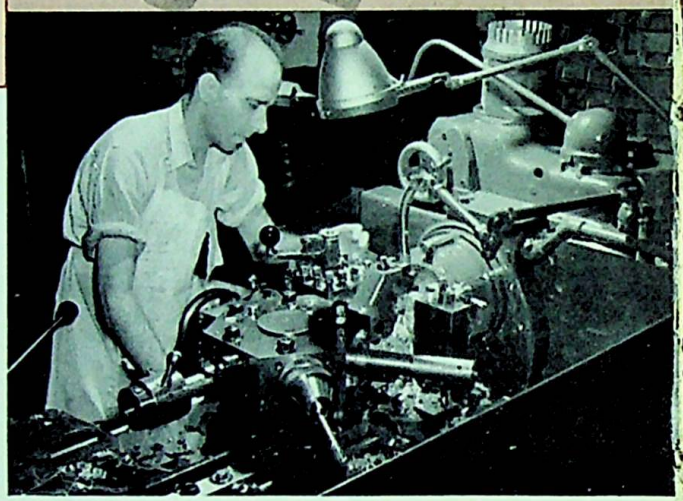


Generating accurate bevels with a forged cutter in the square turret of the Compound Cross Slide.

Small Bushings and Inserts



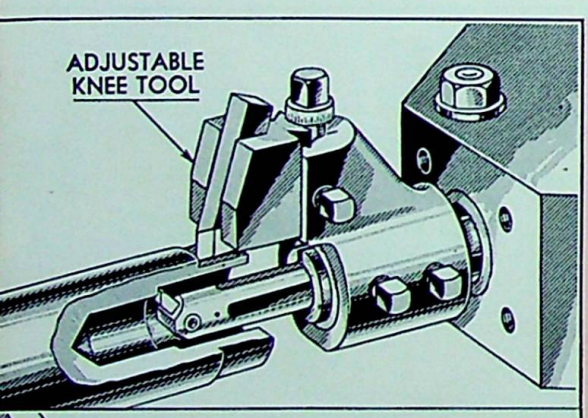




Close concentricity between outside diameter and bore is a common requirement of bushings and inserts. Concentricity is generally obtained by completing all machining operations in one chucking before cutting off from the bar stock.

Combined turning and boring cuts on smaller bushings are performed with the Adjustable Knee Tool. By placing the cutter in the boring bar with the cutting end up, more accurate duplication of internal sizes is assured. Internal grooves on small bushings may be recessed with a Quick Acting Slide Tool.

Inserts are simply threaded bushings. Concentricity requirements determine whether the single point threading method should be used in preference to a die head.

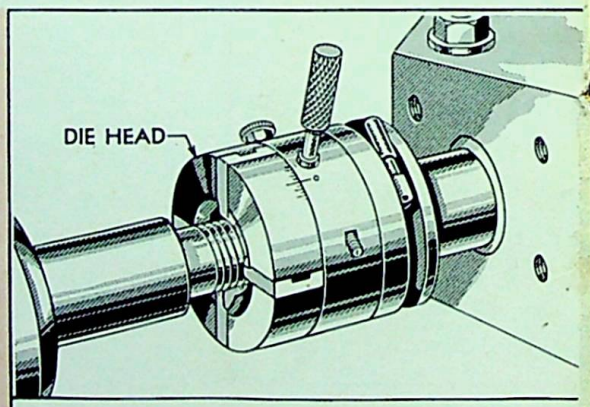


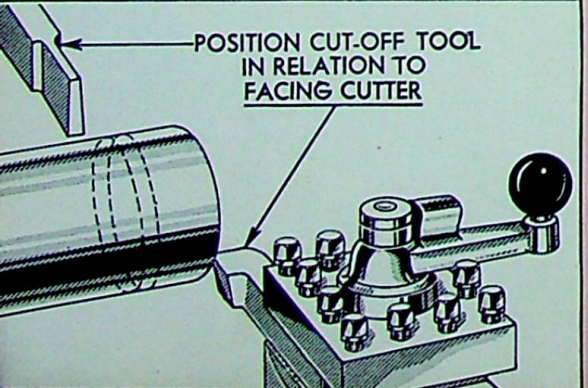
"Multiple Cuts"—Turning and boring with the Adjustable Knee Tool.

Placing the turning and boring cutters vertically assures more accurate duplication of sizes.

The combined hexagon turret boring and square turret turning method may also be used.

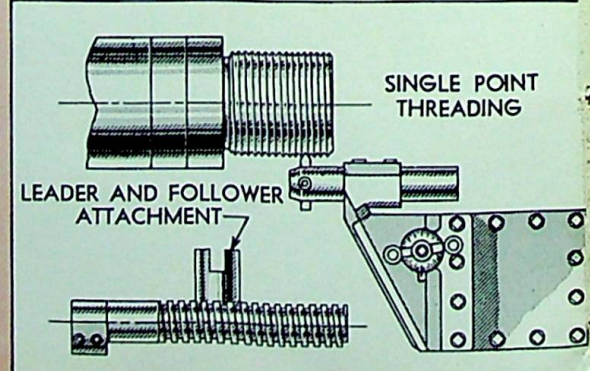
For general threading requirements, a die head or tap may be used to cut the threads on inserts.





Bushing lengths are duplicated by positioning the cut-off in correct relation to the facing cutter.

For close concentricity between the thread and the bore, the single point threading method is preferred.



HOW TO SET UP UNIVERSAL CHUCKING TOOLS

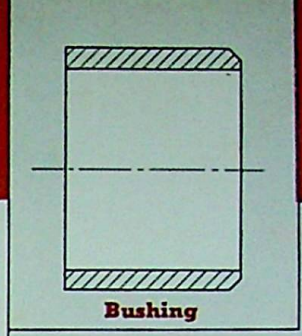
A general tooling set-up should be established that will provide maximum flexibility for machining all types of chucking work in small, medium, or larger quantity lots. A set of Universal Chucking Tools is mounted permanently to the hexagon turret. Each tool, as required, is indexed into position to handle specified turning, boring and other machine cuts.

Small Lot Work: Turning from the square turret and boring from the hexagon turret are done as "combined operations." Where only one or two pieces are to be made, machine stops are not set and scales or bar gauges are used for determining length.

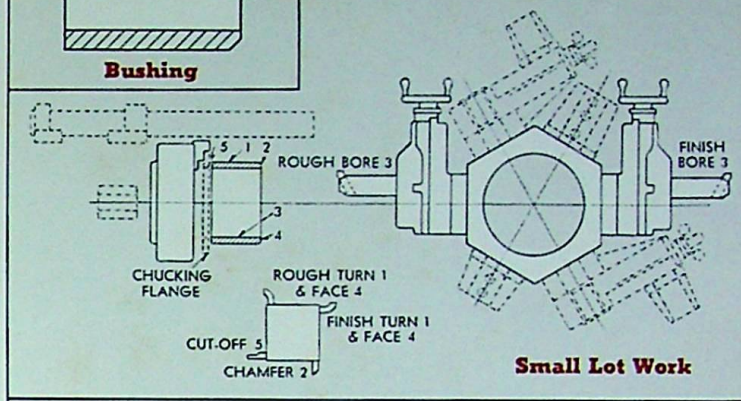
Medium Quantity Lots: Turning and boring are handled as "multiple cutting operations" in one pass of the hexagon turret. Square turret operations, like turning and facing, are combined with longitudinal cuts from the hexagon turret.

The suggested "Universal Chucking Tool Set-up" is adaptable for all general purpose chucking work. Since the heavy tools like the turning heads and slide tools remain fixed to the hexagon turret, it is only necessary to reposition the cutter holders during set-up changes. Standard tools, like drills, reamers, and taps, are inserted in the Flanged Tool Holders.

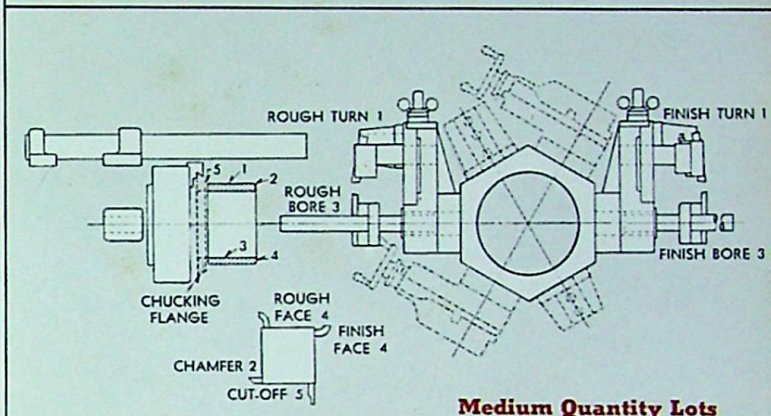
PERMANENT CHUCKING SET-UP



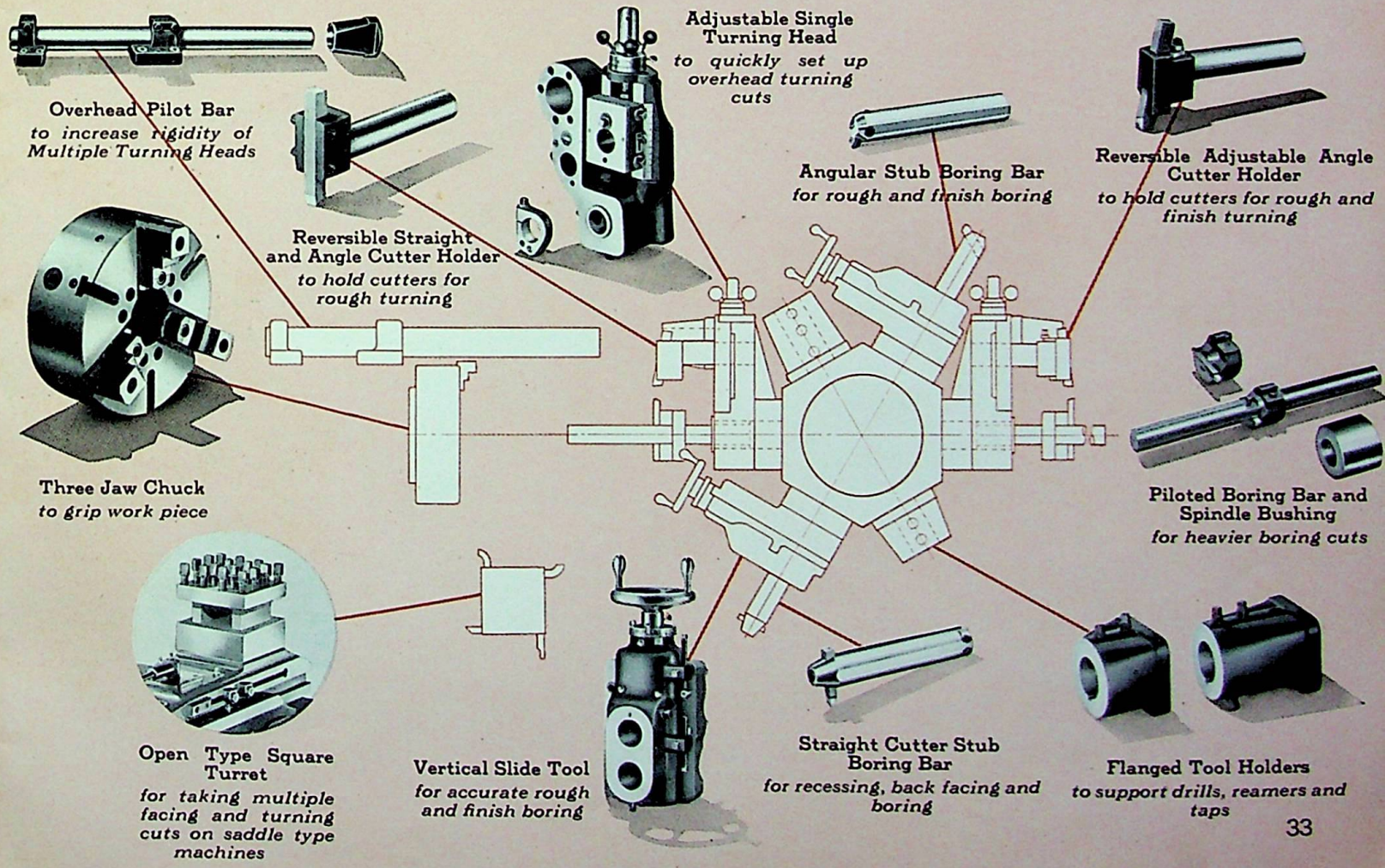
Bushing



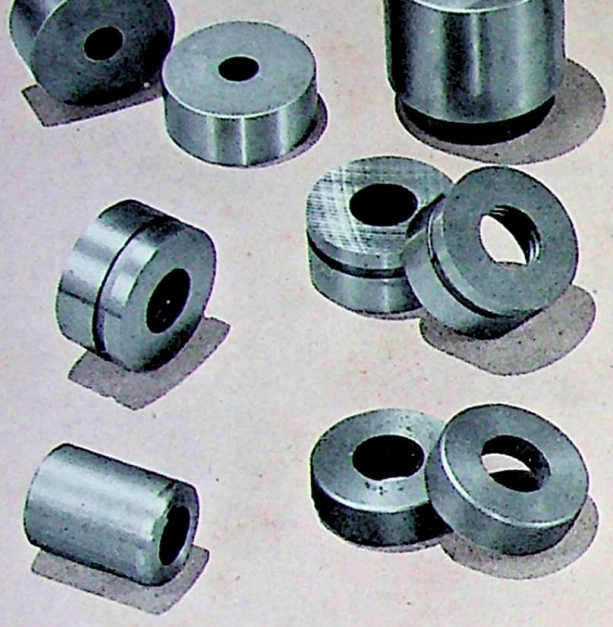
Small Lot Work



Medium Quantity Lots

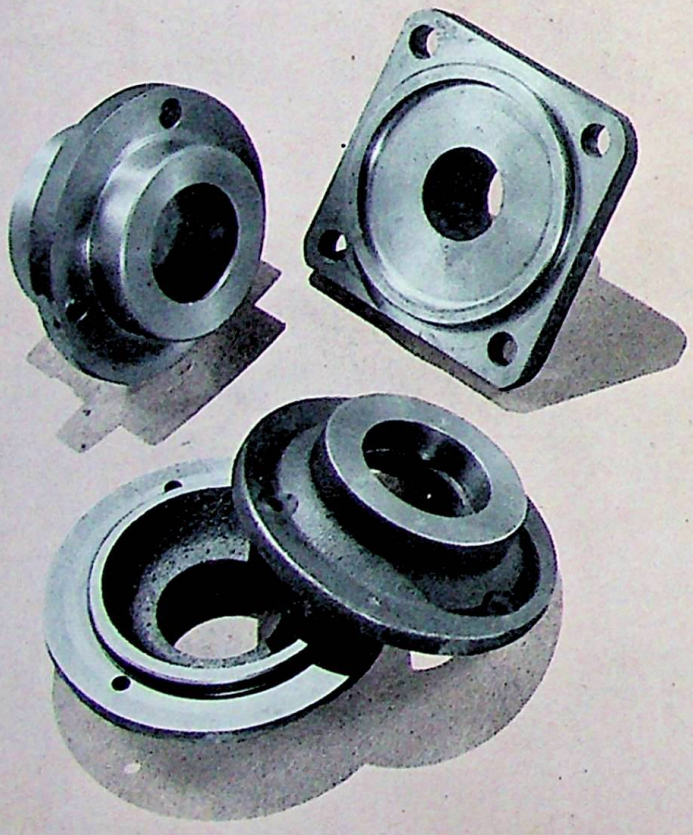


REPRESENTATIVE

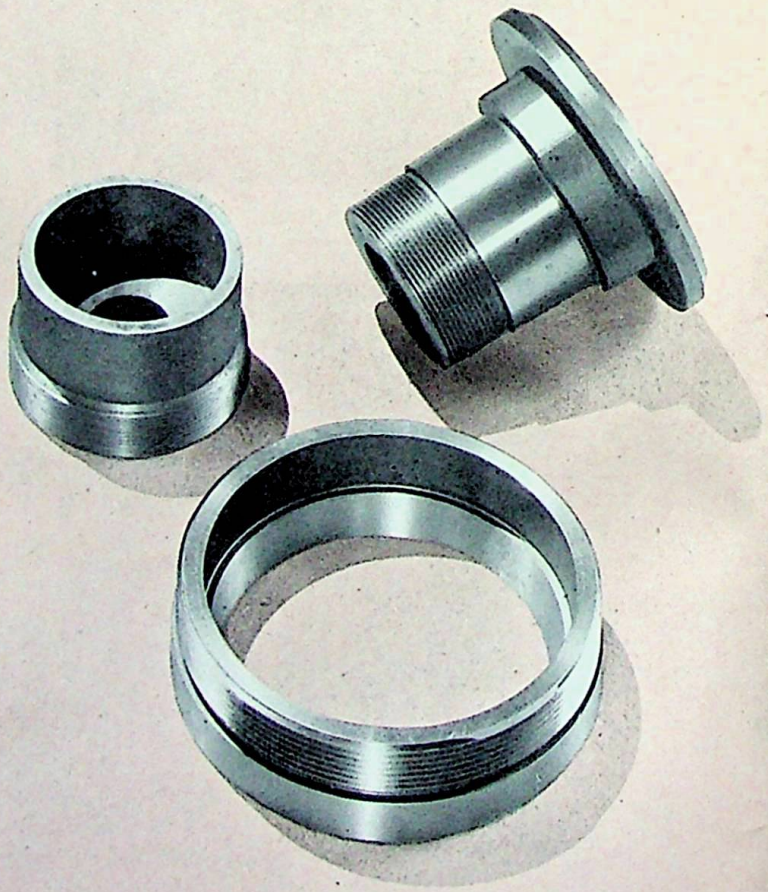


Rolls and Thrust Washers . . . Page 38

Collars . . . Page 39

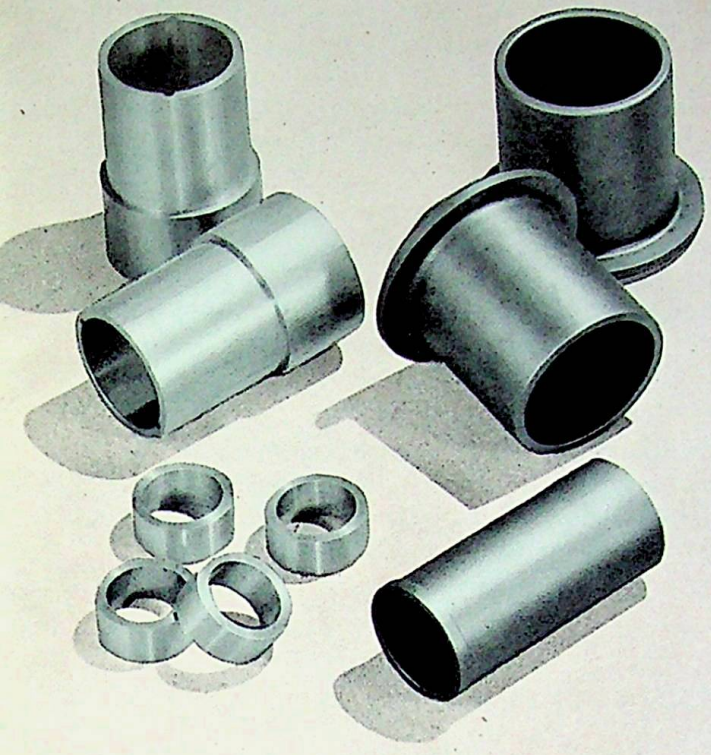


Flanges . . . Page 40

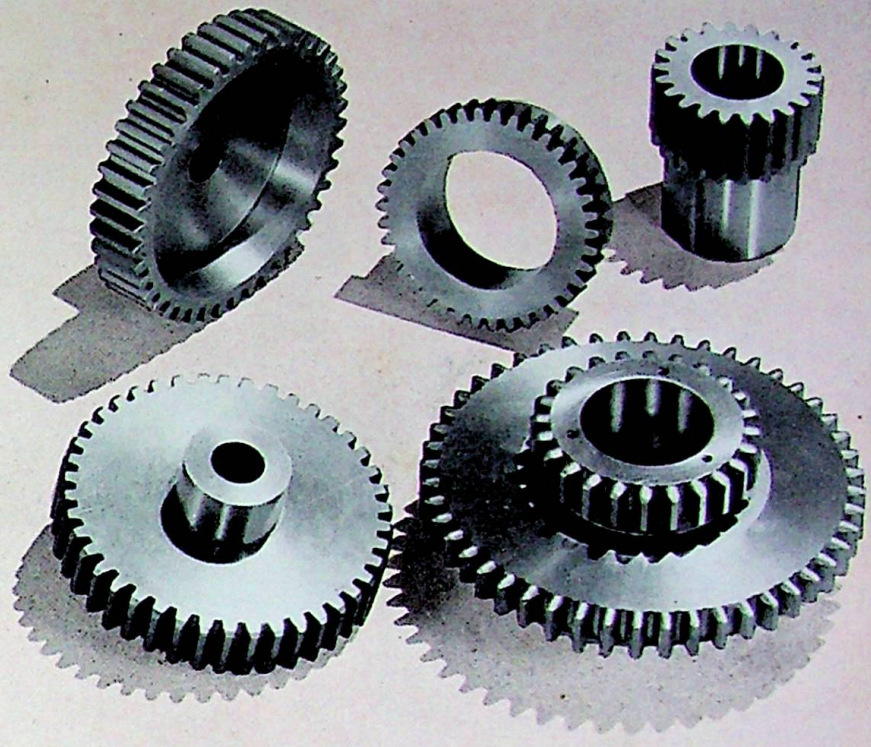


Sleeves and Inserts . . . Page 41

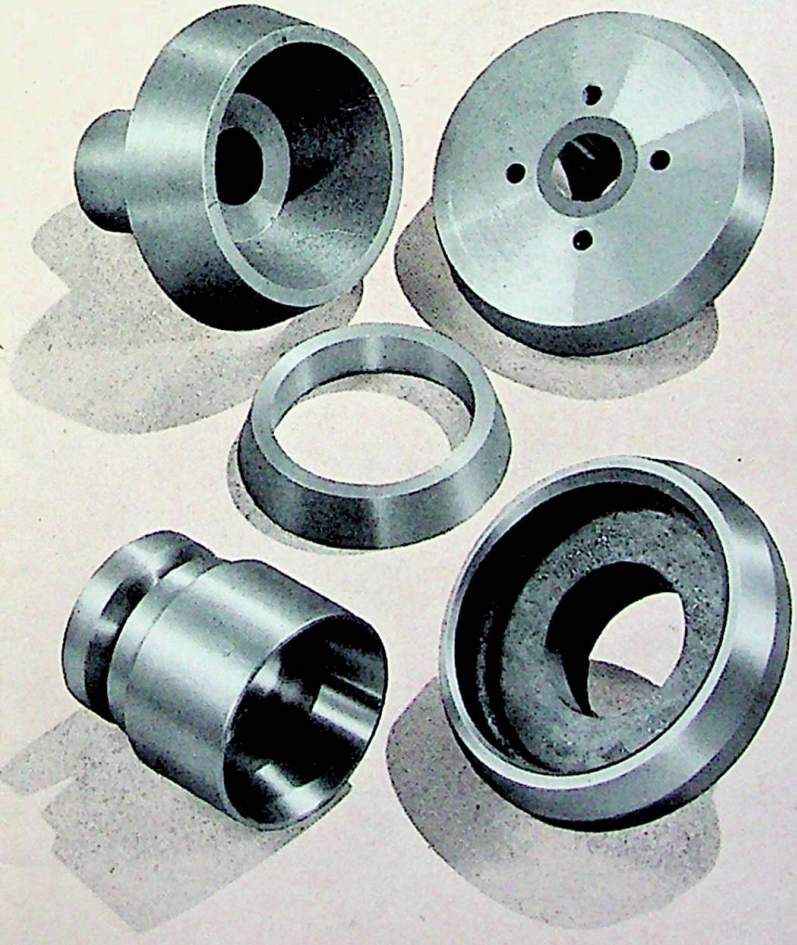
CHUCKING WORK



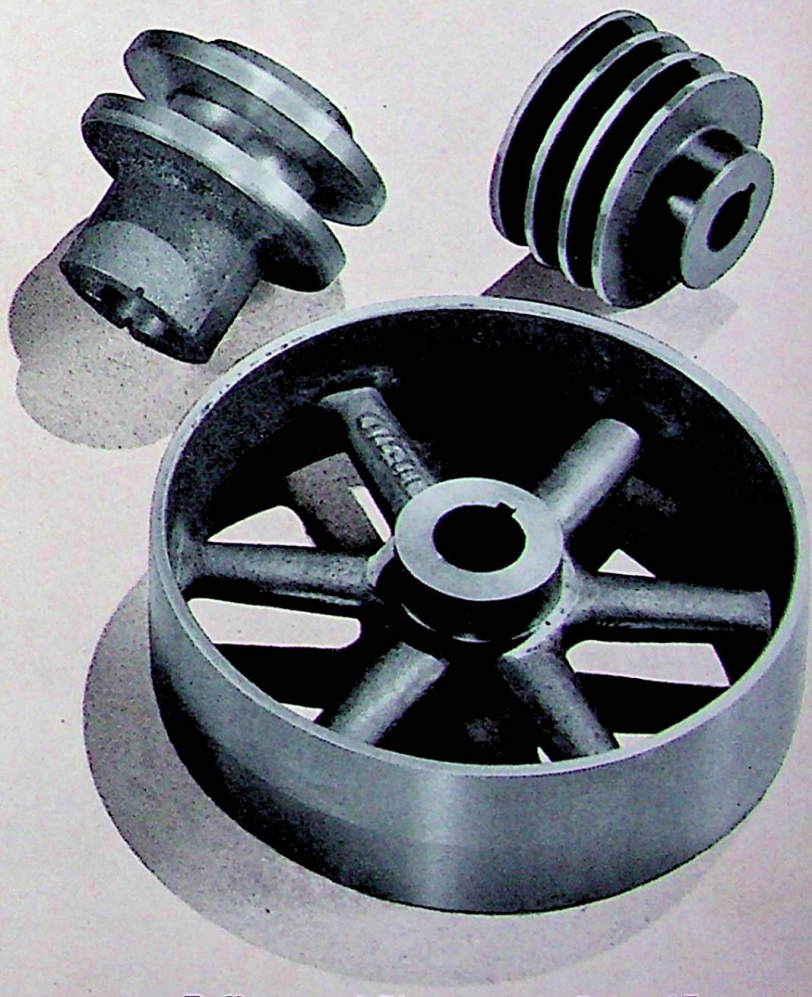
Bushings . . . Page 42



Gear Blanks . . . Page 43

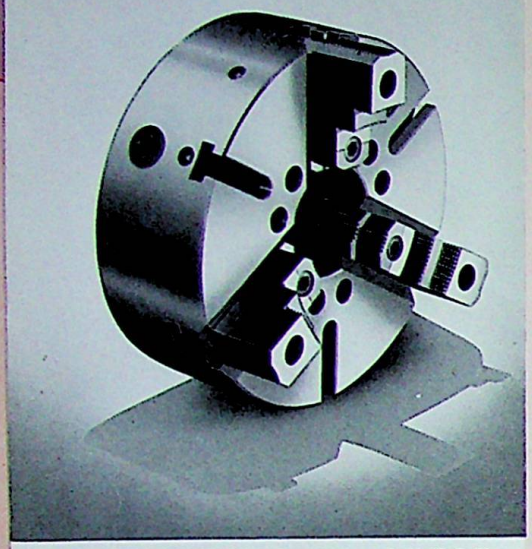


Cone Frictions . . . Page 44



Pulleys and Sheaves . . . Page 45

GENERAL PURPOSE HEXAGON TURRET

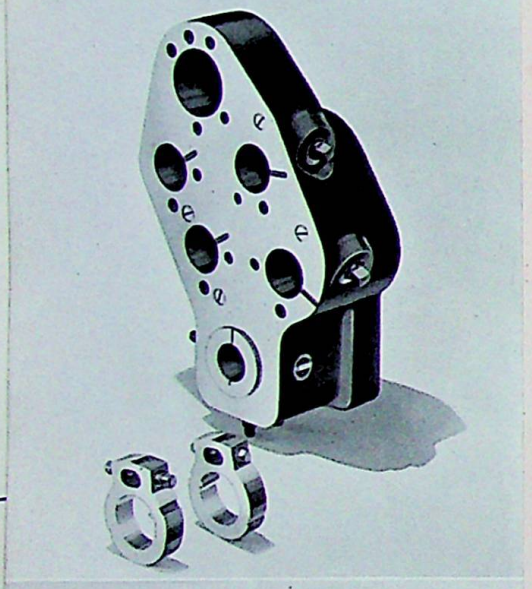


3 JAW UNIVERSAL CHUCK

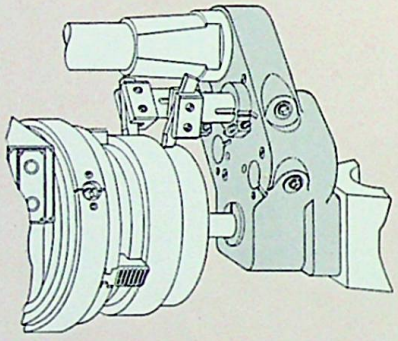
Chucking type turret lathe tools must necessarily overhang the hexagon turret to reach forgings and castings held in chucks and fixtures. As a result, maximum tool and turret rigidity are of prime importance when handling multiple cutting operations from the hexagon turret.

Reliable accuracy in quickly setting cutting tools to size is also an essential requirement with chucking equipment. Cutter slide blocks on Adjustable Single Turning Heads and Vertical Slide Tools are equipped with micrometer screws and dials to allow instant adjustment on diameters to thousandths of an inch, both for obtaining size and maintaining diameters in the event of cutter wear.

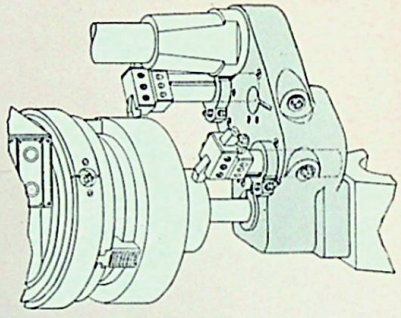
Illustrated here are the fundamental tools incorporated in hexagon turret chucking set-ups. Other available supplementary tools may also be incorporated into chucking set-ups for machining jobs of unusual shape or specification.



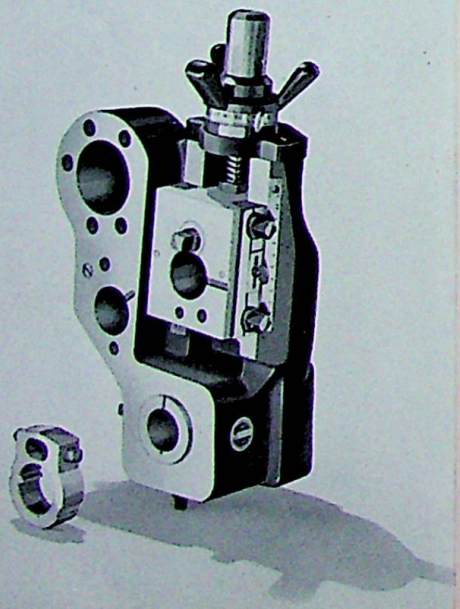
MULTIPLE TURNING HEAD



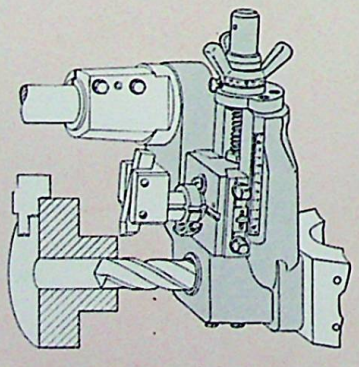
To rough turn one or more diameters



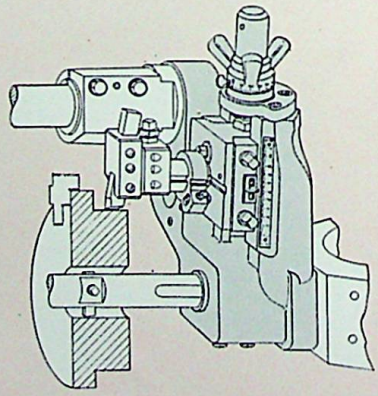
To finish turn one or more diameters



ADJUSTABLE SINGLE TURNING HEAD

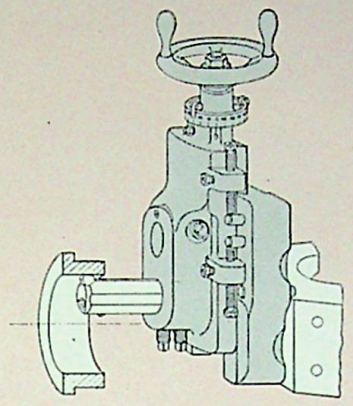


Drilling and rough turning at one time

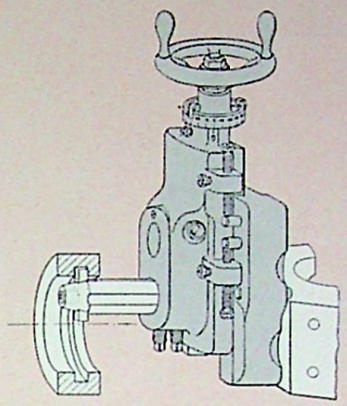


Boring and turning at one time

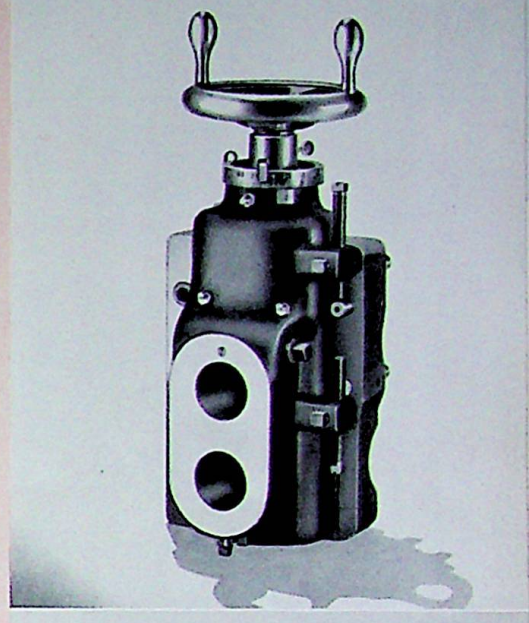
VERTICAL SLIDE TOOL



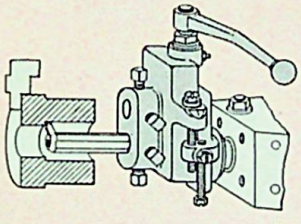
For accurate boring



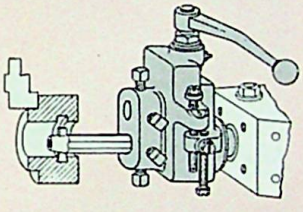
For recessing



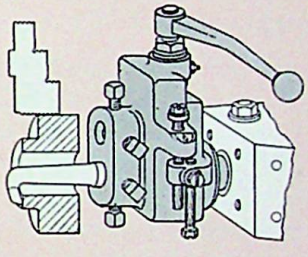
QUICK ACTING SLIDE TOOL



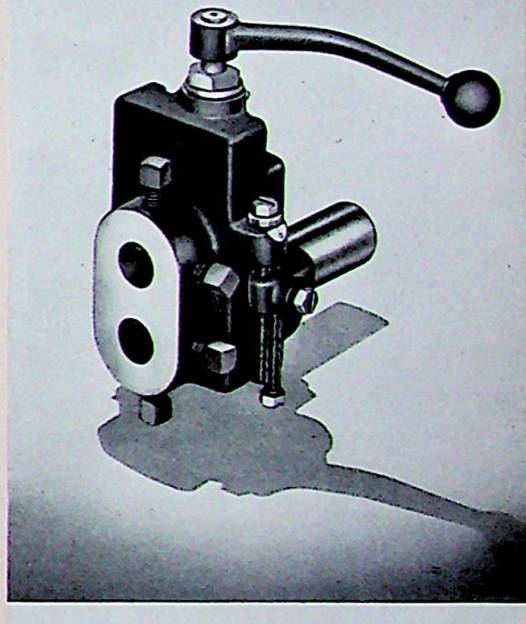
For boring.



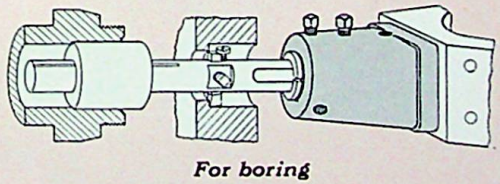
For recessing



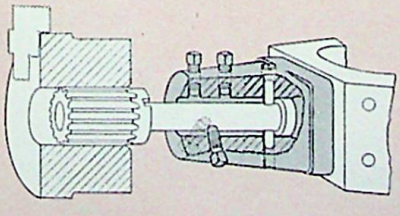
For back-facing



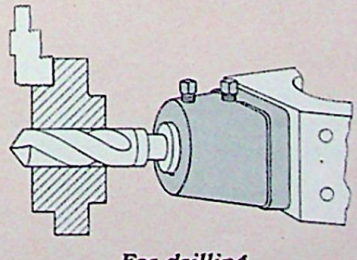
FLANGED TOOL HOLDERS



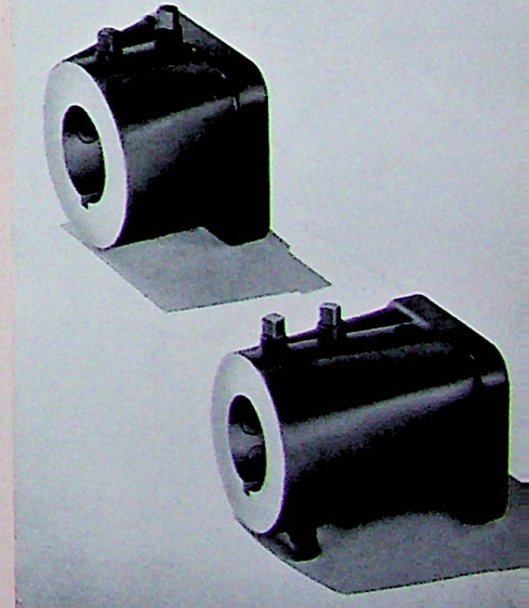
For boring



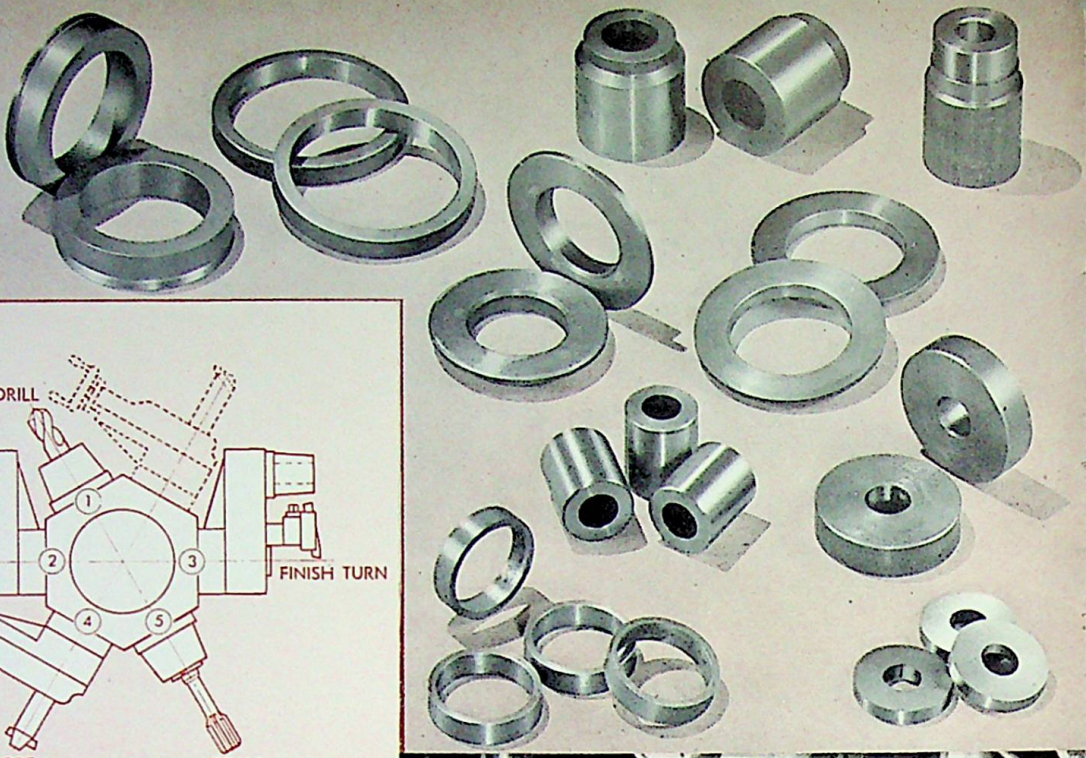
For reaming.

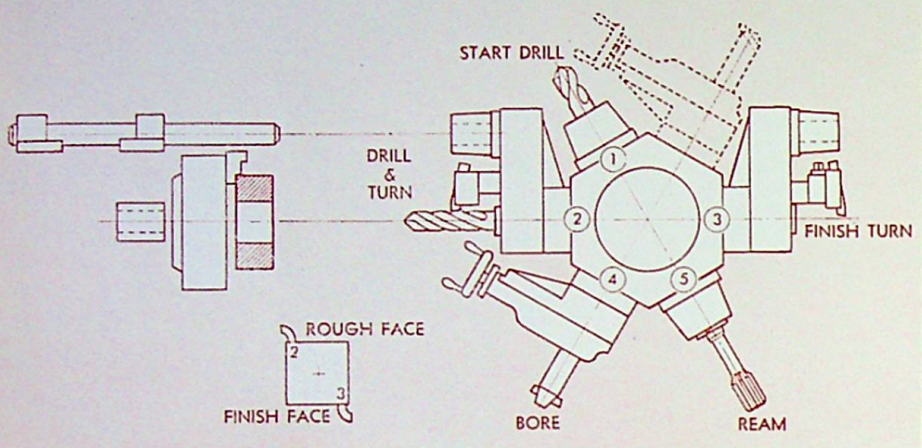


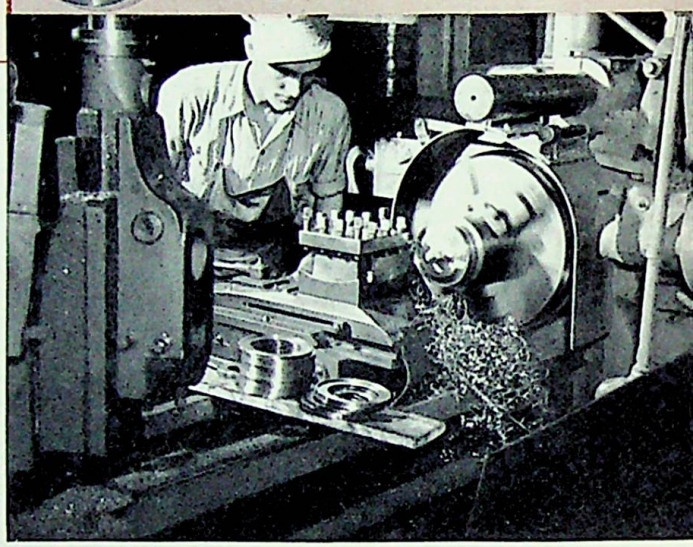
For drilling.



Rolls and Thrust Washers

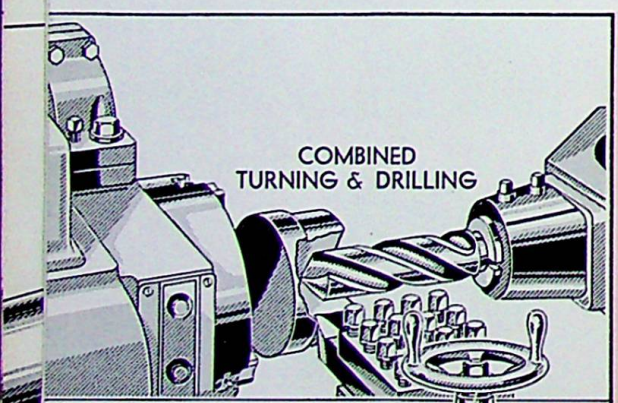




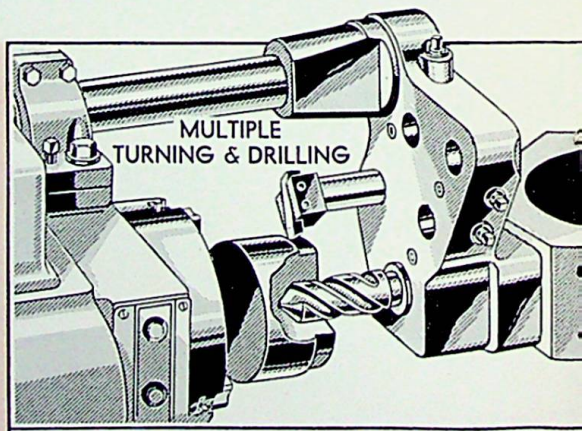


Plain turning, boring and facing cuts are basic operations on rolls and washers. To remove as much metal at one time as possible, the internal and external operations are done as "Combined Cuts" (hexagon turret turning and square turret drilling), or, as "Multiple Cuts" (drilling and turning from the hexagon turret). "Combined Cuts" are commonly used on small lot work—"Multiple Cuts" on larger quantity lots.

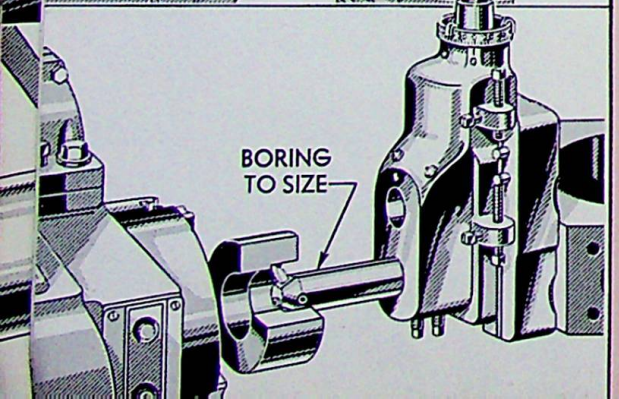
In a second operation, the work is gripped in soft jaws of a scroll chuck and the unfinished diameter turned to size. This procedure, referred to as "Matched Cuts," is used except in cases where extremely close limits of size and concentricity are specified. In such cases sufficient stock is left on the outside diameter for a third finishing operation which is performed by mounting the roll on an arbor between centers.



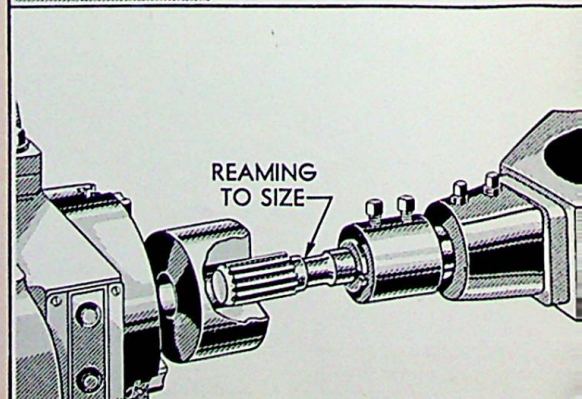
Combined Cuts—Square turret turning while drilling from the hexagon turret.



Multiple Cuts—Drilling and turning from the hexagon turret with an Overhead Piloted Multiple Turning Head.

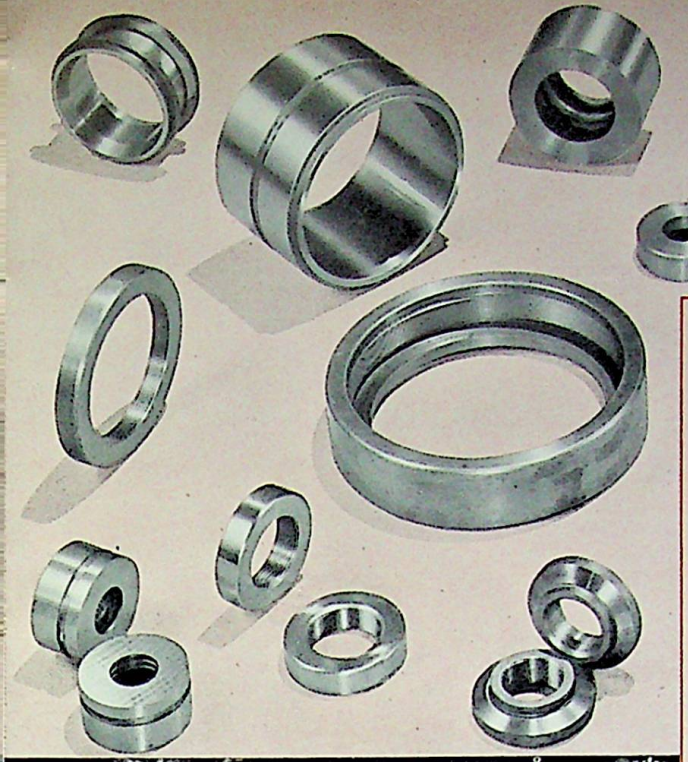


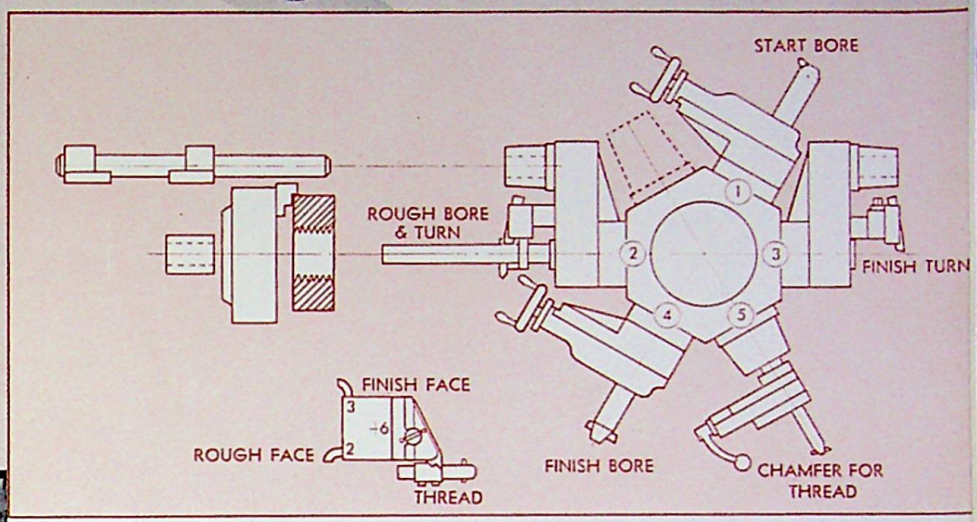
Finish Boring—Single point boring for concentricity, size and finish using a Vertical Slide Tool.

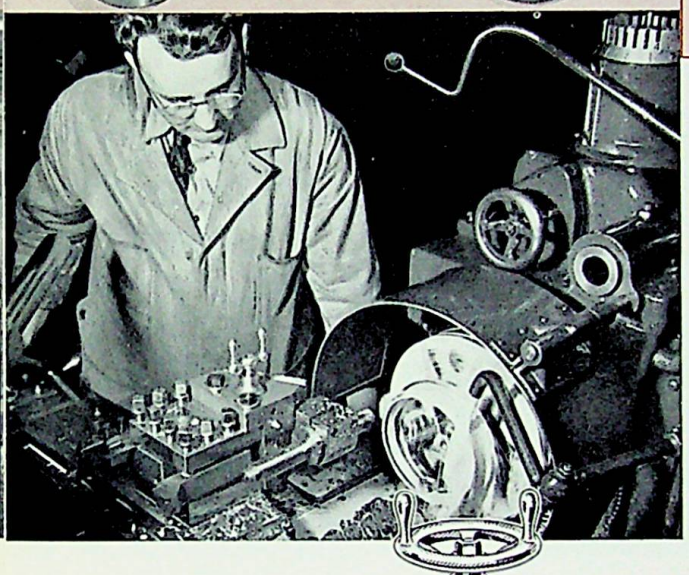


Reaming—Accurate hole size and finish are obtained with a reamer in a Floating Tool Holder.

Collars



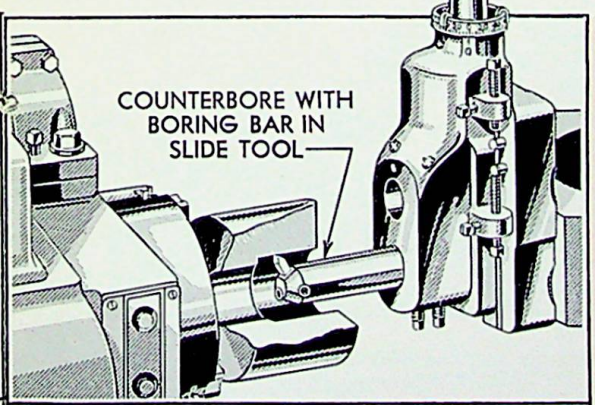




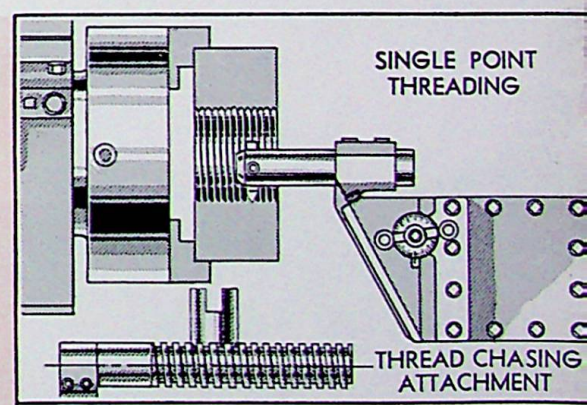
Larger diameter collars, usually produced from castings or forgings, require close attention to the internal operations—boring, threading or taper finishing. When the internal surfaces must be held square and concentric with the external surfaces, these cuts are completed as far as possible in one chucking.

Larger diameter or odd size internal threads are finished with single point threading tools using a Thread Chasing Attachment or Lead Screw for leading-on the square turret unit. The Vertical Slide Tool is used for counter boring or bottom facing the shoulder of the thread. A Quick Acting Slide Tool provides means for quickly chamfering the first thread. Threads of small diameter are generally cut with taps.

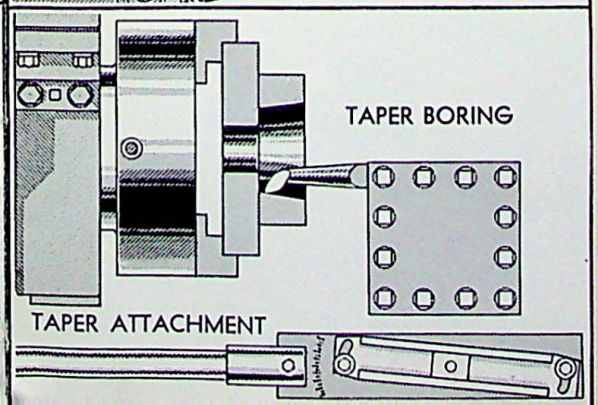
Internal or external tapers may be formed, or, using a Taper Attachment, may be single pointed from the square turret.



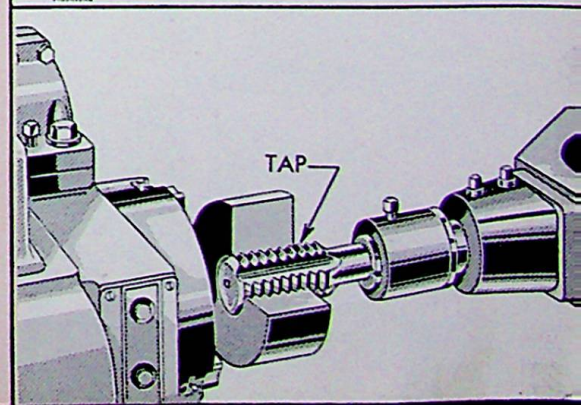
← **Counter boring** and bottom facing for the thread using the Vertical Slide Tool.



→ **Single point threading** with the Square Turret Adjustable Threading Tool Holder.

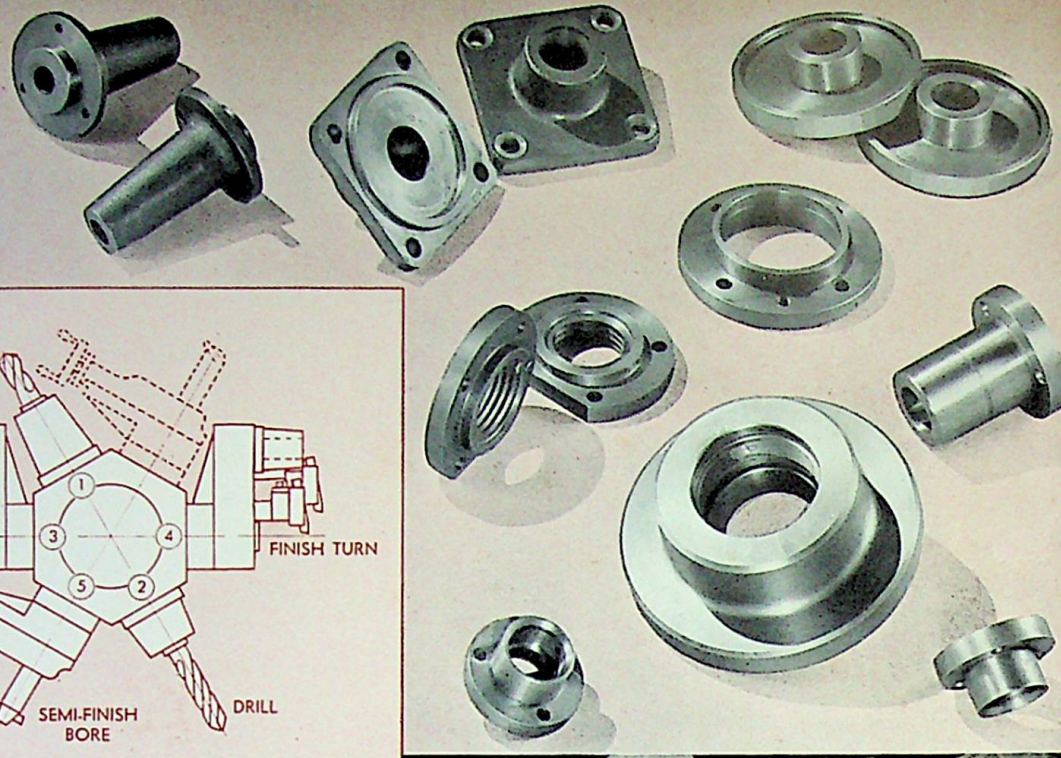


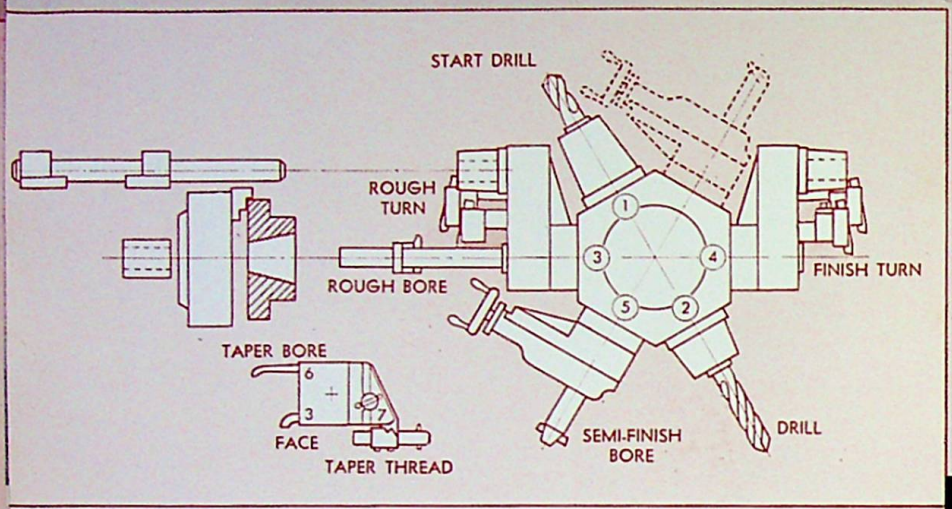
← **Single pointing** the internal taper using the square turret and Taper Attachment.



→ **Cutting standard small diameter threads** with a tap held in a Clutch Tap and Die Holder.

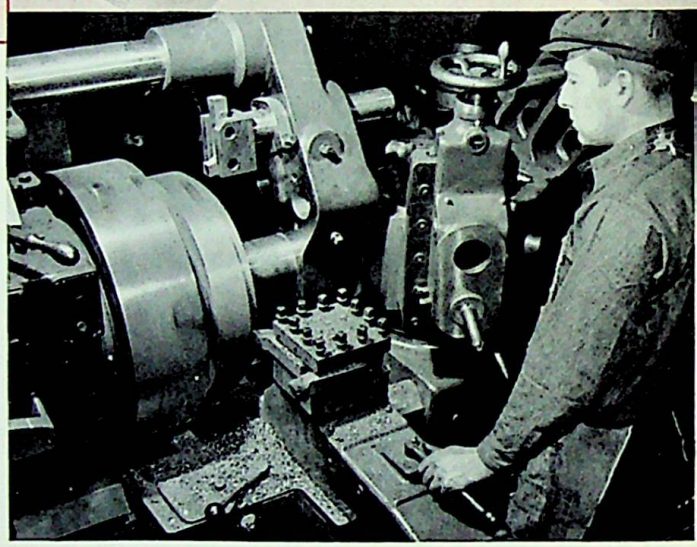
Flanges

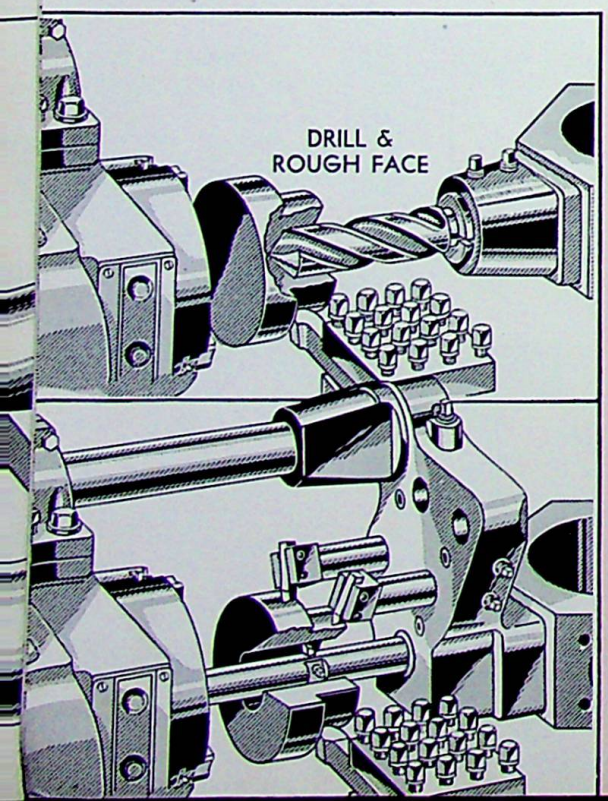




Two or more turned diameters on flanged parts call for "Multiple Cuts" on the outside turning operations. Multiple Turning Heads equipped with Overhead Pilot Bars are set up to rough the outside diameters and bore the hole. Adjustable Angle Cutter Holders in a second Multiple Turning Head provide for the finish turning operations. Facing cuts from the square turret are taken while the turning cuts from the hexagon turret are in progress. Internal taper threads, requiring accurate limits, are single pointed. Internal grooves are cut with a boring bar in a Quick Acting Slide Tool.

In pipe flange machining, a "phonograph" finish may be specified on the mating flanged face to assure steam tight joints when assembled with packing or gaskets. A sharp pointed facing cutter and coarse cross feeds produce such a finish.



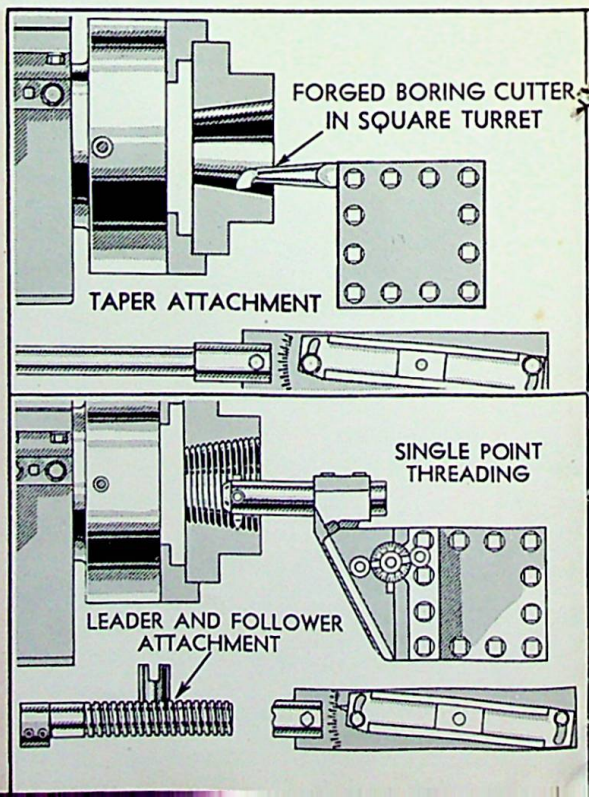


←
Rough facing from the square turret while drilling from the hexagon turret.

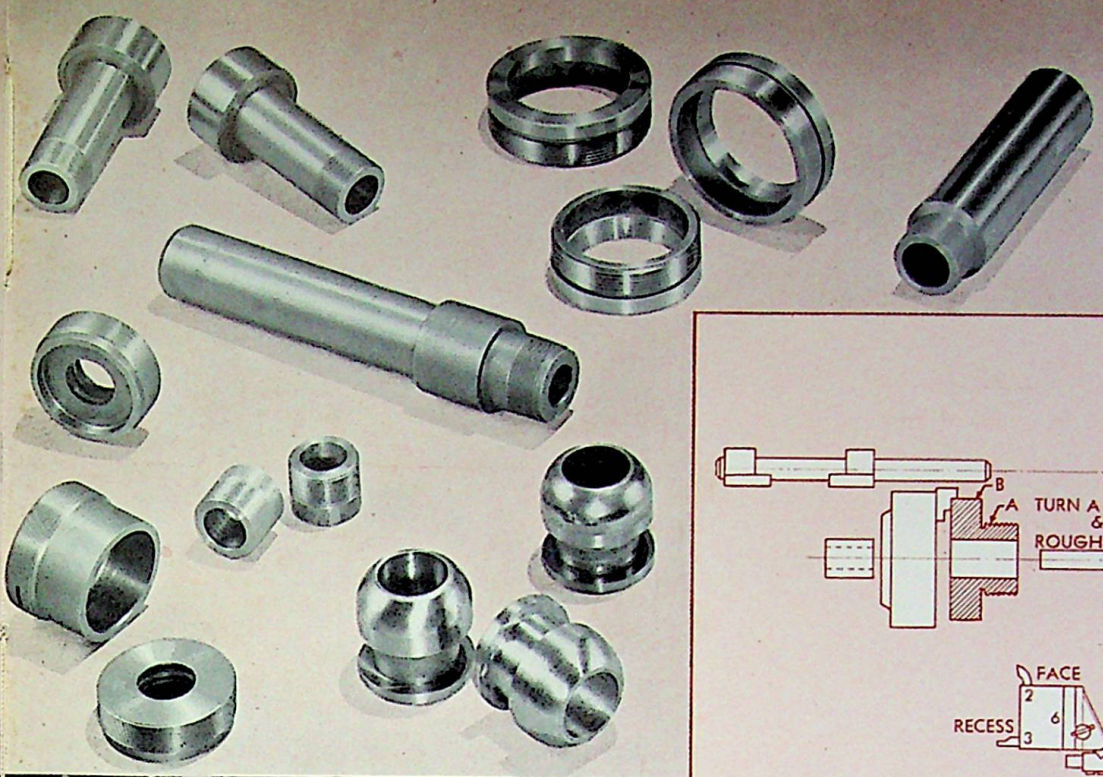
→
Taper boring flanges with the cross slide Taper Attachment.

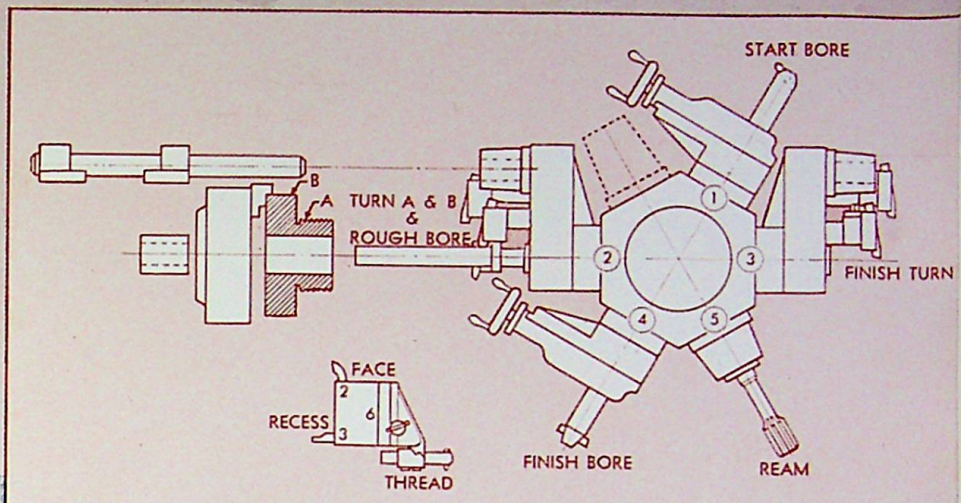
←
Cross slide facing while multiple turning and boring from the hexagon turret.

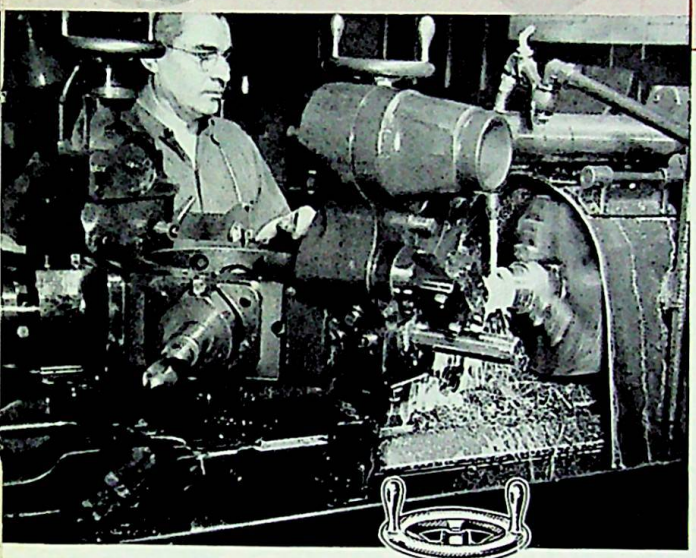
→
Single point taper threading using a cross slide Taper Attachment and Leader and Follower Thread Chasing Attachment.



Sleeves and Inserts



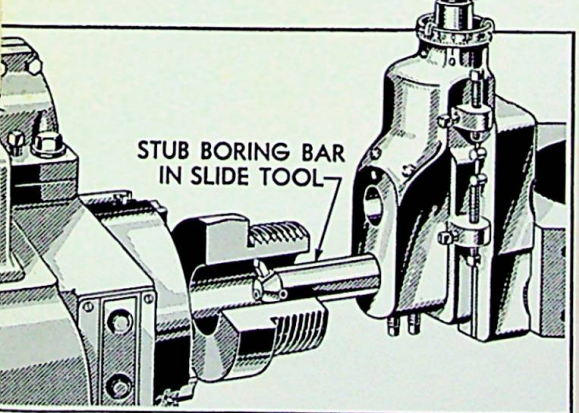




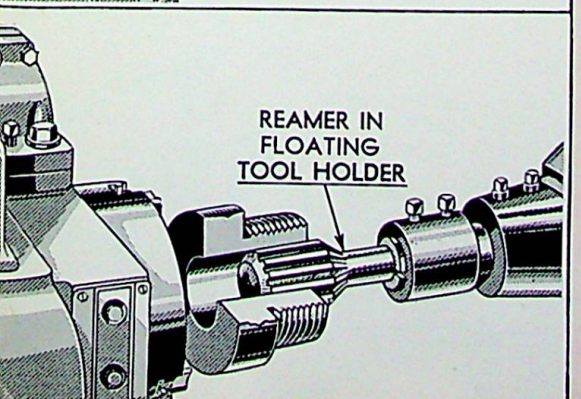
Sleeves and inserts, produced from forgings or castings, present the problem of machining accurate internal and external threads. In addition to the accuracy and thread finish specified, the concentricity of the threads with other machined diameters largely determines the best threading method.

More accurate threading specifications can be maintained when threads are cut by the single point method. Any existing eccentricity or run-out will not affect the threading accuracy as is the case where floating die heads or taps are used. On high production jobs, the threads are often milled or hobbed as a separate operation on an entirely different machine tool.

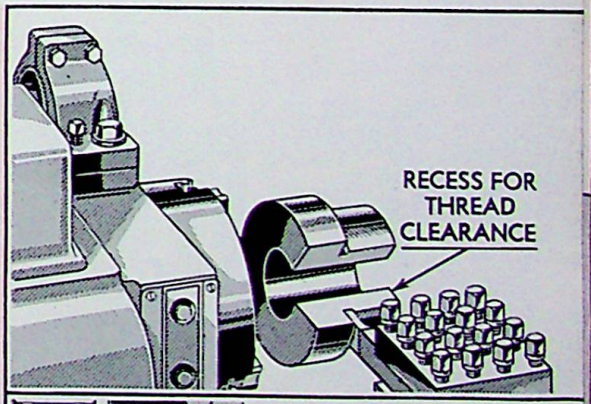
To assure accurate concentricity between internal bores and external diameters, one or more finish boring cuts are needed to remove all traces of run-out before the final boring or reaming.



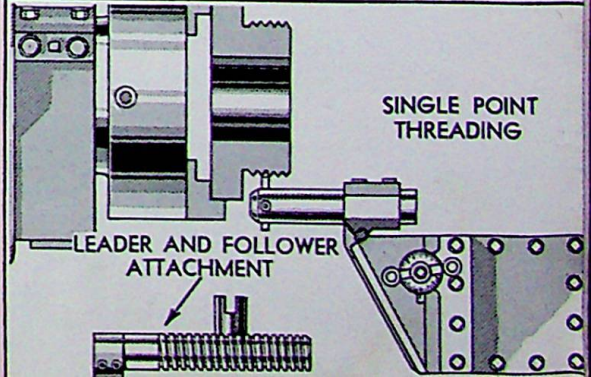
← **Finish boring for roundness** and concentricity with a Stub Boring Bar in a Vertical Slide Tool.



→ **Recessing the clearance groove** for ending external threads.

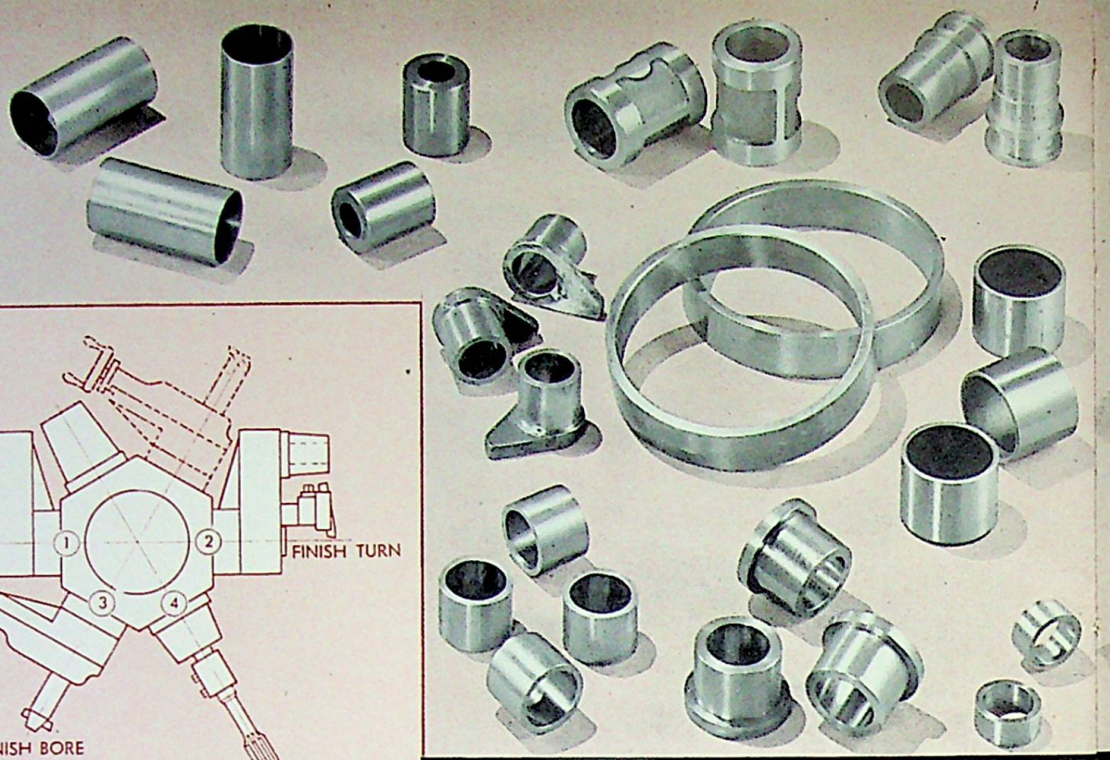


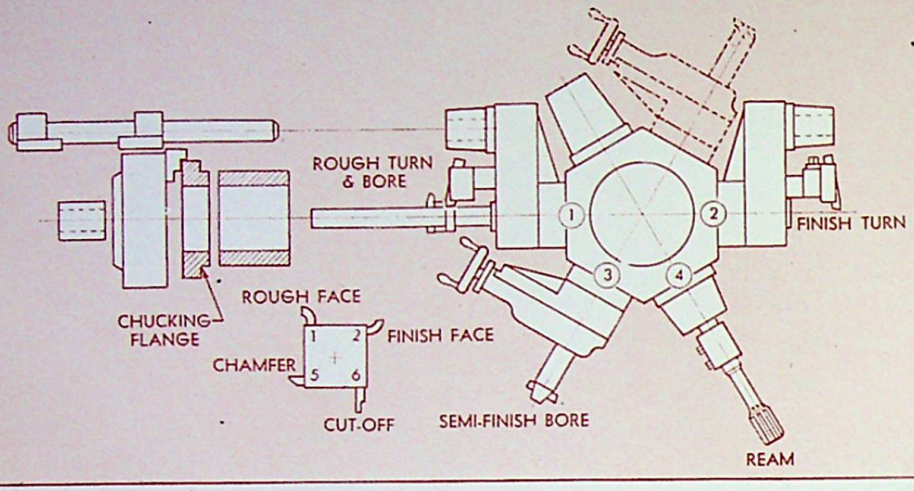
← **Reaming a previously bored hole** to obtain accurate size and finish.

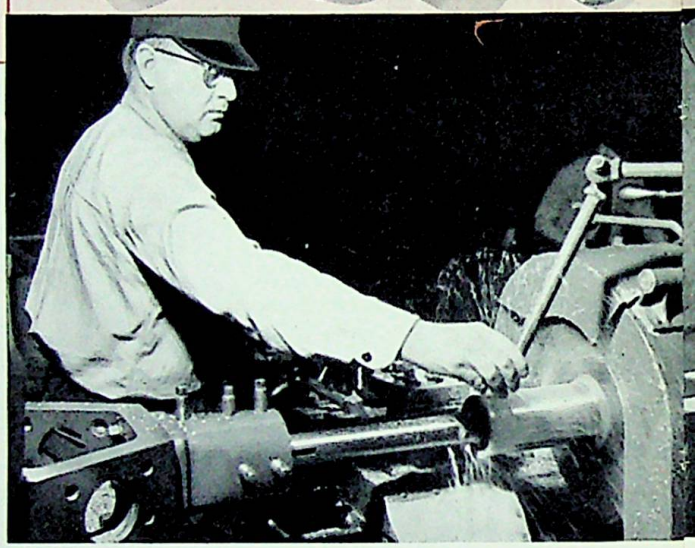


→ **Cutting External Threads** with the Square Turret Adjustable Threading Tool Holder.

Bushings



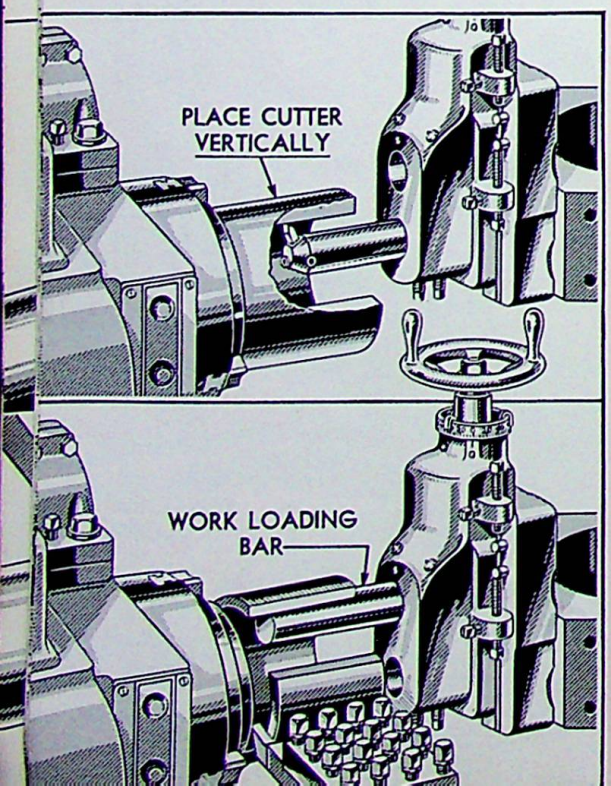




The concentricity between the bore and the outside diameter, as well as the tolerances and the quality of finish, govern the tooling method best suited for producing bushings. To avoid run-out and to produce roundness and trueness of bore, single point turning and boring cuts are preferred.

Rough boring cuts are best handled with piloted boring bars to withstand the impact of unevenly cast surfaces. Finishing cuts to close tolerances are taken with Stub Boring Bars held in Vertical Slide Tools. For most accurate duplication of size, boring cutters are positioned vertically with the cutting edge up.

When turning and boring from the same station, place the turning and boring cutters opposite each other. This helps avoid work spring from the cutter, especially on thin walled bushings.

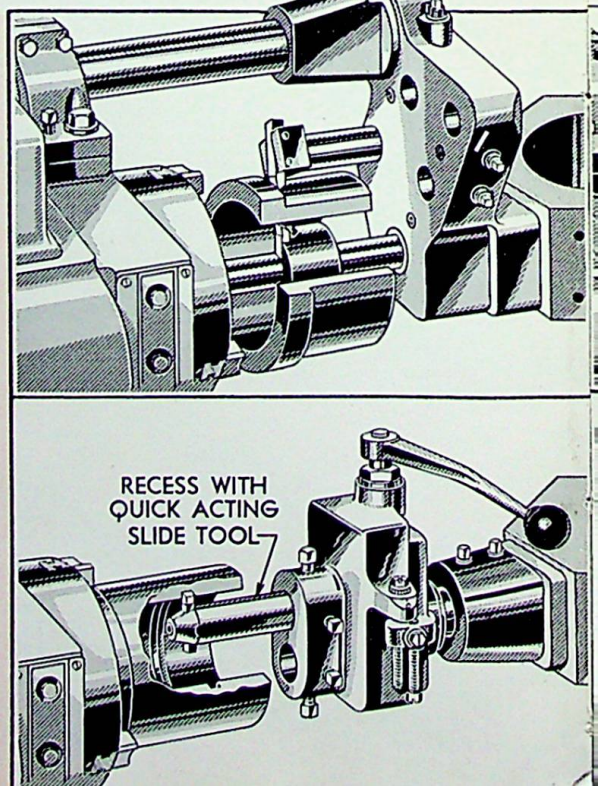


← **Independent finish boring cuts** for size, finish and straightness of bore.

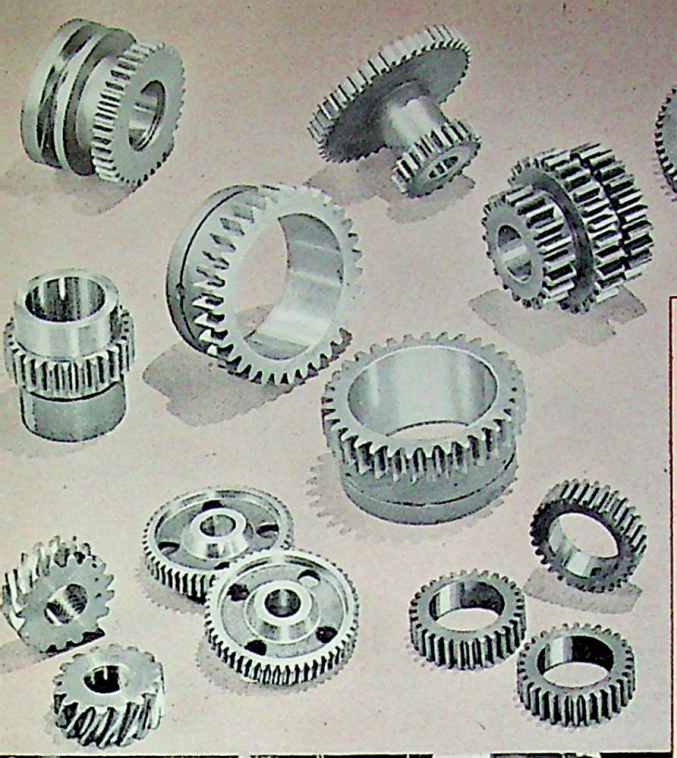
→ **Multiple turning and boring** using balanced cuts from the hexagon turret.

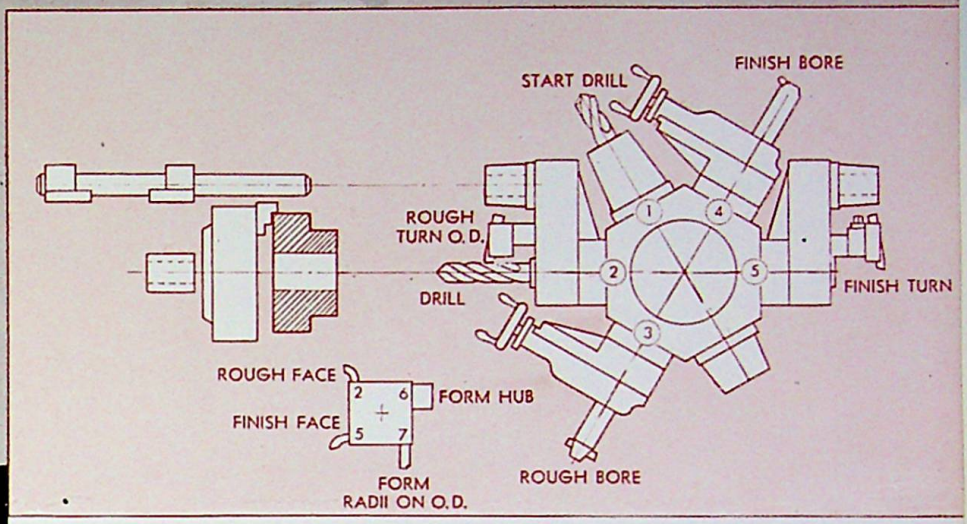
← **Loading a heavy bushing** into the chuck using a loading bar and a Vertical Slide Tool.

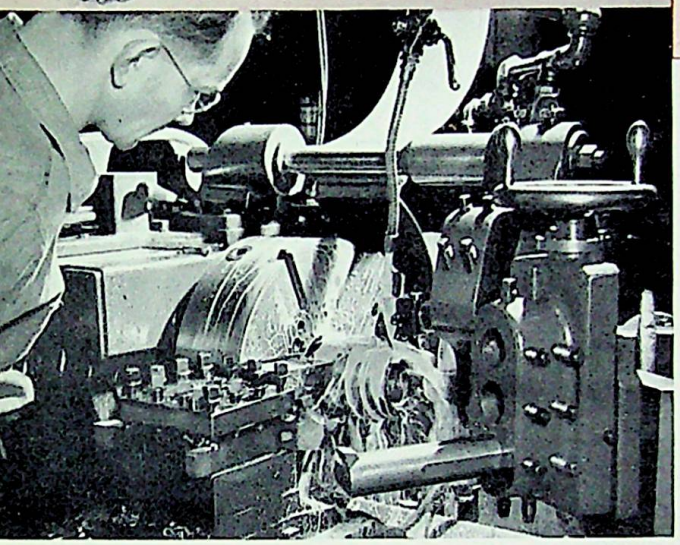
→ **Recessing grooves in bushings** with the Quick Acting Slide Tool using stop screws for gauging depth.



Gear Blanks



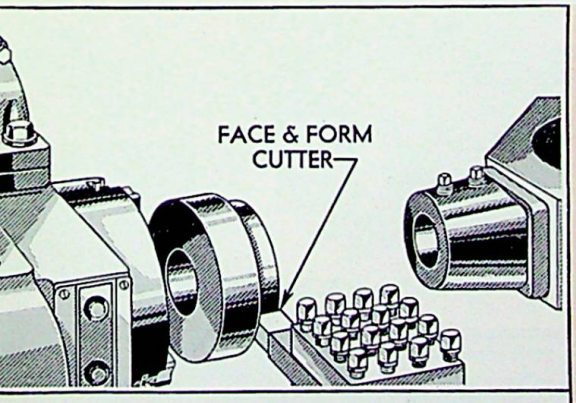




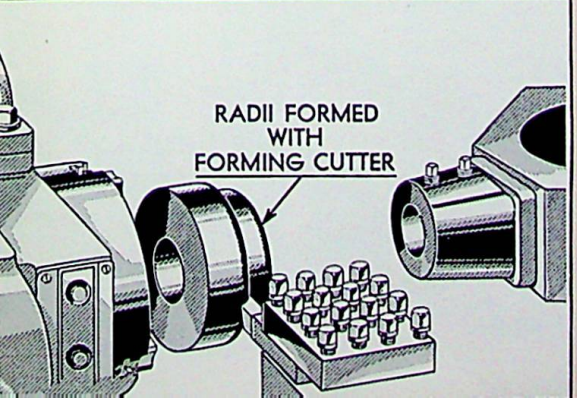
Since internal work on gear blanks is often held to close limits to assure proper fits on gear shafts, three internal cuts are generally required: (1) Drilling or rough boring to hog out metal; (2) Semi-finish boring to remove runout and produce true round hole; (3) Finish boring or reaming for size and smooth finish.

External turning and facing can often be done while boring work is in progress. Short hubs on gear blanks can be formed to size after completion of the front facing cut. For precision tolerances on longer hubs, an additional finish turning cut can be taken from the hexagon turret.

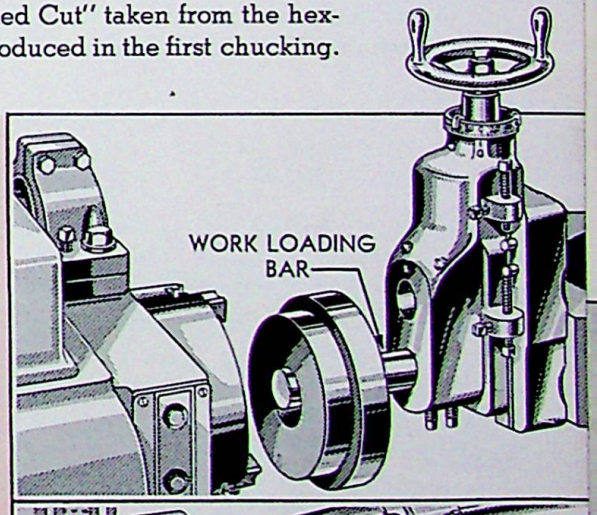
In the second operation, the gear blank is held in soft jaws and a "Matched Cut" taken from the hexagon turret to the size produced in the first chucking.



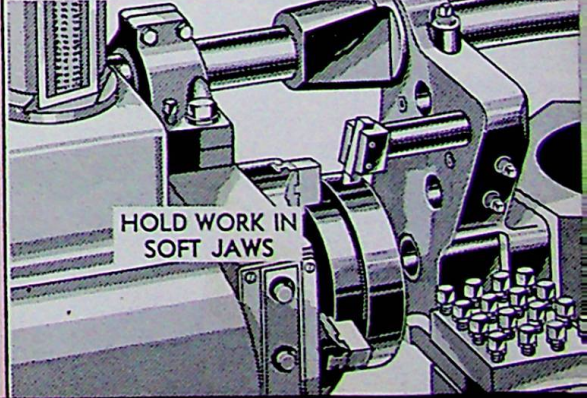
← **Facing the gear blank** and forming the hub from the square turret.



← **Forming corner radii** with a form cutter held in the square turret.

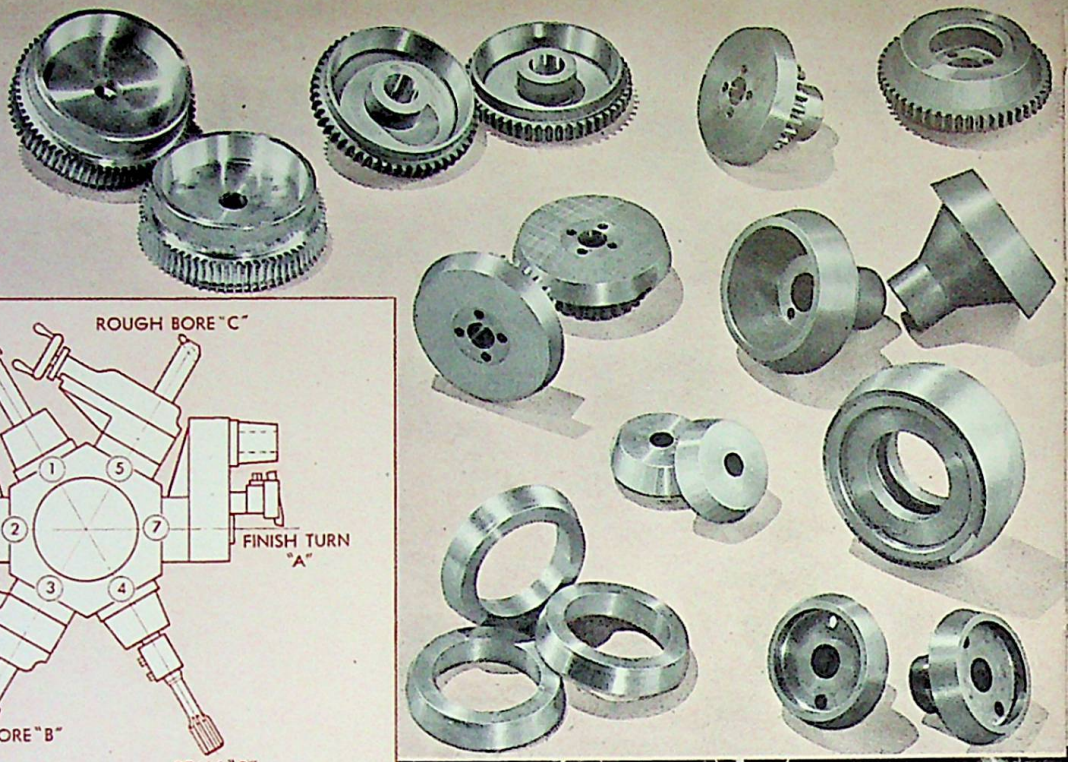


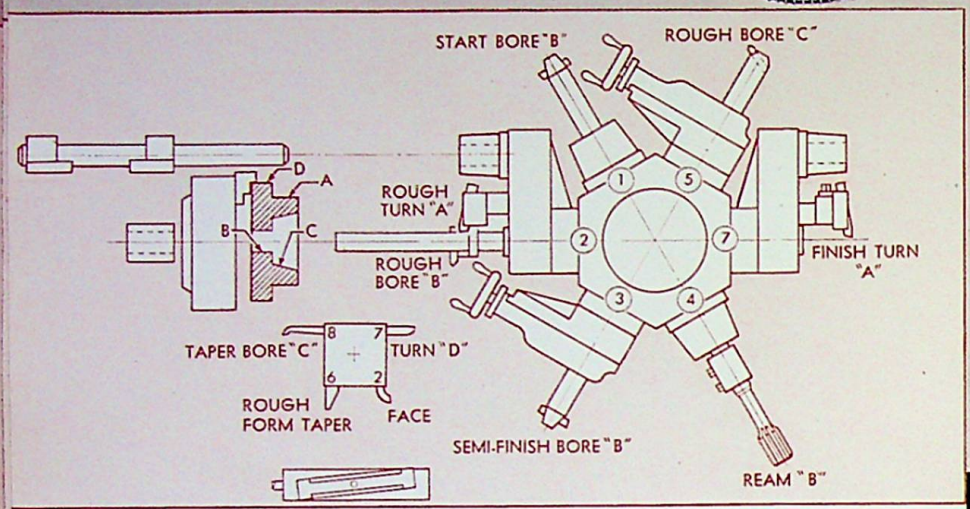
→ **When loading a heavy gear blank** into the chuck a loading bar in a Vertical Slide Tool may be used.

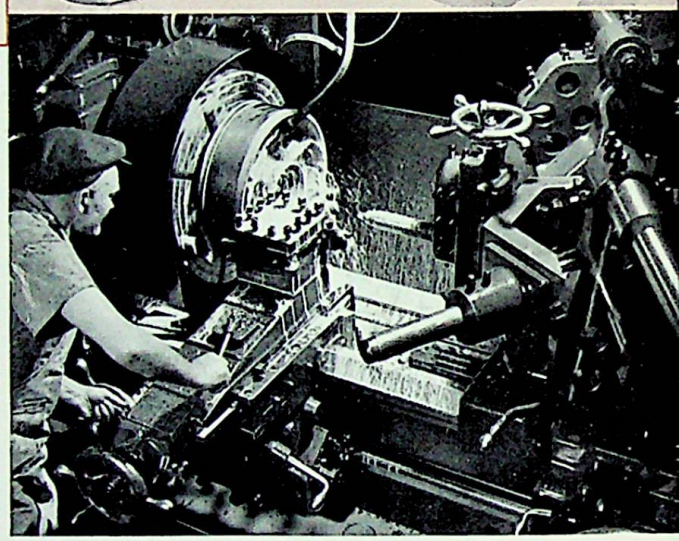


→ **Second operation turning** and facing of the gear blank gripped in soft jaws of a scroll chuck.

Cone Frictions



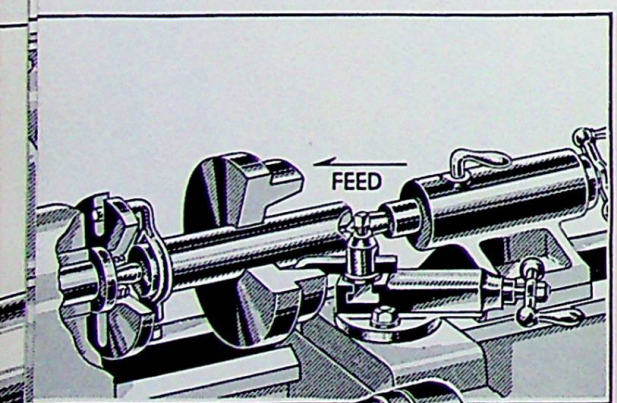




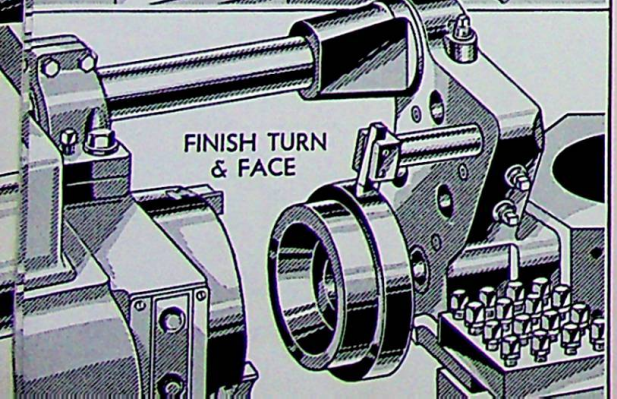
The bevels or tapered surfaces on cone frictions are the most important diameters. They must be held to gauge fit for size and angle of taper, and run dead true with the center hole to accurately match with mating taper friction units.

The internal or external tapers can be produced in several ways. Short tapers with medium tolerances may be formed with cutters held in the square turret. The more accurate tapers are single pointed with the cross slide using a Taper Attachment. For close limits of concentricity between the taper and bore, the piece may be mounted on an arbor between lathe centers and a light finishing cut taken with the cross slide compound.

In the second chucking, the work is held in soft jaws bored to size, and the opposite face finished from the cross slide while the outside diameter is finish turned.



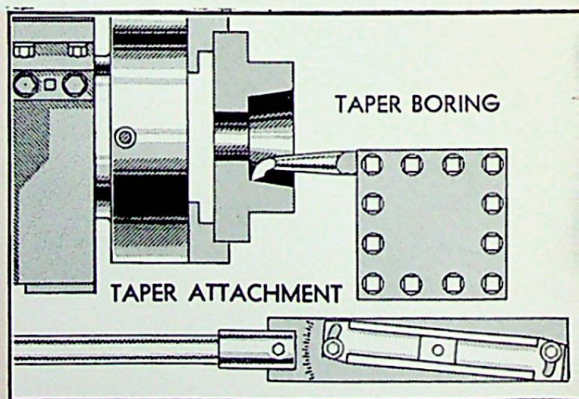
Taper finishing on centers using a lathe Compound Cross Slide.

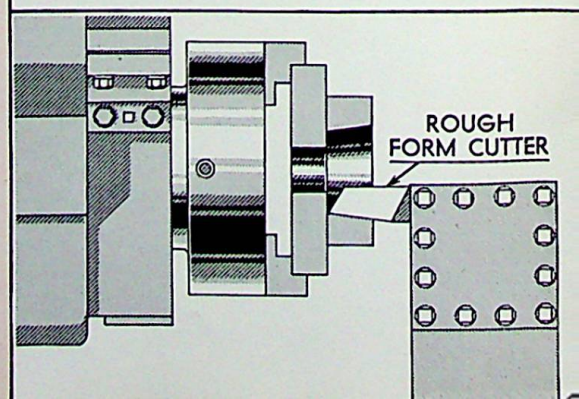


Finish boring internal tapers with the square turret and Taper Attachment.

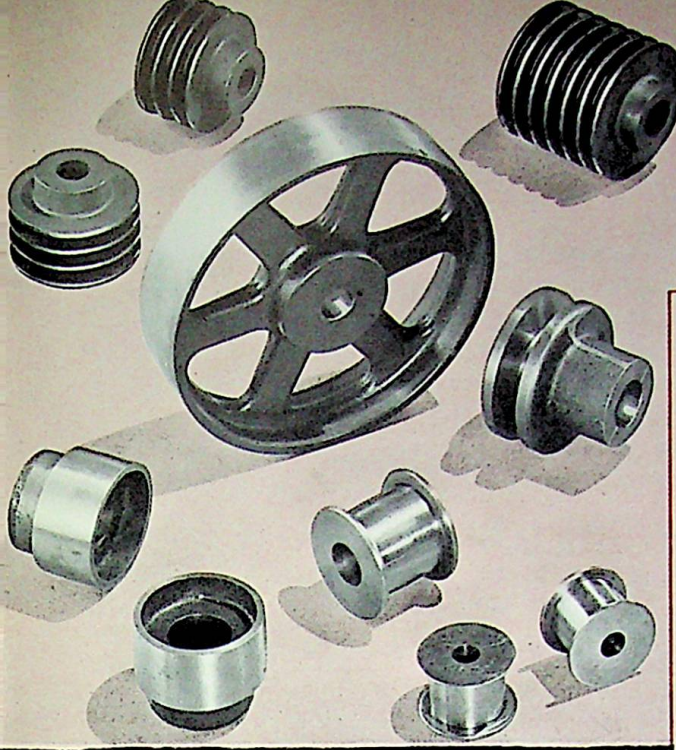
Second operation facing and turning with the piece held in soft chuck jaws.

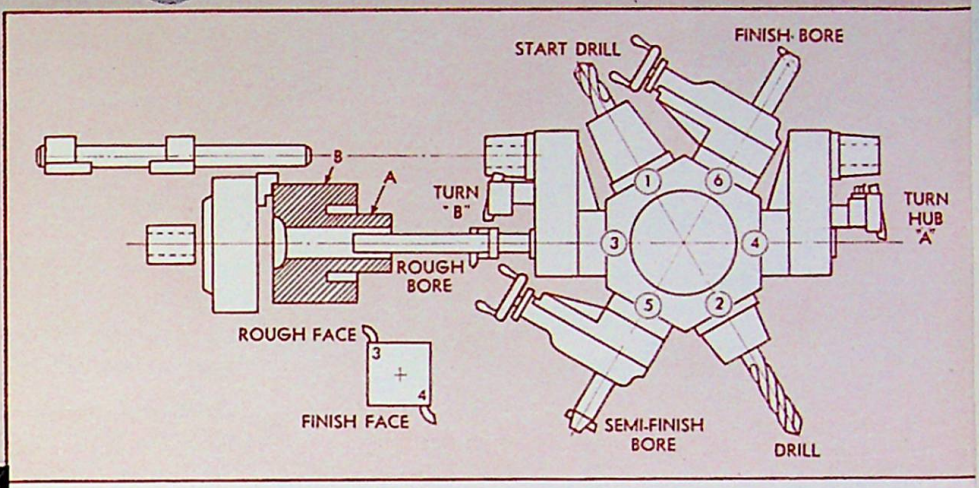
Roughing internal tapers with a Forming Cutter in the cross slide.

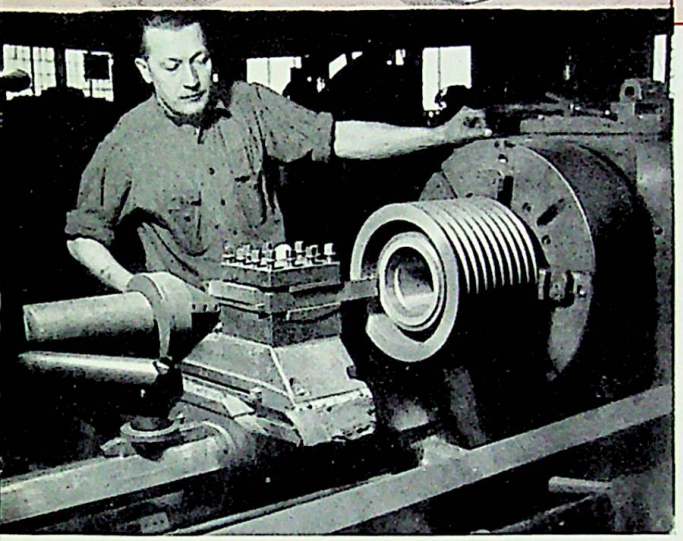




Pulleys and Sheaves



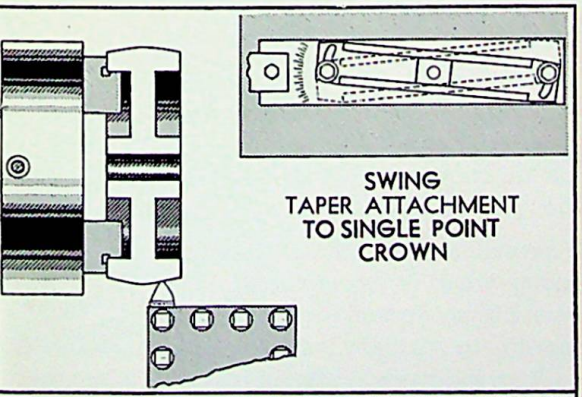




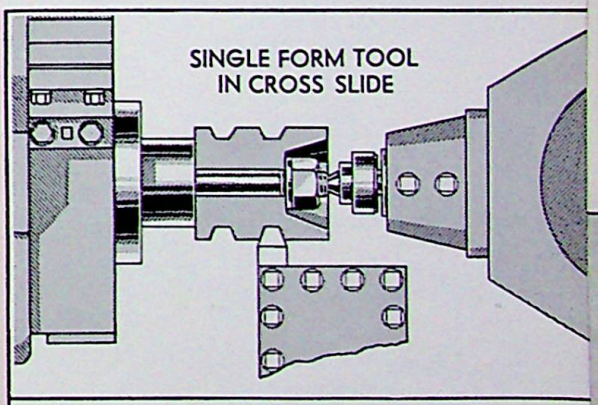
The Vee grooves of sheaves and the belt diameter of flat belt pulleys must run true with the bore.

The double taper on the outside diameter of flat belt pulleys is finished with a single point cutter in the square turret and a Taper Attachment on the cross slide. Where only a few pulleys are to be produced, the Taper Attachment Plate is swung from one angle to the opposite angle for outside double taper cuts. On larger quantity lots, the Taper Attachment may be provided with a special crowning plate and roller guide to avoid resetting the Taper Attachment.

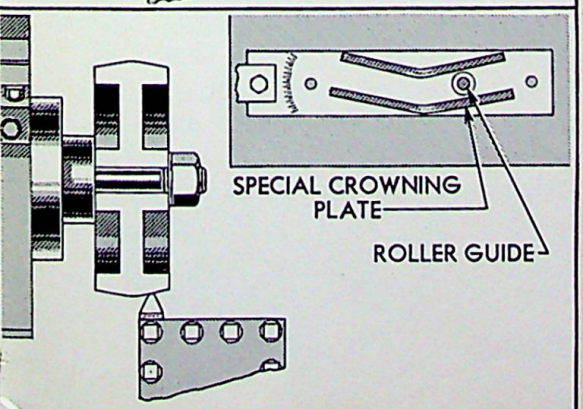
Concentricity between the grooves and bore on Vee belt sheaves is assured by cutting the Vee grooves individually in a separate chucking with the sheave blank mounted on an arbor. In this way excessive heat and distortion are avoided.



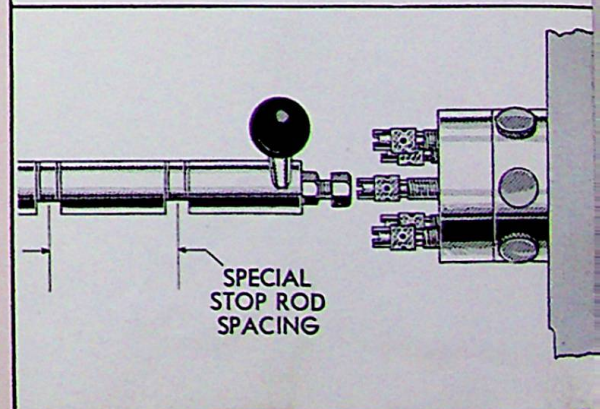
← **Finishing the double outside taper** on flat belt pulleys with the Taper Attachment.



→ **Grooving Vee belt sheaves** from the square turret.



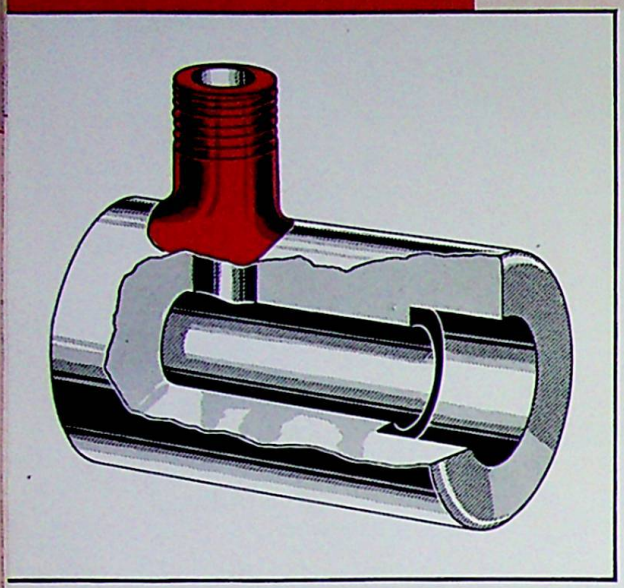
← **Crowning flat belt pulleys** with a special crowning plate and roller guide on the Taper Attachment.



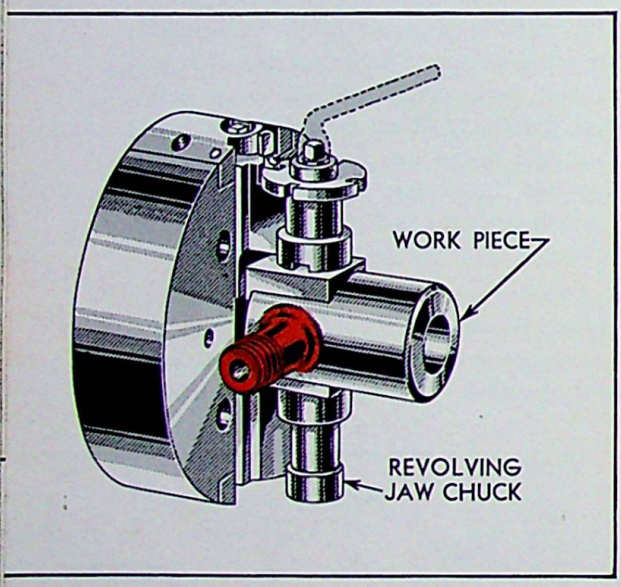
→ **Special Carriage stop rod** spacing provides correct setting of cross slide for forming Vee grooves in sheaves.

Irregularly Shaped Work

Once correctly gripped in a proper holding device, irregularly shaped parts can be machined like any round part.



Colored portion shows external work. Black cross-section shows internal work.



Above illustration shows how right angle adapter is held in a Revolving Jaw Chuck and indicates wrench used for indexing piece 90°.

Analyzing basic operations on irregularly shaped work. At first appearance, castings and forgings having odd shapes seem to present a more difficult problem of machining than normally experienced with general chucking work. Upon further study, however, it becomes evident that the same basic operations used on round chucking work apply to odd shaped pieces. As a result, the same fundamental principles of turret lathe tooling apply when machining irregularly shaped work.

Determine what holding methods should be used: Odd shaped pieces must be located and held so that machined surfaces are in correct relation to other surfaces from which the tolerances are measured. This is discussed on the next page.

Illustrated as an example of machining irregularly shaped work is the right angle adapter requiring machining operations on two center lines 90° apart. The piece is gripped in special jaws of a Revolving Jaw Chuck allowing the piece to be indexed 90° without removing the piece from the chuck.

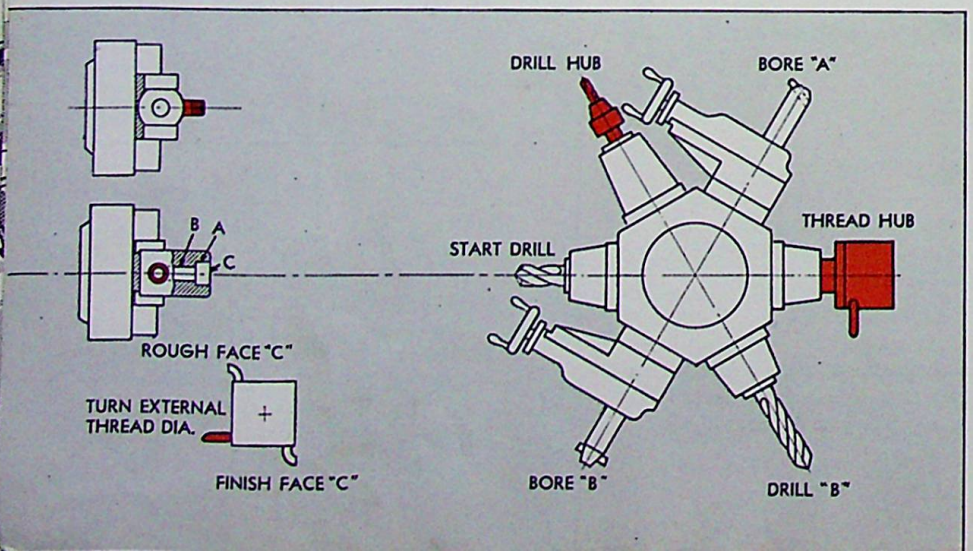
Apply the basic machining operations using the Universal Chucking Set-Up. As in general turret lathe tooling practice, the machining operations may be divided into two basic classes—internal work and external work. Bearing in mind the number of pieces to be produced, the internal and external tooling is set up with the minimum number of cuts to produce the tolerances required.

The internal cuts on the adapter body are set up first (start drill, drill and bore the two internal diameters). Facing and chamfering is done from the square turret while the drilling operation is under way.

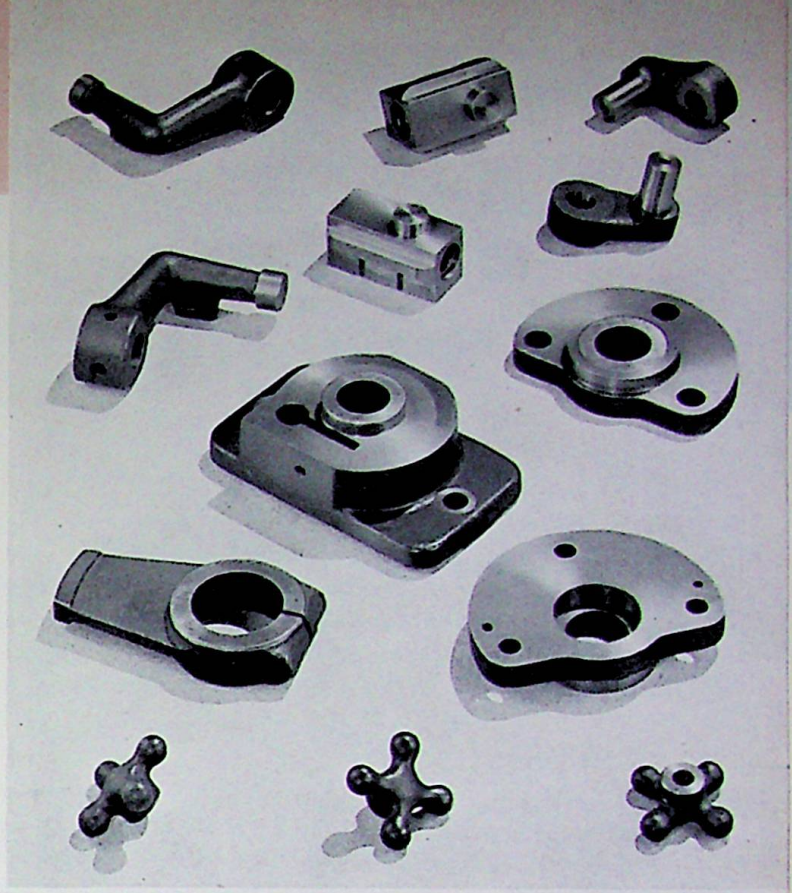
The threaded extension is set up next. The internal cuts (start drill and drill from the hexagon turret and the turning cuts from the square turret) are taken. The threads on the hub are cut with a die head from the hexagon turret.

More complicated jobs in small and medium size lots may not make it practical to set up the tool holders on the turret in continuous sequence for the order of operations desired. In such cases the turret is skip-indexed or back-indexed to bring the cutting tools into position in the proper order.

Wherever a great amount of irregular shop work is encountered, and the machining operations are limited primarily to drilling, boring and threading, the hexagon turret may be provided only with Flanged Tool Holders and Slide Tools. These will allow shank type tools such as drills, boring bars, reamers, taps and die heads to be inserted quickly into the set-up when changing jobs.



Machining irregularly shaped parts on turret lathes enables many accurate operations to be completed on a single machine.



Chucking Irregularly Shaped Parts:

The first step in the machining of unusually shaped work is to determine the best way to grip or hold the work piece consistent with the number of parts to be produced in the lot.

Small size parts are usually held in collect chucks with special collet pads made to suit the contour of the work piece. This method provides for quick and accurate gripping on small die castings and forgings.

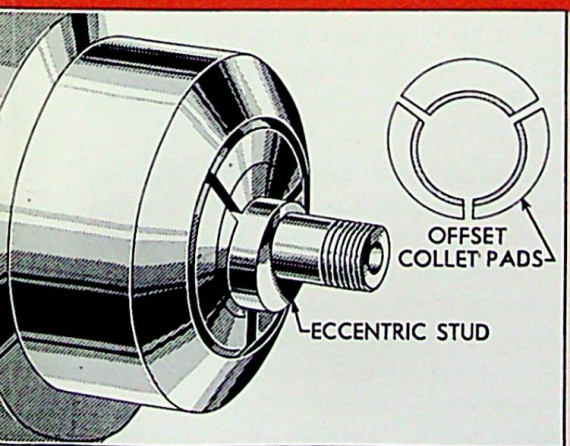
Small odd shaped work is also held in 2-jaw chucks incorporating special chuck jaws machined to the form of the work. Where opposite faces are to be machined, the revolving jaw type of chuck is generally used.

Larger parts may be held in 4-jaw Independent chucks with individual adjustment on each chuck jaw to allow gripping on odd shaped contours. Irregular pieces that cannot be gripped with chuck jaws are often mounted on face plates and held with clamps or bolts.

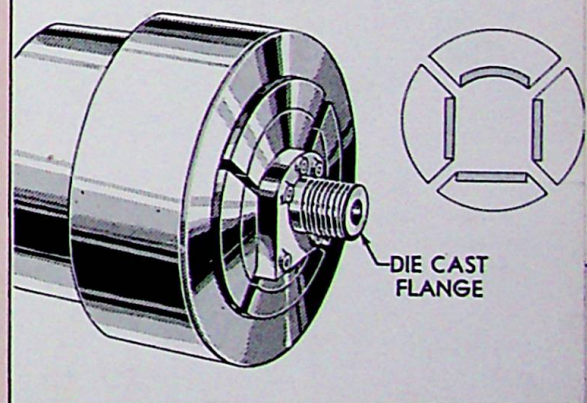
It is generally advisable on larger quantity lots to use 3-jaw scroll chucks with special top jaws built to suit the shape of the piece and provide locating and gripping surfaces for accurately positioning the work. More elaborate parts, and those with thin wall sections requiring additional rigidity or support, may be held in fixtures built for the individual job requirement.

Where exceedingly close limits are required for locating second operation surfaces from bores or faces that have been machined in the first chucking, face plate fixtures, rather than conventional gripping with chuck jaws, are preferred.

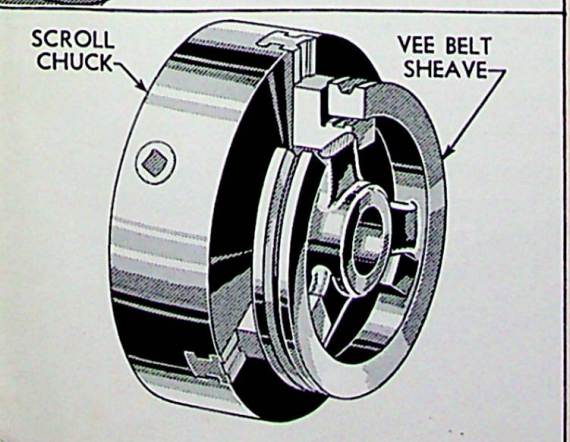
PRACTICAL METHODS FOR HOLDING IRREGULARLY SHAPED WORK



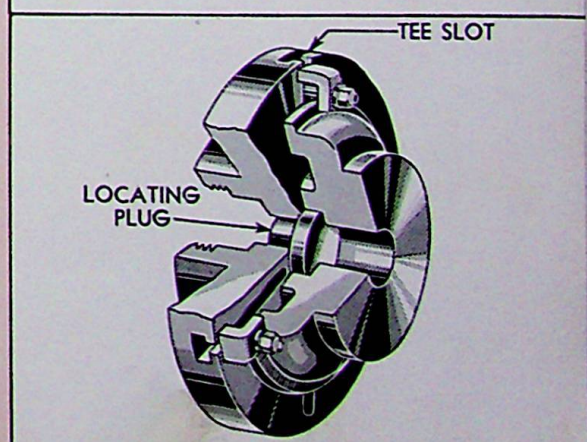
←
Small Size Parts—Gripping round offset work with special collet pads in a standard bar stock collet.



→
Holding small die castings in an extra capacity collet chuck using special collet pads machined to the work shape.



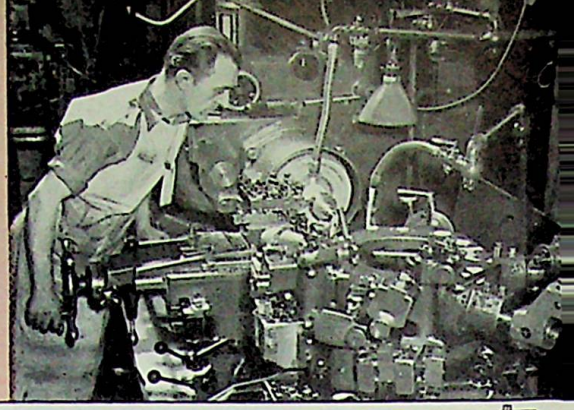
←
Large Size Parts—Holding pulley sheaves in a standard 3-jaw scroll chuck with special chuck jaws to locate and grip the work piece internally.

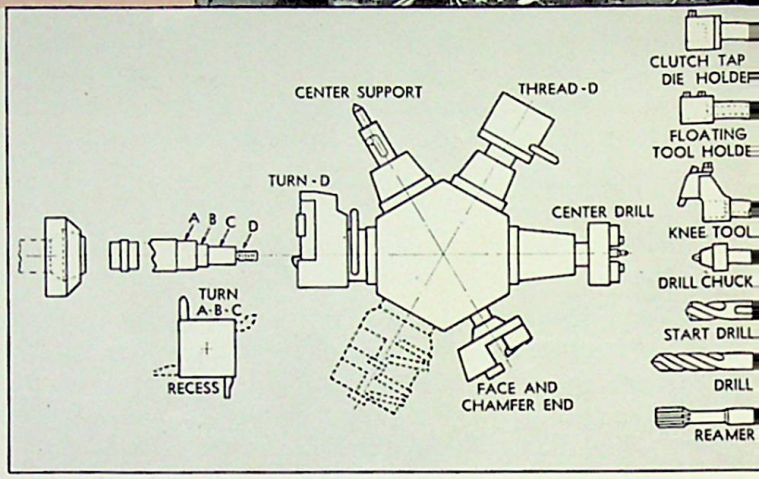


→
A face plate accurately positions the work piece for a second operation set-up. The centering plug locates the work on the face plate while the tee bolts and clamps hold the work through a solid metal section to avoid distortion.

Production Planning

» » » » Plan Tooling Set-ups for Overall Production Needs » » » »



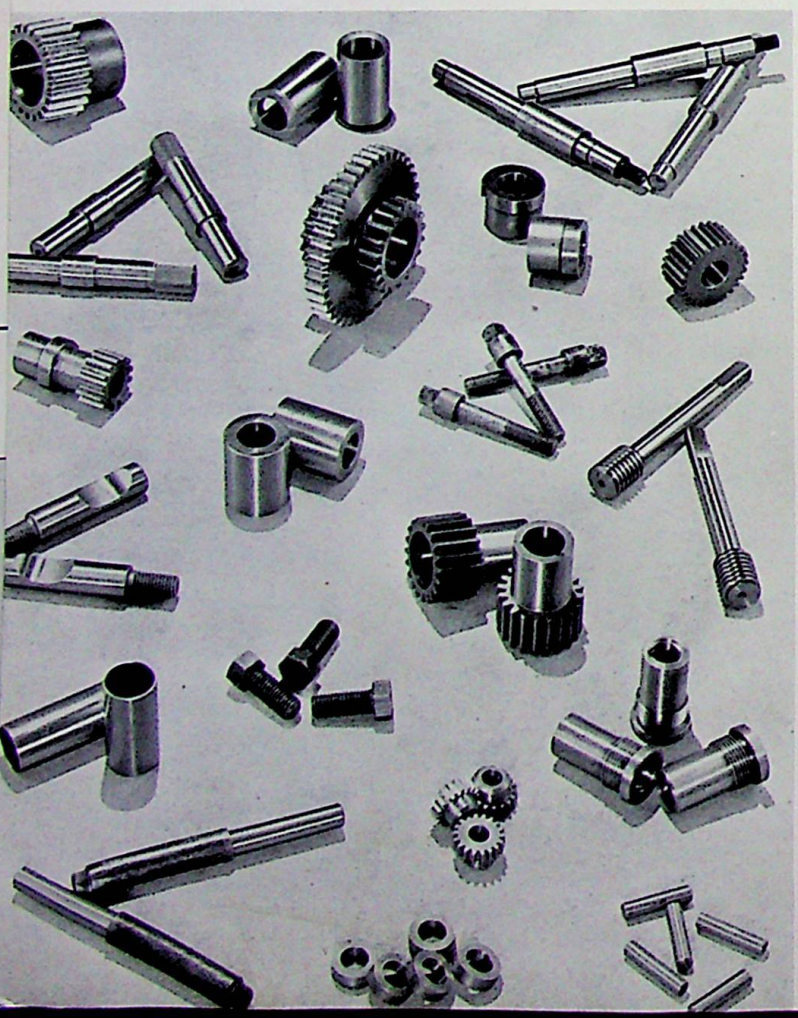


What is Production Planning?

Production Planning is planning in advance for the most efficient machining of turret lathe jobs with minimum set-up time. Production planning takes into consideration the overall requirements of all jobs assigned to a particular machine as well as the individual job needs. No one job should necessarily be run at an outstanding performance at the expense of other work scheduled for the turret lathe.

For example, production planning avoids the use of a special tool particularly suited to an individual job rather than a standard tool that might be more effectively used on many jobs. Production planning is a logical approach to assigning the correct standard turret lathe tools that will assure a minimum of set-up effort and yet maintain the tolerances required.

Two important items largely determine the correct turret lathe tooling to be used—the type of work to be machined (bar work or chucking work) and the number of pieces to be produced in the lot. The basis for selecting the bar and chucking tools has already been reviewed. *The rate of production, normally referred to as number of pieces in the lot, affects the general application of bar and chucking tools in the hexagon turret set-up. Here is how.*

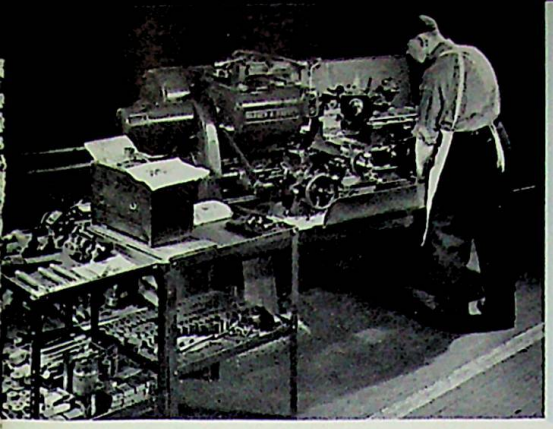


Small Lot Bar Work

Since all the time involved in the set-up must necessarily be divided between the number of pieces to be produced, small lots can be machined economically only when quick set-ups are used. In these cases it is preferable to select tools that can be quickly set into the turret and adjusted to size.

In lots of one and two pieces, external cuts (turning and facing) are taken from the square turret, and the internal work (drilling and boring) from the hexagon turret. When turning bar work from the cross slide and using a center support in the hexagon turret where necessary, the set-up time for the turning cut requires only the setting of the cross slide dial for diameter size. Where larger quantities of five or more pieces are to be made, the Single Cutter Turner is set up allowing heavier feeds to be taken. Supplementary operations such as center drilling, end facing, and threading are done from the hexagon turret with shank type tools that can be quickly inserted into the Flanged Tool Holders.

On lots of one or two pieces, machine stops are seldom set up. Scales or micrometers are used to check the size on each individual piece. Little effort is made to combine square turret and hexagon turret cuts or to take multiple cuts from either turret station unless extremely long cuts are involved.



Production Planning

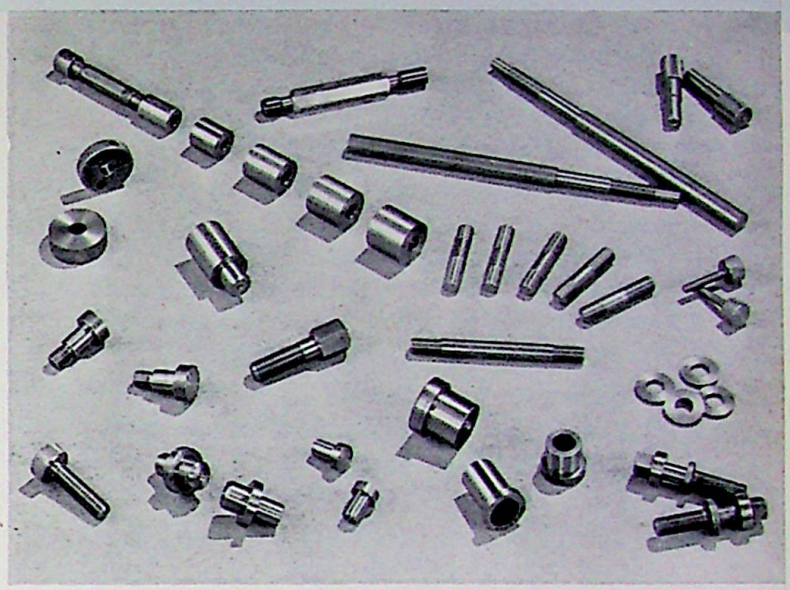
» » Small Lot Tool Room Bar Work » »

A large proportion of tool room bar work consists of drill bushings, gauges, bolts and studs usually produced in small quantities. Because a turret lathe equipped with a flexible tooling set-up lends itself to quick changes in set-up from job to job, it is the most desirable machine for producing such parts.

Each tool room turret lathe should be provided with a complete set of small lot bar tools, all cross slide cutters and a full complement of collet pads and die head chasers. Such an independent machine and tooling set-up is important. It assures minimum set-up time by avoiding delay in locating collet pads or other bar tools that might be in use on other machines.

The machining method for producing typical tool room parts is similar to small lot bar work production. External cuts — — turning, facing, grooving, and cut-off are taken from the cross slide — — threading, knurling, and center drilling are done from the hexagon turret. Internal cuts — — drilling, boring and reaming are taken from the hexagon turret.

Shank type turret lathe tools are preferred for the hexagon turret set-up since they can be quickly mounted or removed when changing from job to job. Where but one or two pieces are to be made, machine stops are seldom set. Instead, scales and micrometers are used for checking each piece.



Representative Tool Room Bar Work

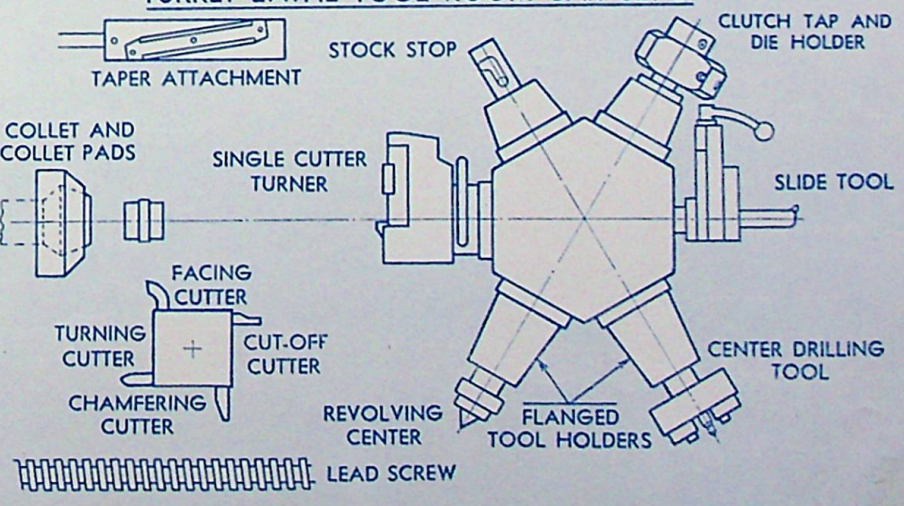
Modern tool rooms equipped with turret lathes have greater productive capacity and increased flexibility to handle all types of bar work. Plain lathes relieved of this small lot bar work, become available for strictly "between center" work.

Lead Screw for Thread Cutting

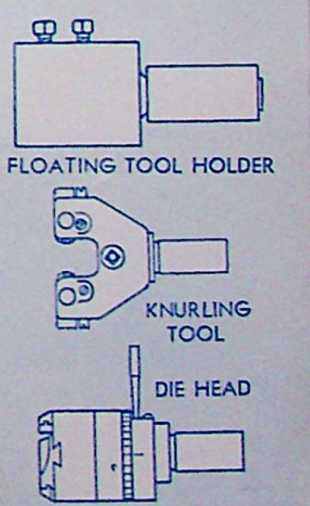
Where accurate "single point" threading is required, the tool room turret lathe is equipped with a Precision Lead Screw and quick change gear box arrangement. The Lead Screw is used for producing threads of any required pitch on standard and odd size diameters.

PPLEMENTARY TOOLS

TURRET LATHE TOOL ROOM BAR SET-UP

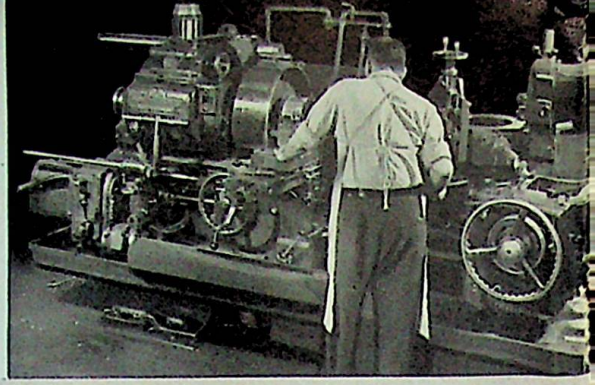


SUPPLEMENTARY TOOLS



Production Planning

» » » » Fixed Center Turret Tooling Method » » » » » »



Hexagon turret chucking tools with individual micrometer screw adjustments for quick change from one size to another, are the basis for producing small lot chucking work on fixed hexagon turret center turret lathes.

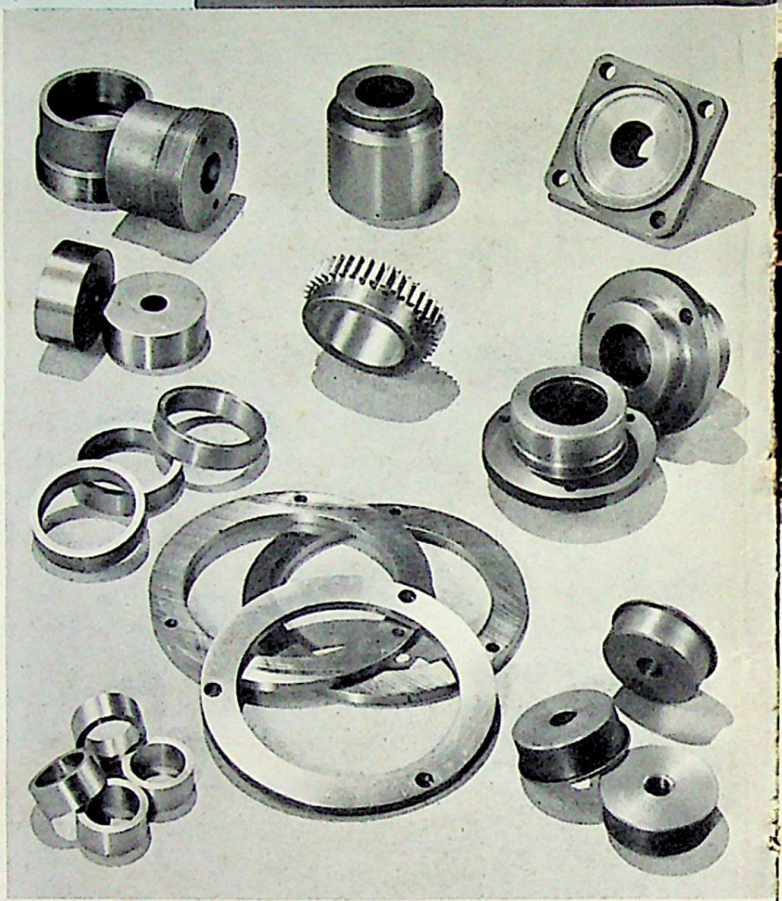
These "quick set-up" hexagon turret tools for fixed center turret lathes, are the Adjustable Single Turning Heads, the Vertical Slide Tools and the Reversible Adjustable Angle Cutter Holders. Flanged Tool Holders are added for mounting drills, reamers and taps.

On small lot chucking work, drilling, boring and some overhead turning is done from the hexagon turret . . . facing and some side turning from the square turret. Wherever possible, hexagon turret operations are done at the same time square turret cuts are taken.

Where only one or two pieces are required per set-up, machine stops on the hexagon turret and square turret units are seldom used. Instead, the length of the cut is checked with a scale and each piece is individually "miked" for diameter.

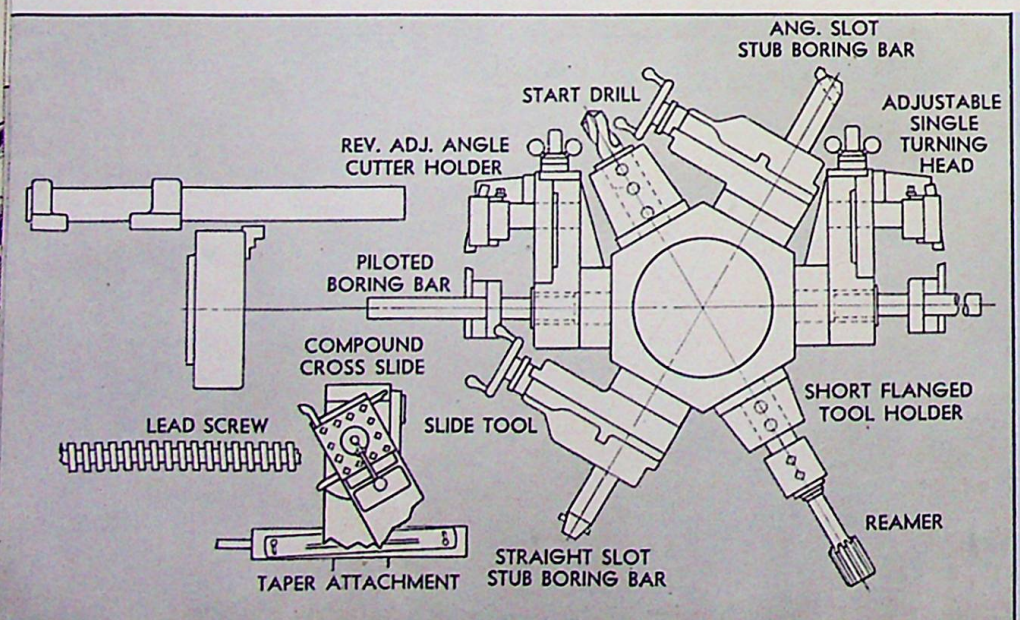
Tool Room Work

Turret lathes are used for small lot chucking work in tool rooms. These turret lathes are often equipped with Full Length Independent Lead Screws and Compound Cross Slides to provide greater machine flexibility on tool room chucking jobs. The precision Lead Screw is used for cutting threads only. It provides the means for single pointing all standard pitches for threaded studs and thread gauge work. The Compound Cross Slide is used for threading and cutting steep tapers or bevels.



Representative Small Lot Chucking Work

Repair and Maintenance Shops also experience considerable small-lot turret lathe work. Since repair parts must be quickly made on short notice, flexible turret lathe tooling is desirable.

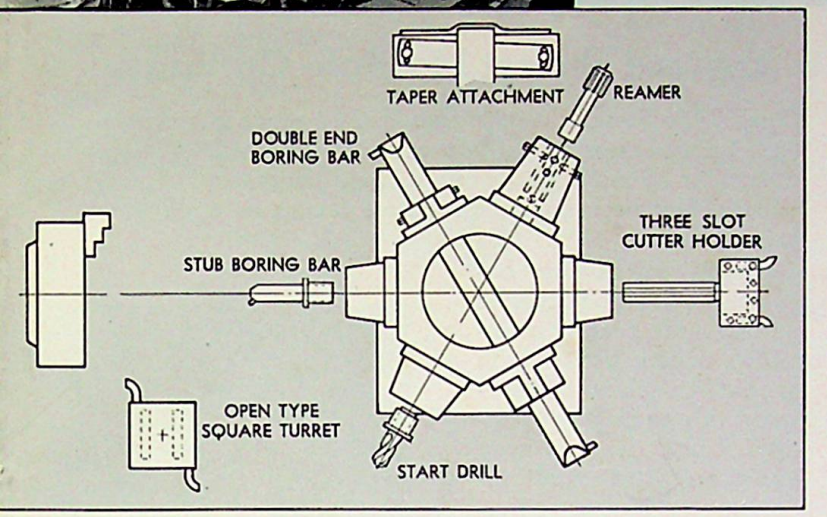


A typical Tool Room set-up for producing small lot chucking work. It includes a precision Lead Screw for cutting threads, and a Compound Cross Slide for threading and for cutting steep tapers and bevels.

Each important Hexagon Turret tool is provided with independent micrometer screw cutter adjustment for quick accurate set-up.

Production Planning

» » » » Cross Sliding Hexagon Turret Tooling Method » » » »



Cross Sliding Turret Tooling set-up for small lot chucking work.

Fixed Center vs. Cross Sliding Turret Tooling

Two types of turret lathe tooling set-ups may be used for small lot chucking work. The "fixed center" tooling set-up where *quick cutter adjustment is built into each individual tool* and the Cross Sliding Hexagon Turret Method where *quick size adjustment is made by changing the hexagon turret cross slide setting.*

A Turret Lathe equipped with a Cross Sliding Hexagon Turret has *cross* feed as well as longitudinal feed to the hexagon turret. The tooling for the Cross Sliding Hexagon Turret consists primarily of boring bars. Each of these boring bars is set to size with the hexagon turret cross slide dial adjustment.

Flanged Tool Holders are included in this set-up for mounting drills, taps and reamers to cut when the hexagon turret is positioned "on center." The Three Slot Cutter Holder is for large diameter boring and long internal facing work.

The Cross Sliding Turret tooling method provides for handling all internal work—(drilling, boring, reaming, internal facing and recessing) from the hexagon turret. All external work (turning, facing and grooving) is done from the square turret.

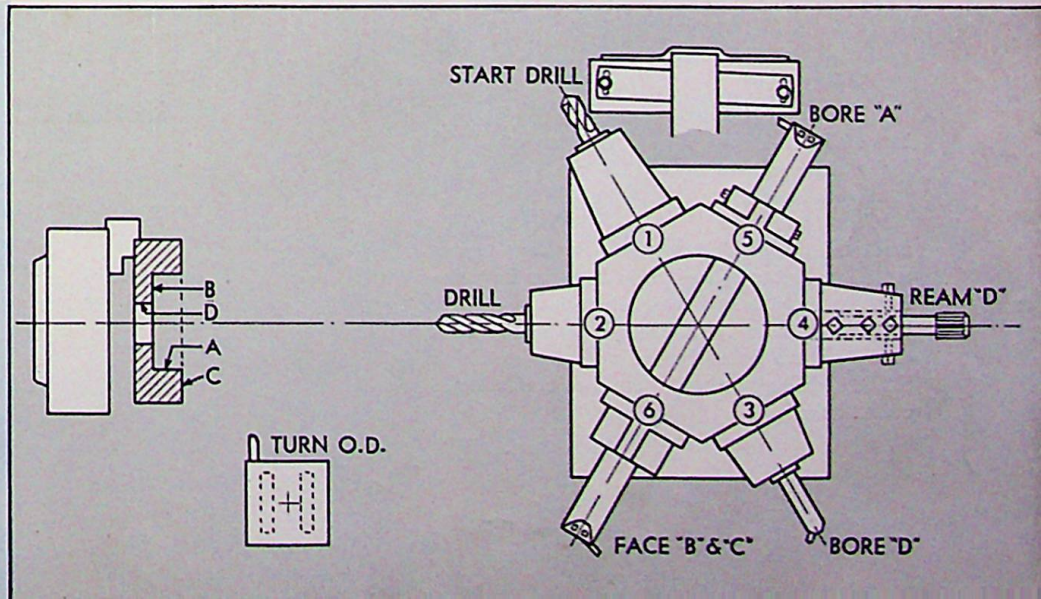
The Double End Boring Bar is the basic cross sliding turret tool. It is used for extremely heavy boring work and on deep internal facing operations. These operations ordinarily are difficult to handle because of tool overhang when small boring bars are used.

Cross sliding turret machines are built for classes of work where multiple step boring and long internal facing is done. Multiple step boring can be done with the use of only one boring tool as the cross sliding turret can be quickly "set over" to size with the hexagon turret cross slide dial adjustment.

The cross sliding turret tooling method has several advantages over the "fixed center" method. Since most of the cutters remain permanently fixed in the boring bars from job to job—(except for tool grinding) the set-up time is lower per piece on small run lots. "Rush jobs" can be put on the cross sliding turret machine without disturbing the tooling set-up as it is necessary only to change the dial reading on the hexagon turret cross slide to produce different pieces.

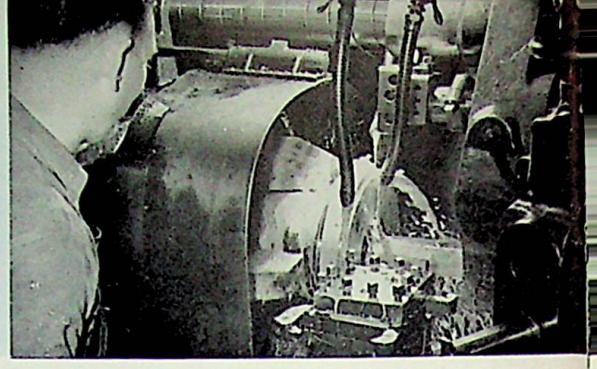
The set-up illustrated here shows one application of cross sliding turret tooling in the handling of small lot chucking work.

The Taper Attachment on the Hexagon Turret provides for quickly handling taper cuts up to 28° included angle. It can be used also for contour boring by using special guide plates.

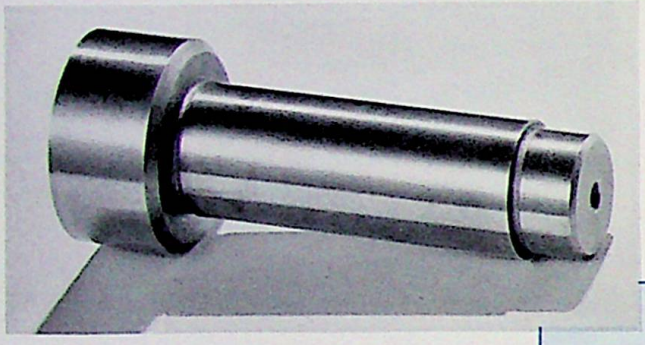


Production Planning

» » » » Take Multiple Cuts Wherever Practicable » » » » »



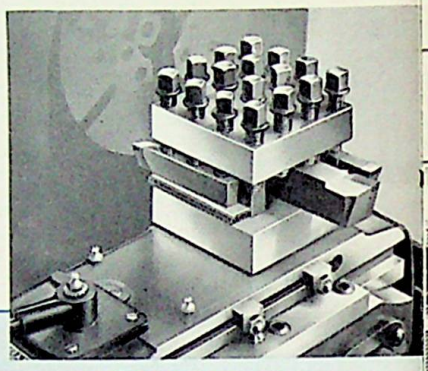
Medium lot work (15 to 100 pieces) justifies more time and effort in the tooling set-up than practical for small lot work. The additional set-up time spent in arranging the tools and cutters to take full advantage of "multiple cuts" (two or more cuts from one turret station) is desirable on medium lot work because it reduces the production time per piece.



Square Turret Multiple Cutting

Open Type Square Turrets provided on modern saddle type turret lathes, allow two or more standard forged cutters to be mounted in one square turret face. The cutters may be set up for multiple facing or multiple turning cuts.

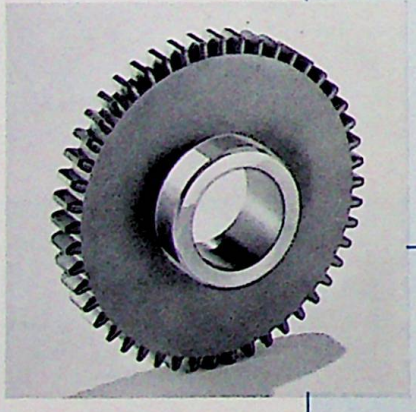
Closer tolerances between two finished surfaces can be more readily maintained when two cutters are set to machine two surfaces in one pass. "Multiple Cuts" in this way avoid an extra turret indexing operation otherwise necessary when separate cuts are taken.



Hexagon Turret Multiple Cutting

Medium Lot Bar Work

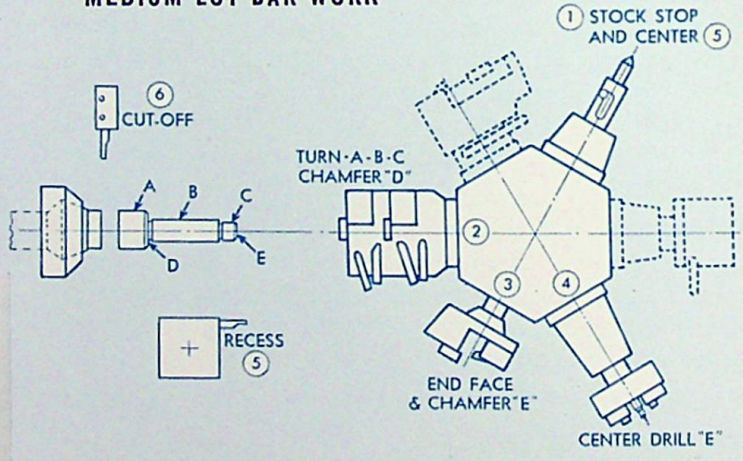
The Multiple Cutter Turner provides the means for taking "Multiple Cuts" on a medium lot bar work. Roller rests support the bar against the cutters, while several machining operations such as turning, facing and chamfering are completed at one pass of the hexagon turret.



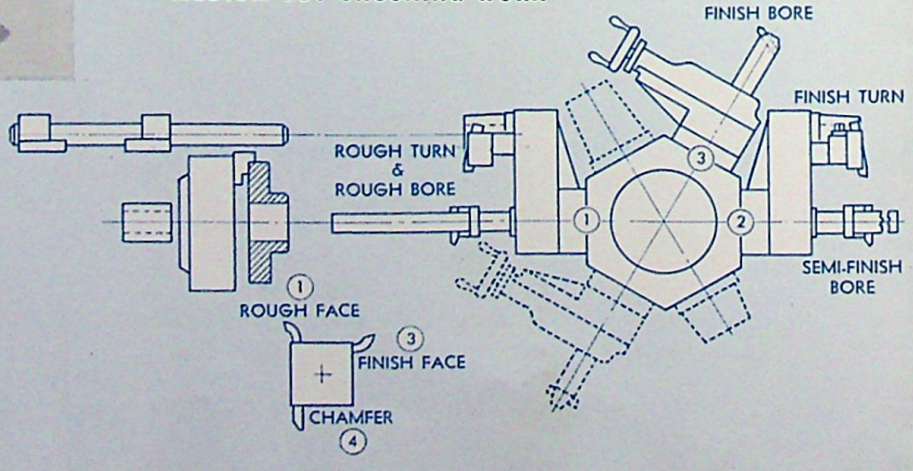
Medium Lot Chucking Work

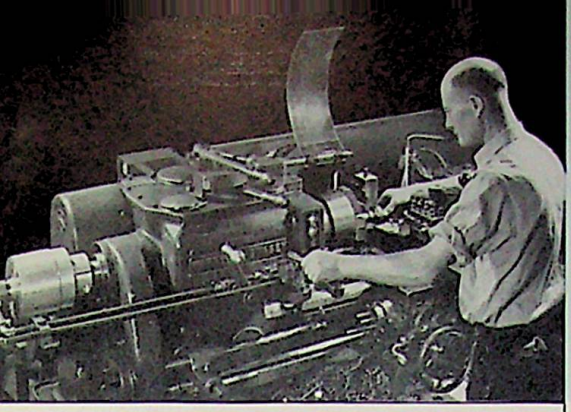
The Multiple Turning Head provides the means for taking "Multiple Cuts" on medium lot chucking set-ups. It allows two or more machining operations to be taken from one hexagon turret face. Any combination of multiple cuts can be set up. For example, as one or more diameters are being turned with Angle Cutter Holders, drilling or boring can be done from the center hole.

MEDIUM LOT BAR WORK

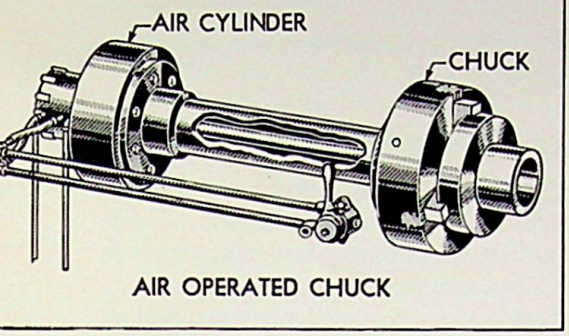


MEDIUM LOT CHUCKING WORK





» » » » Special Tools Reduce Cutting Time and Work Handling Effort

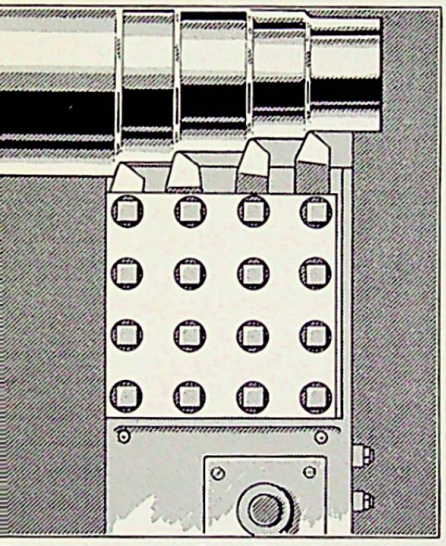


Air Chucks permit quick work loading.

Holding Methods: Quick-operating holding devices such as power operated collets and air controlled chucks are used in high production work to reduce the time and effort necessary to load and unload the work. Where work is of unusual shape, special holding fixtures with quick-operating clamps are built.

Special tools for high production work are designed primarily to group cutters for "multiple cuts" as much as possible. This is done by adding cutter slots to standard tools or building special multiple cutter blocks.

Square Turret Multiple Cutter Holders

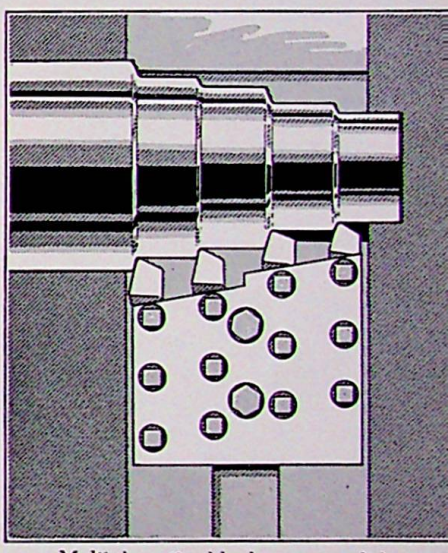


Grouping cutters in Open Type Square Turret.

Grouping or "ganging" of cutters for multiple cuts from the square turret face may be done in two ways. The cutters may either be held in a special multiple cutter block bolted to the face of the square turret or grouped in the Open Type Square Turret that has the hollow center specifically provided for this purpose.

On Ram Type turret lathes, special multiple cutter blocks are often built for the cross slide for completing multiple cross slide operations in one pass.

On small size high production jobs, machine handling time becomes a substantial proportion of the total production time. Where these jobs are run, the cross slide is equipped with a lever operated cross feed to permit fast operation.



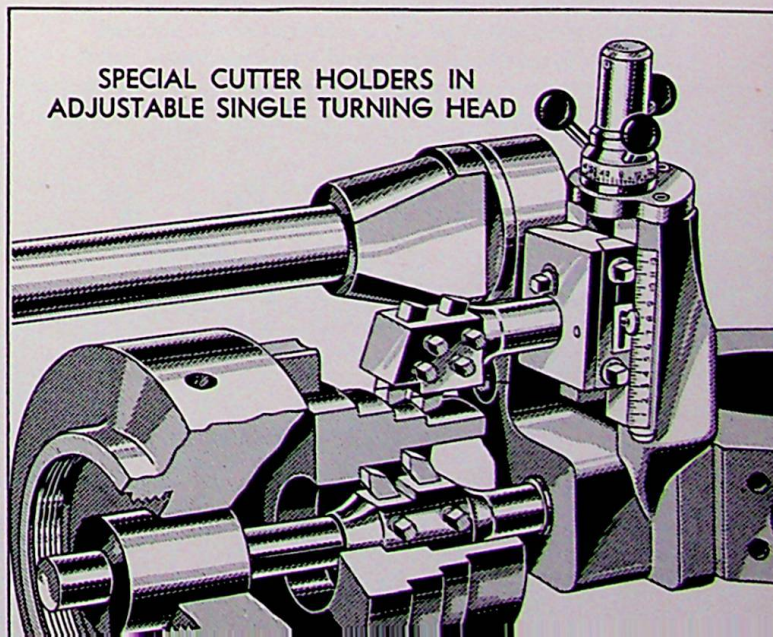
Multiple cutter block on cross slide.

Hexagon Turret Multiple Cutter Holders

Multiple Turning Heads used on high production set-ups are often equipped with multiple cutter holders for machining two or more surfaces at one time. Similarly, special boring bars are used in the Multiple Turning Heads. These boring bars have additional cutter slots for holding several cutters for multiple boring work.

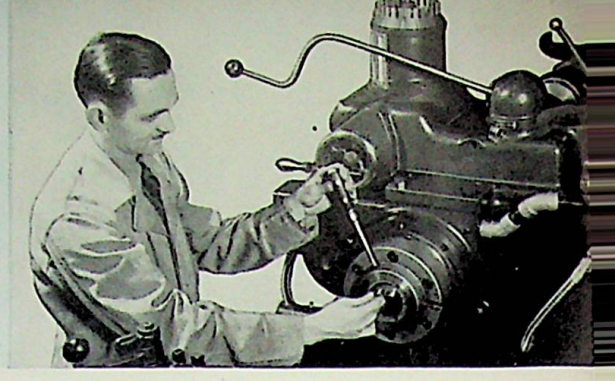
On continuous production, or where unusually shaped pieces are involved, entirely special turning heads may be designed and built. These turning heads incorporate integral cutter blocks to handle the turning and boring requirements for the one job alone.

Large quantity production work justifies increased expense and effort to develop a special tooling set-up for the job. Such special tooling is designed to reduce machine handling and indexing time and to machine a maximum number of surfaces at one pass of the tool.



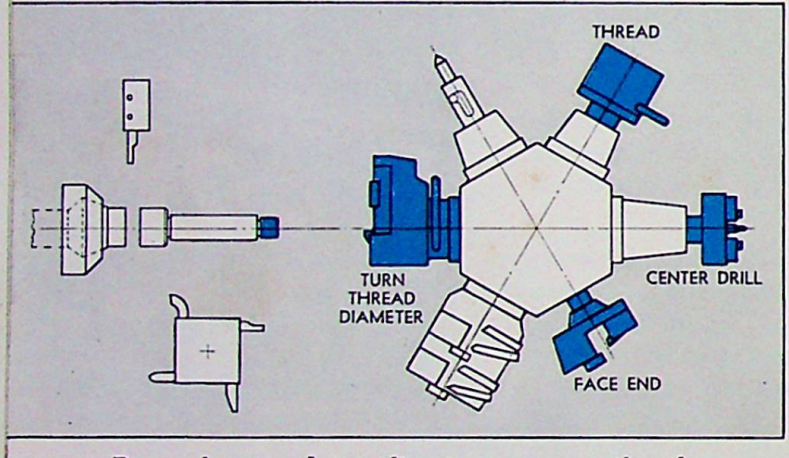
Production Planning

» » » Grouping Turret Lathe Set-ups

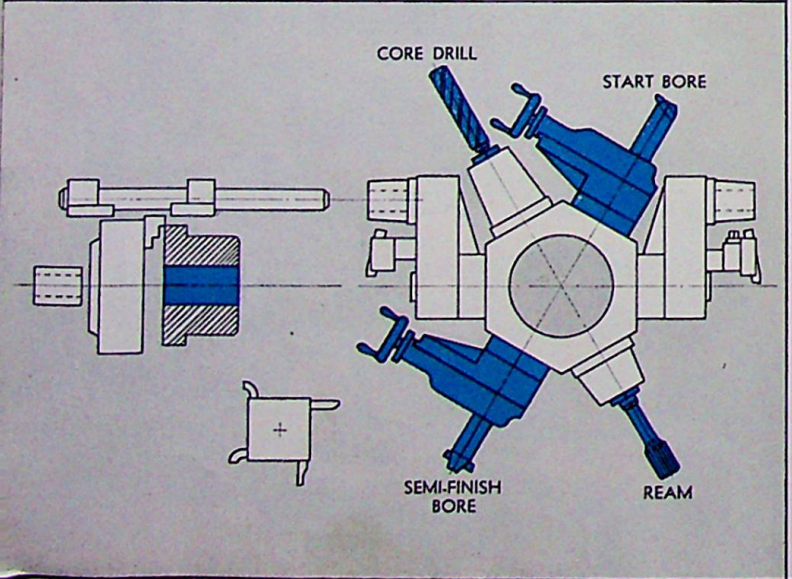


A thorough job of production planning goes beyond analyzing the immediate job to decide upon the correct tooling set-up. Good production planning also takes into account the jobs ahead for each turret lathe paying particular attention to finished external sizes and internal bores.

Careful observation of the work scheduled ahead for any one turret lathe or a group of turret lathes will often show that certain diameters on bar work and bore sizes on chucking jobs are duplicated in succeeding lots of work waiting to be machined. When scheduling jobs for any one turret lathe, it is advisable to group the bar jobs with common diameters and to group chucking jobs having the same finished bore. This is done to avoid unnecessary resetting of cutters for diameters or bores that may be duplicated on successive jobs assigned to the machine.



Bar work grouped according to a common thread avoids resetting major bar tools. Chucking work grouped by bores that are duplicated avoids resetting of internal chucking tools.



Group Bar Parts by Diameter

Blueprints of scheduled bar jobs can often be sorted into groups on the basis of a common diameter. These individual jobs can then be assigned to the machine in successive order. For example, all parts having 1" diameters are grouped, 1¼" diameter parts are placed in another group and so on.

Advance production planning reduces the time required to set up the job. For a group of parts having a common diameter, the Single Cutter Turner is set to turn this size and then left set up for the entire group of bar jobs having the same common size.

Jobs may also be grouped according to a thread common to a number of parts. This step in Production Planning simplifies the problem of machine set-up by eliminating the resetting of such tools as the Single Cutter Turner, the Combination End Facer and Turner, the Die Head and the Center Drilling Tool, all set up to machine the threaded diameter.

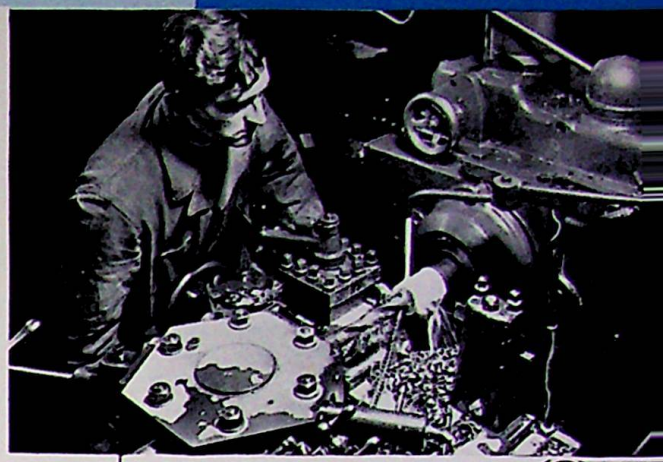
Group Chucking Work According to Bore

Chucking jobs are grouped on the basis of the same size bore duplicated on different jobs. A finished bore generally involves a start bore or start drill, a drilling cut, one or more boring operations, and reaming. By grouping chucking work according to a common bore, the tooling necessary to finish the bore remains untouched. Only external cuts need be reset for size, for different shapes of work to be done.

Select the Correct Size Turret Lathe

One important item to consider when assigning jobs to turret lathes is to use the correct size of machine for the job. The turret lathe selected should be large enough to grip the bar stock or swing the forging. It should have enough power to pull the cuts and rigidity to withstand the feeds and depths of cut that must be taken. It should not be of too large a size, however, as to require excessive operating time and effort to run through the operations.

How to Combine Machining Operations



When cutters in both the square and hexagon turrets are removing metal at the same time, "Combined Cuts" are being taken.

Two types of "Combined Cuts" are possible on bar or chucking work. Internal operations from the hexagon turret such as drilling and boring may be combined with external cuts such as turning, facing and grooving from the square turret. External cuts from the hexagon turret can likewise be combined with external cuts from the square turret.

Combined Cuts on Bar Work

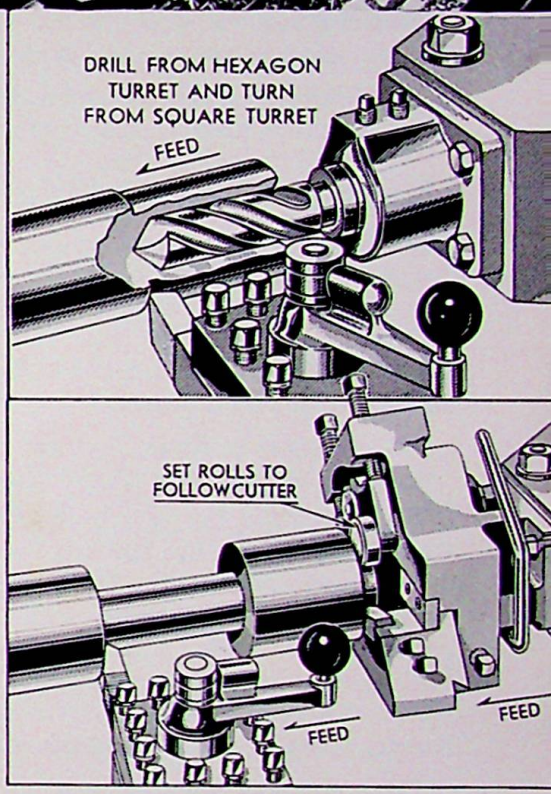
"Combined Cuts" are desirable on bar work because they help to support the work against the cutter, thereby avoiding spring and chatter. Combined cutting operations on bar work consist mainly of turning, grooving and chamfering from the square turret while the Single Cutter Turner is turning a diameter from the hexagon turret. The Single Cutter Turner acts as a steady rest to support the bar stock against the square turret cutters. Another means for combining cuts on bar work is to perform square turret turning, facing and grooving operations while drilling from the hexagon turret. In this case, the drill helps support the work against the square turret cutters avoiding spring and chatter.

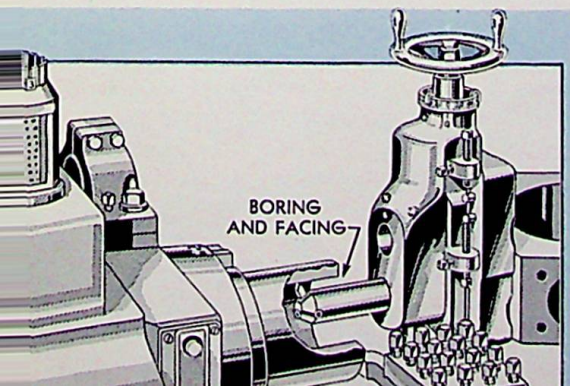
Combined turning from both the hexagon turret and square turret is often desirable on long bar work. On long shafts having a single turned diameter, the turning cut may be "split" by taking the same size turning cut from the square turret and the hexagon turret at the same time. The square turret turning cutter starts near the middle of the bar and machines the diameter at the same feed selected for the hexagon turret Single Cutter Turner.

Combined Cuts on Chucking Work

Turning from the hexagon turret while facing with the cross slide represents the greater portion of "Combined Cuts" generally experienced on chucking jobs. Hexagon turret drilling or boring may also be combined with longer facing cuts taken with the square turret. Turning cuts may be taken at the same time on both the hexagon turret and the square turret, as combined cutting operations.

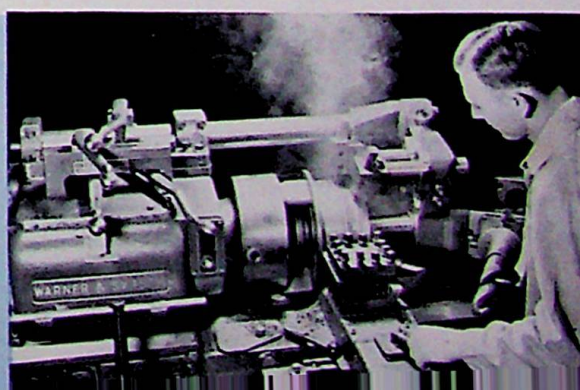
Supplementary cuts, like grooving and chamfering, can be taken while the hexagon turret is turning or boring. Sufficient time is often available during a hexagon turret cut to allow the square turret to be indexed to the next station and the succeeding cut started before the hexagon turret feed has knocked off, allowing the machine to be actually cutting metal a greater proportion of the time. "Combined Cuts" in a set-up are the best indication that the tooling is being used to its fullest advantage. Combine all square turret and hexagon turret operations wherever possible.





← Combined internal and external operations. Facing from the Square Turret while boring with the Vertical Slide Tool.

→ Combined external operations. Facing from the Square Turret while turning with overhead cutters in the Multiple Turning Head.



Multiple Cuts

How to Combine Machining Operations

"Multiple Cuts" are the taking of two or more cuts at one time from either the square turret or the hexagon turret. "Multiple Cuts" increase the amount of metal removed at each pass of the turret unit. Since two or more surfaces are machined at each pass of the turret, fewer indexing operations are needed and there is less machine handling required to run off the work.

Square Turret and Cross Slide "Multiple Cuts"

"Multiple Cuts" from the Cross Slide can be set up in several ways:

1. Multiple Facing, using an Open Type Square Turret or the Two Cutter Rear Facing Block.

2. Multiple Turning from an Open Type Square Turret or two Cutter Rear Facing Block.

3. Multiple end facing and cut-off or grooving.

Accurate tolerances are assured with "Multiple Cuts" because all cutters remain fixed in relation to each other, and no indexing of tools is involved.

Hexagon Turret "Multiple Cuts"

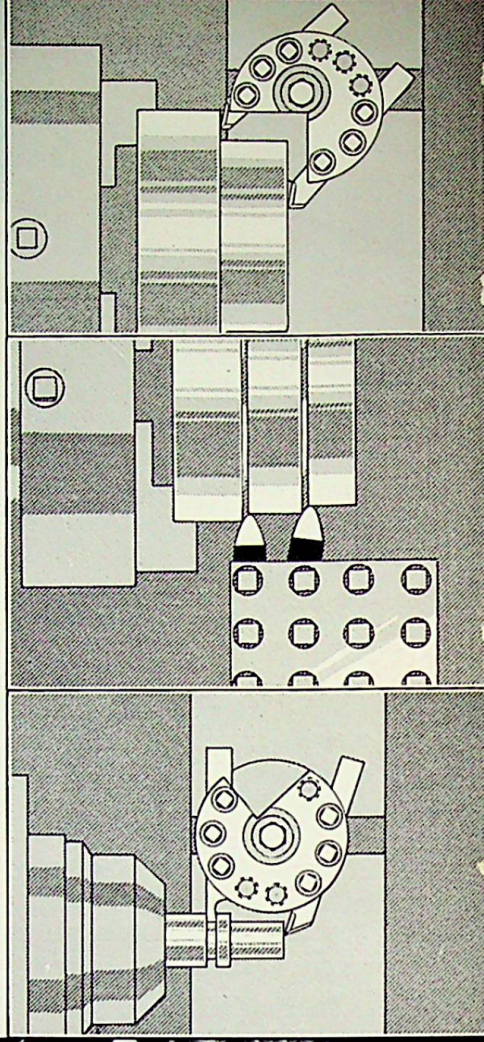
Bar Work. The principal tool for "Multiple Cuts" on bar work is the Multiple Cutter Turner. This tool is set up with two or more cutters to turn several diameters at one time. The Multiple Cutter Turner may also be set up to face and chamfer the end of the workpiece in one pass of the hexagon turret.

The Adjustable Knee Tool can also be used for "Multiple Cuts" on bar work. With this tool, turning and boring or turning and drilling can be done at one time.

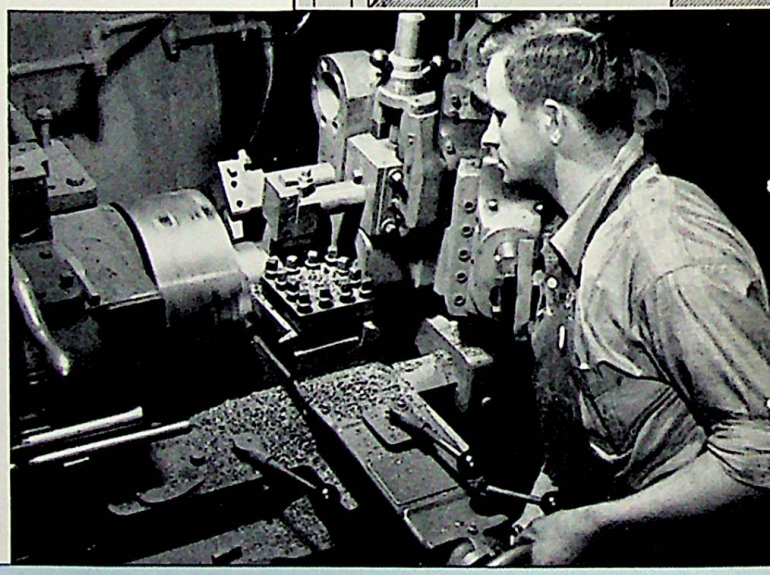
Chucking Work. The Multiple Turning Head and the Adjustable Single Turning Head provide the means for "Multiple Cuts" on chucking work. Overhead turning cutters held in Angle Cutter Holders are combined with drilling or boring operations from the center hole of these heads. Overhead piloting provides added rigidity for heavier feeds on multiple cutting operations.

The practice of mounting as many cutters as possible into one hexagon turret station frees other hexagon turret faces for essential machining operations.

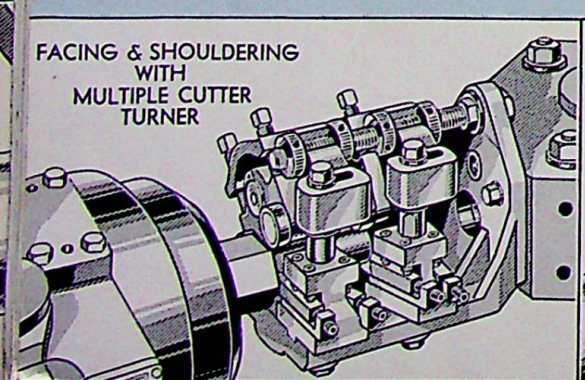
Group cutters for multiple cuts wherever possible.

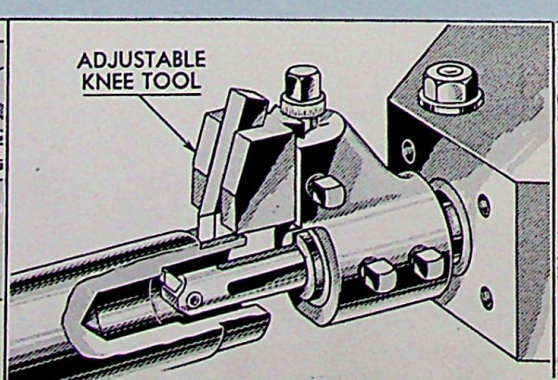


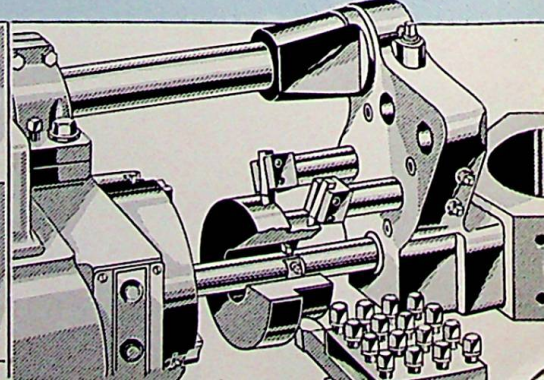
Typical examples of "Multiple Cuts" taken from the Cross Slide.



TYPICAL EXAMPLES OF HEXAGON TURRET MULTIPLE CUTS







Correct Cutter Grinding Assures Smoother Work Finish and Longer Cutter Life

The grinding of the cutter is important because it largely determines the speed and feed at which the metal can be removed, as well as the accuracy and quality of finish produced on a given job.

Illustrated below are the general types of cutters used for turret lathe work. Basically all cutters are the same in that they have a cutting edge to remove the metal. The only difference between cutters is in the relation of the cutting edge to the shank of the tool. The cutting edge is the starting point from which all important cutting angles are ground and measured.

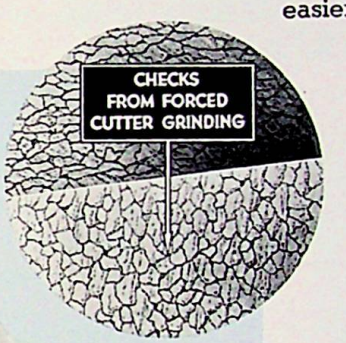
Since various materials have widely different machining characteristics, each cutter must be individually ground to suit the material to be machined. The correct cutter rake must be selected and the proper clearances provided. The cutter rake establishes the surface or angle over which the chips flow—the clearance permits only the cutting edge to come in contact with the work.

First determine the cutting edge, then grind the correct angle of the cutter rake. Next, grind the correct angles of clearance to avoid any rubbing or interference between the cutter and the work piece. Check these angles with the Cutter Grinding Gauge. A cutter chart on page 63 shows approximate rakes and clearances for High Speed Steel and Carbide tipped cutters.

Chip grooves are ground on most cutters used for steel turning. The chip groove curls and breaks chips into short lengths and thus avoids long stringy chips becoming entangled with the other tools in the set-up.

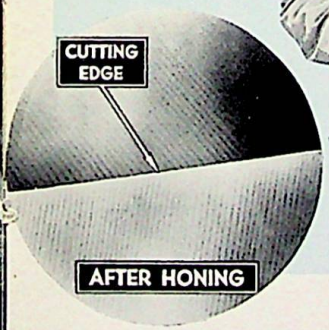
Honing or lapping the cutting edge and top rake of the cutter increases the life of the tool between grinds. By honing grinding wheel scratches from the tool, easier chip flow results in smoother work finish.

Consult Chart Before Grinding



Avoid "Forcing" The Cutter Grind

Hone Cutter Edge After Grinding

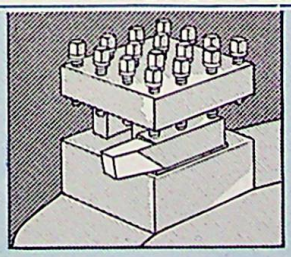


Check Cutter Angles

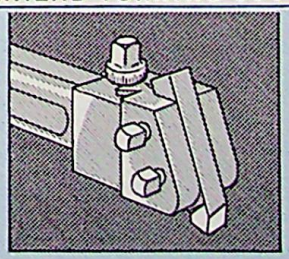
Check Points for Grinding Cutters

1. Refer to a cutter grinding chart for suggested angles of rake and clearance for the material to be machined.
2. Avoid "forcing" the cutter grind. Grind the cutter on a tool grinder by holding the cutter lightly but firmly against the grinding wheel.
3. Grind the cutter entirely dry or under a flood of water. Avoid quenching the cutter during grinding.
4. Check all cutter angles with the Cutter Grinding Gauge.
5. Hone the top rake and cutting edge to remove scratches caused by the grinding wheel.

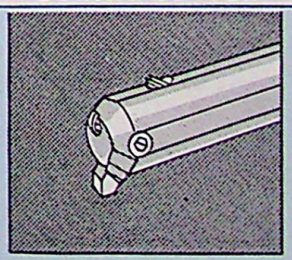
SQUARE TURRET CUTTER



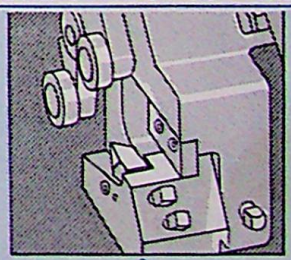
OVERHEAD TURNING CUTTER

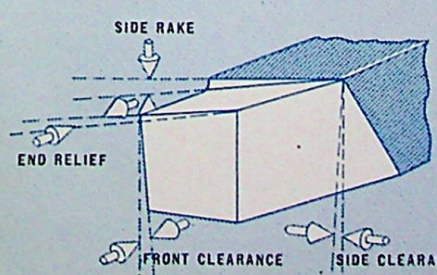


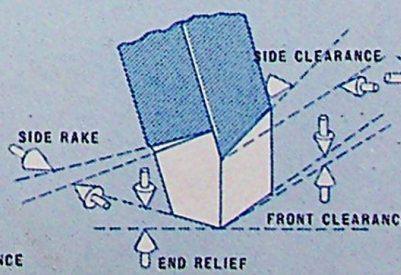
BORING CUTTER

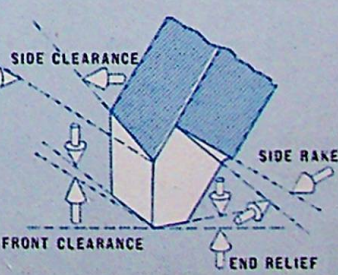


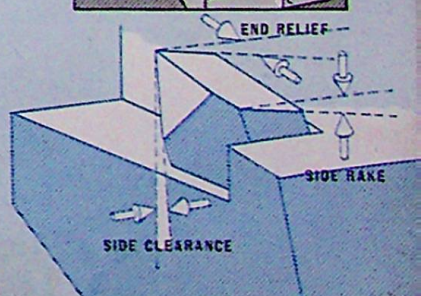
BAR TURNER CUTTER











Setting Cutters

Set Cutters on Center to Maintain Correct Cutter Rake and Clearance

Setting the cutter correctly in the holder is just as important as grinding. The angles of rake and clearance established when the cutter is ground must be carefully maintained when the cutter is mounted in a holder, or in the square turret. To maintain the correct angle of cutter rake and clearance against the work piece, set all cutters on or as near center as possible.

A cutter set *below* center decreases cutter rake and increases cutter clearance. A cutter placed *above* center does just the opposite—increases the top rake and decreases the clearance.

Set the cutter on center and you will be sure it's right.

HOW TO SET CUTTERS ON CENTER

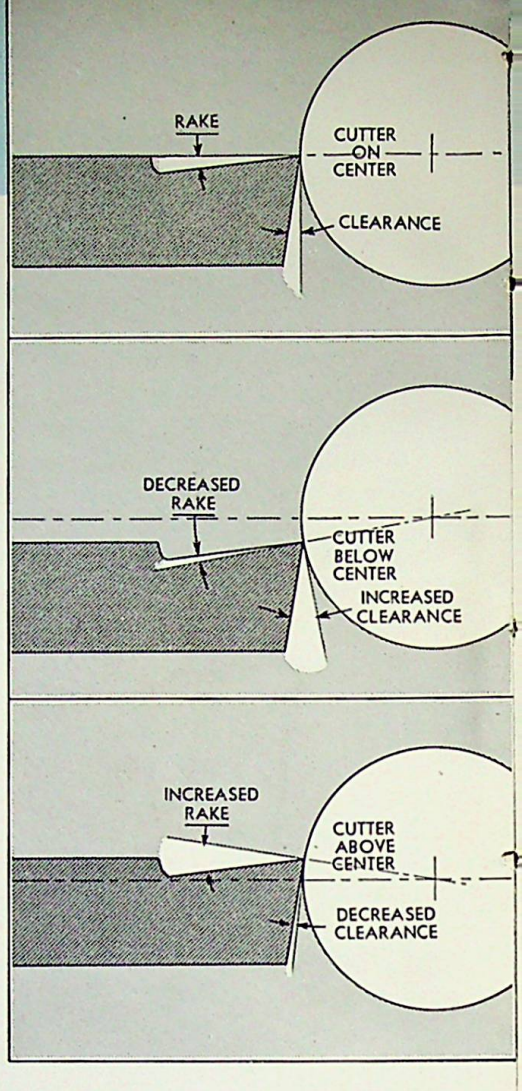
Square Turret Cutters can be set on center by measuring from the top of the turret. A scale or a Cutter Grinding and Setting Gauge positions the cutter on center.

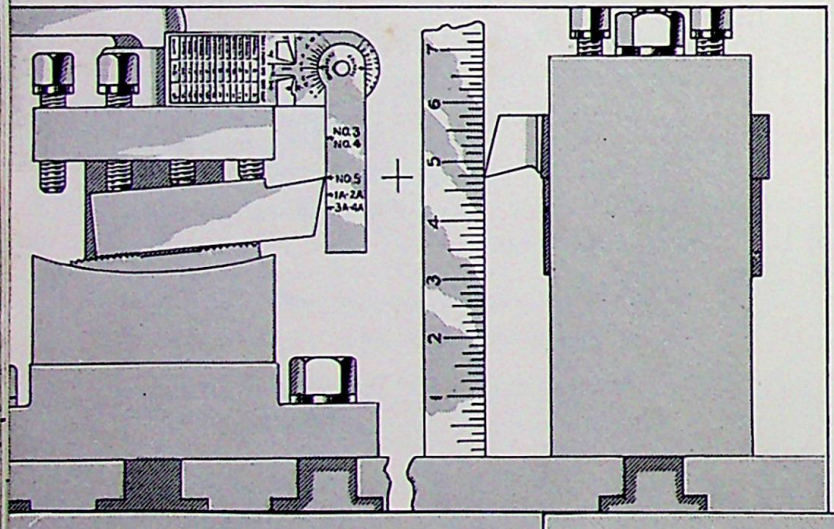
Rear Tool Post—Use a scale to measure the correct position of the cutter from the top of the cross slide.

Multiple Turning Head—Use a scale or straight edge to align the *shank* of the cutter with a radial line to the center of the Turning Head.

Vertical Slide Tool—Use a scale to align the shank of the cutter with the center line of the other hole in the block.

Single Cutter Turner—Use the Bar Turner Cutter Grinding Gauge to establish the correct height of the cutting edge.

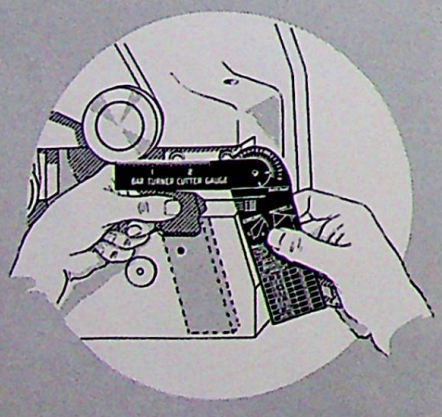




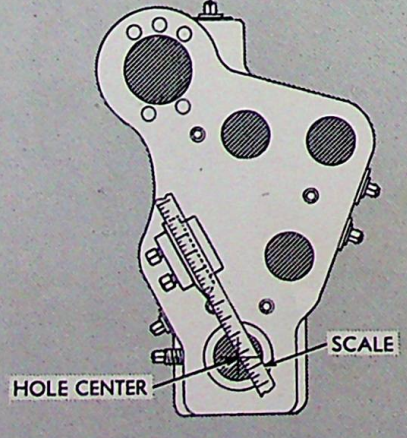
MAINTAIN MINIMUM OVERHANG OF THE CUTTER FROM THE HOLDER

Maximum cutter rigidity for withstanding spring or chatter of the cutting tool is necessary for smooth work finish. Mount the cutter in the holder with minimum overhang to reach the work diameter. A good rule is to keep the overhang of the cutter to within twice the cross section of the cutter shank.

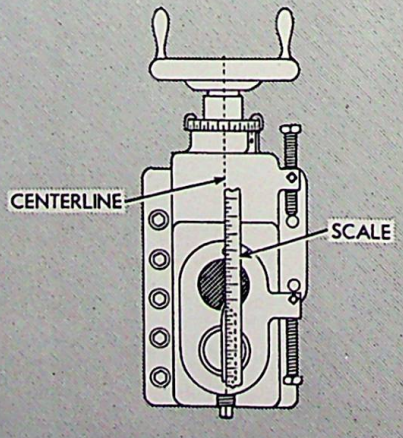
Check all cutters for center after the cutter holding screws are firmly secured.



SINGLE CUTTER TURNER



MULTIPLE TURNING HEAD



VERTICAL SLIDE TOOL

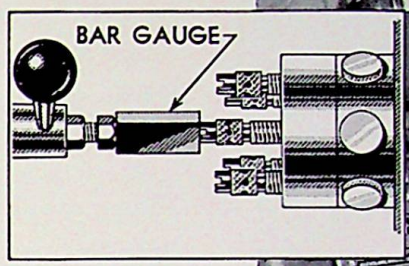
Machine Stops Assure Accurate Duplication of Parts

After turret lathe tools have been set to size, the machine stops are adjusted for accurately duplicating parts. The stops control the power feed knock-off. They also locate the hexagon turret along the bed to govern accurate depths of bore and position the cross slide for facing cuts.

Wherever three or more pieces are to be made, the machine stops are set up. On fewer pieces, scales and micrometers are used to check each machined surface.

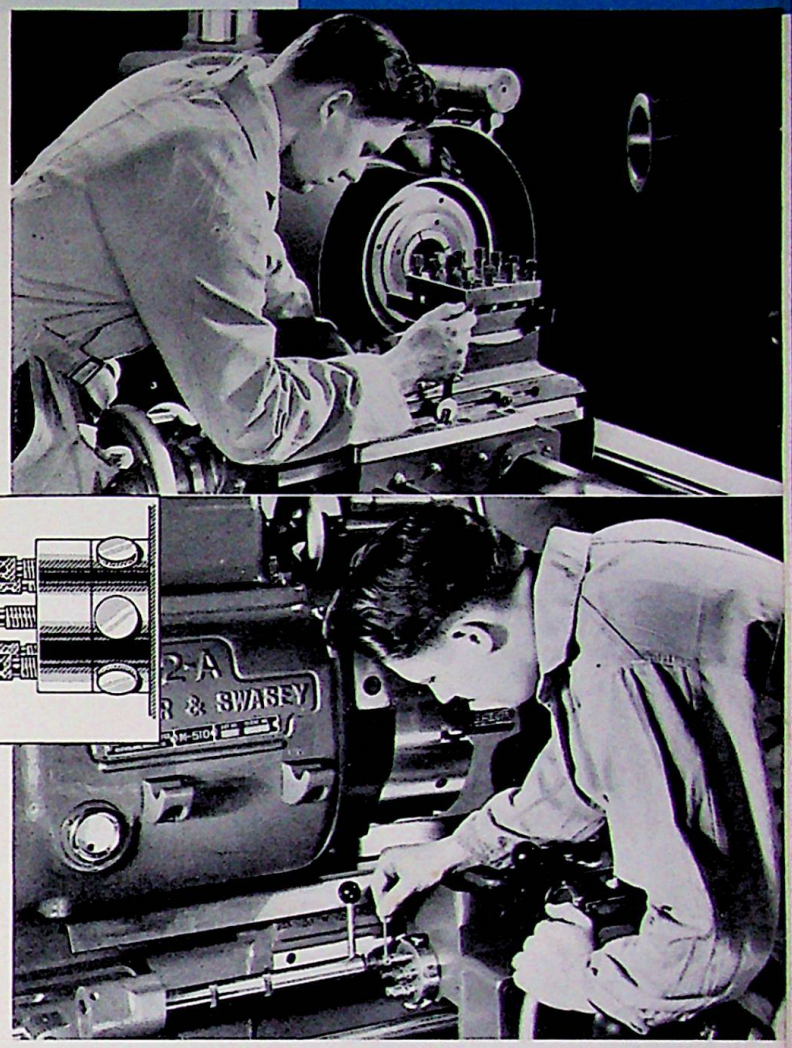
Cross Slide Carriage Stops

Longitudinal Feed—A six position stop roll for longitudinal positioning of the square turret is located at the left of the carriage apron. The threaded stop screws are adjusted quickly with a pin. After adjustment, the stop screws should be locked in place with the binder screws. Where extremely close limits are to be held between faces or shoulders, bar gauges are used between the stop rod and the carriage stop screws, to position the square turret carriage along the bed. This avoids indexing the stop roll for such operations.



The screw in the end of the stop rod is a master stop screw. It permits an overall set-up adjustment without disturbing the relation of one stop screw to another.

Cross Feed—Adjustable feed trip-off dogs on the right of the cross slide disengage power cross feeds to and from the spindle. The micrometer dial accurately positions the cross slide for size.



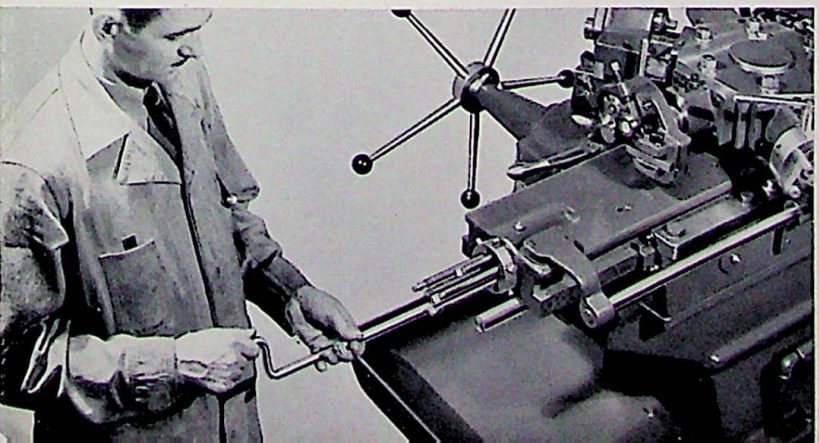
Above: Adjusting feed dogs to disengage power cross feeds.

Below: Adjusting the stop roll to trip longitudinal feeds of the cross slide carriage.

Hexagon Turret Stops

Ram Type Turret Lathes—Independent stop screws for the hexagon turret slide are mounted in an automatically indexing stop roll. They are quickly adjusted with a stop screw wrench. To accurately set the power feed knock-off, the turret slide is brought into position by hand and the binder clamped. The machine is stopped and the hexagon turret feed lever is engaged. The stop screw is tightened until the feed disengages and the dead stop position is reached.

Independent stop screws trip hexagon turret feeds on ram type machines.

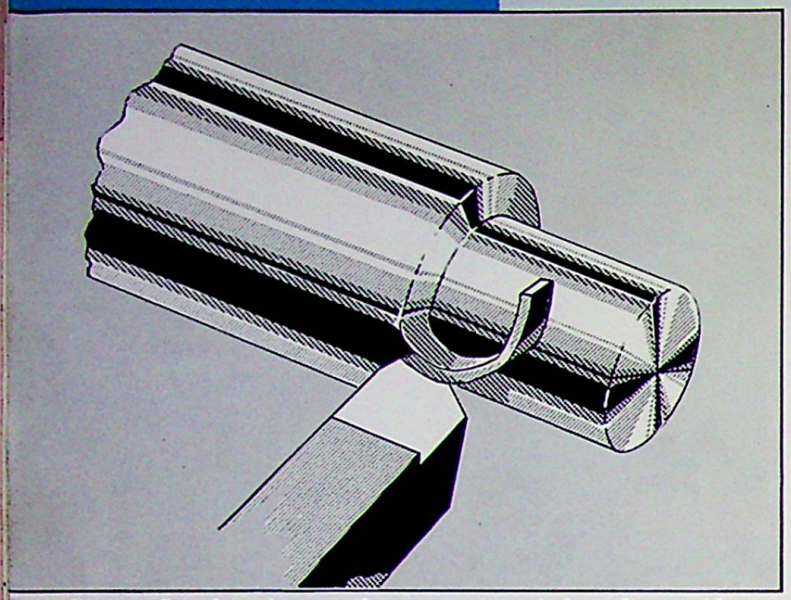


Saddle Type Turret Lathes—The stop screws on saddle type machines are mounted on an automatically indexing stop roll. To set the hexagon turret stop screws quickly and accurately, the hexagon turret is brought into position by hand and bound in place. The longitudinal feed lever is engaged with the machine stopped. The stop screw is adjusted until the feed disengages and the dead stop position is reached.

Adjustable stop dogs trip hexagon turret feeds on saddle type machines.

Cutting Speeds

Correct Cutting Speeds Produce Accurate Size and Smooth Finish



Cutting Speed is the rate (feet-per-minute) that the outside of the work moves past the cutting edge of the tool.

A good turret lathe operator knows the correct cutting speed to be used on the job. He knows that the quality of finish and the tolerances that can be maintained are governed by the cutting speed (feet-per-minute) at which the material is turned. The faster metal can be cut, the smoother the finish. The rate at which metal can be cut is usually limited only by the ability of the cutter to support the cutting loads and carry away the heat generated as the chips are pried away from the work.

Heat generated in cutting is governed by the hardness and toughness of the material. Tough stringy materials, like carbon or alloy steels must be run at lower speeds than brittle materials like cast iron or brass that require less pressure with lower resultant heat to pry the chips.

How to Select Correct Cutting Speeds

Since the rate at which the work passes the cutter edge is the actual cutting speed, the operator thinks in terms of "feet-per-minute" cutting speed rather than in spindle r.p.m. Cutting speed or surface speed in feet-per-minute takes into account the diameter of the work. The surface speed is greatest at the outside diameter and zero at the exact center.

The cutting speed chart on page 63 suggests metal cutting rates for different materials. Since most metals vary slightly in machinability (the ease with which a chip can be removed), the recommended cutting speeds can be varied slightly on any new job to suit the material.

Roughing cuts are taken at slightly reduced cutting speeds since they are usually deep cuts to shape the piece to approximate size. Finishing cuts are lighter cuts at decreased feeds. They are run at the maximum possible surface speeds.

Cutting speeds that are too low tear the work, causing a poor finish, incorrect size, and often premature cutter failure. On the other hand, running the job too fast dulls the cutter or breaks down the cutting edge completely.

How to Figure Cutting Speeds

For practical purposes the approximate surface speed for a job can be figured quickly by using the following simple formula:

$$\text{Cutting Speed in feet per minute} = \frac{\text{Diameter in inches} \times \text{r.p.m.}}{4}$$

The spindle speed that most nearly provides a selected cutting speed from a speed table is figured as follows:

$$\text{Spindle Speed in r.p.m.} = \frac{\text{Cutting Speed in feet per min.} \times 4}{\text{Diameter in inches}}$$

Most later model turret lathes have "Preselector" heads that automatically figure the cutting speed in feet per minute. The Preselector eliminates calculations to convert r.p.m. into feet-per-minute, or feet-per-minute to spindle r.p.m. Figuring cutting speeds or spindle r.p.m. can also be done with cutting speed and feed calculators or similar devices.

For any one spindle speed (r.p.m.) the cutting speed (feet-per-minute) varies directly with the diameter. The larger the diameter the higher the surface speed. Since the surface speed is maximum at the outside diameter and zero at the center, when taking long facing cuts, it is good practice to change the spindle speed part way through the facing cut to maintain the correct surface speed at which the metal should be cut.

Setting number Tabs on Preselector Head to indicate Sequence of Speed Changes.

Proper Feeds Increase Cutter Life

Feed is the distance the cutter travels for each revolution of the spindle. It is also the thickness of metal removed each turn of the work piece. As in cutting speed, the amount of feed used depends upon the material to be cut. Brittle materials, like cast iron and brasses, can be cut at heavier feeds than tough stringy metals such as heat treated Alloy Steels.

To establish the correct feed for a job, it is advisable to consult a speed and feed chart, similar to the one found on page 63. The suggested feed can be increased or decreased within the range recommended to satisfy other factors, such as:

1. Whether the cut is roughing or finishing.
2. The degree of surface smoothness required.
3. Whether the wall thickness of the work piece will withstand the tool pressure.
4. Whether the tooling has sufficient rigidity to resist vibration and chatter.

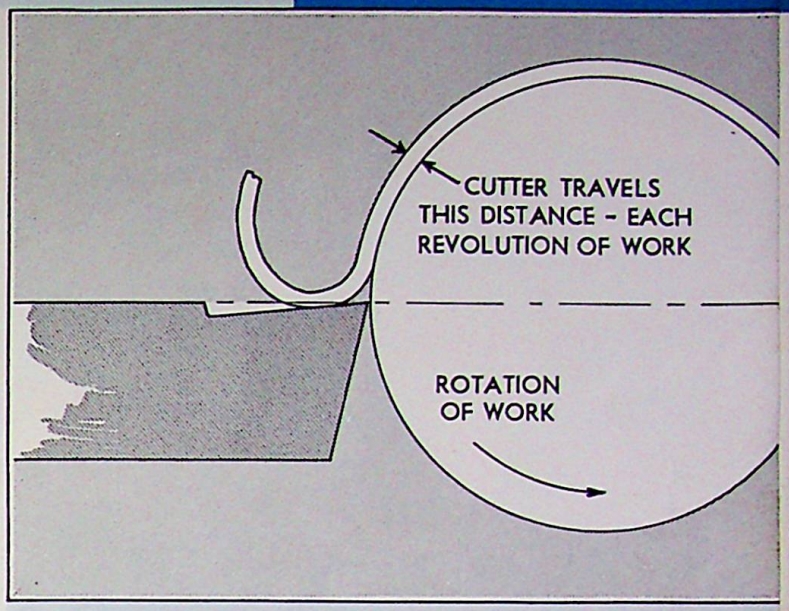
One range of feeds suggested in the chart is for roughing work on a forging or casting or where the piece is being shaped from solid bar stock. Heavier feeds on roughing work help increase tool life. Since the contact of the chip against the tool is at a distance away from the cutting edge there is less abrasion and wear at the tip of the tool. The finer range of feeds is suggested for finishing work. On finishing operations, tool marks are avoided and smooth finish obtained on the work by using finer feeds and greater cutter nose radii.

Depth of Cut

Depth of cut is the width of metal being removed. Depth of cut is important because with feed it determines the amount of metal removed at each turn of the work piece.

On roughing cuts, a depth of cut is taken to shape the work to approximate size in one pass of the cutter. Roughing cuts usually allow approximately .010" to .012" for the finishing operations. Since finishing generally involves but small depth of cut, higher surface speeds can be used without burning the edge of the tool. The high surface speed in a finishing cut produces the smooth finish.

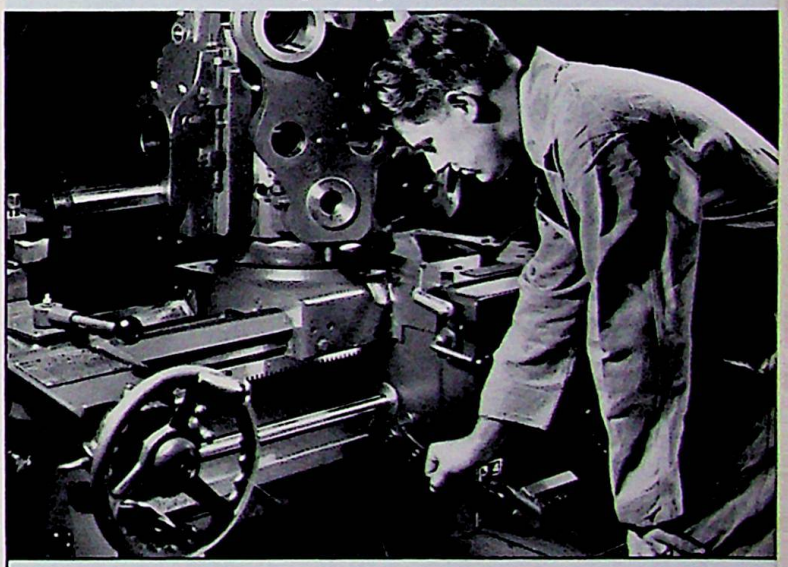
Every metal cutting operation is a compromise. As each tool is set up, a balance between speed, feed and depth of cut is carefully established. The experienced turret lathe operator knows how to arrive at this balance. Where the depth of cut is great, he uses a slightly lower speed and feed. When taking light cuts, he steps up the speed and feed for accurate size and smooth finish.

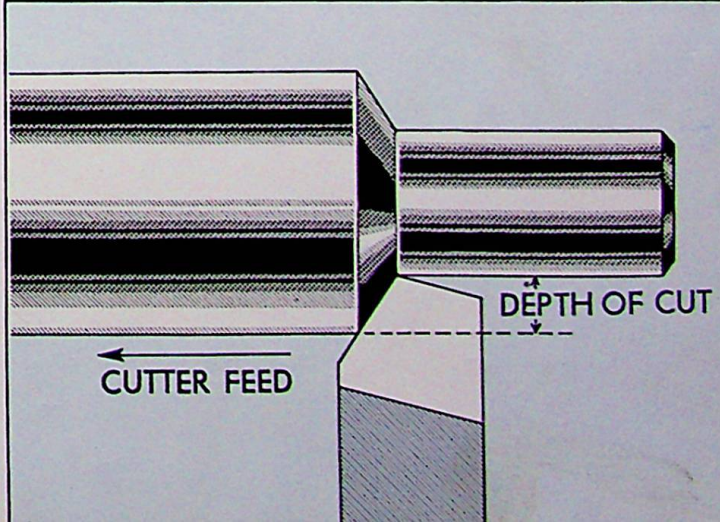


On heavy cuts—the pressure of the cut is directed away from the cutting edge.

Consult Feed Chart on Page 63 to select the correct feed for the metal to be cut.

Selecting Hexagon Turret Feeds





Aids to Operators

Helps that Make Better Turret Lathe Operators

An operator who fully understands his job produces better work with less effort. As a skilled workman he is worth more to his company and is always in demand.

The Operator's Service Bureau at Warner & Swasey has prepared many printed bulletins and other aids to help turret lathe operators become more proficient at their machines. These are available to turret lathe operators interested in doing a better job.

The Turret Lathe Operator's Manual is an easy-to-read and easy-to-understand text book of 240 pages containing more than 350 illustrations and drawings. It will help the turret lathe operator understand his present set-ups better and prepare him for better jobs. This book sells for $1.00 postpaid, (plus state tax).

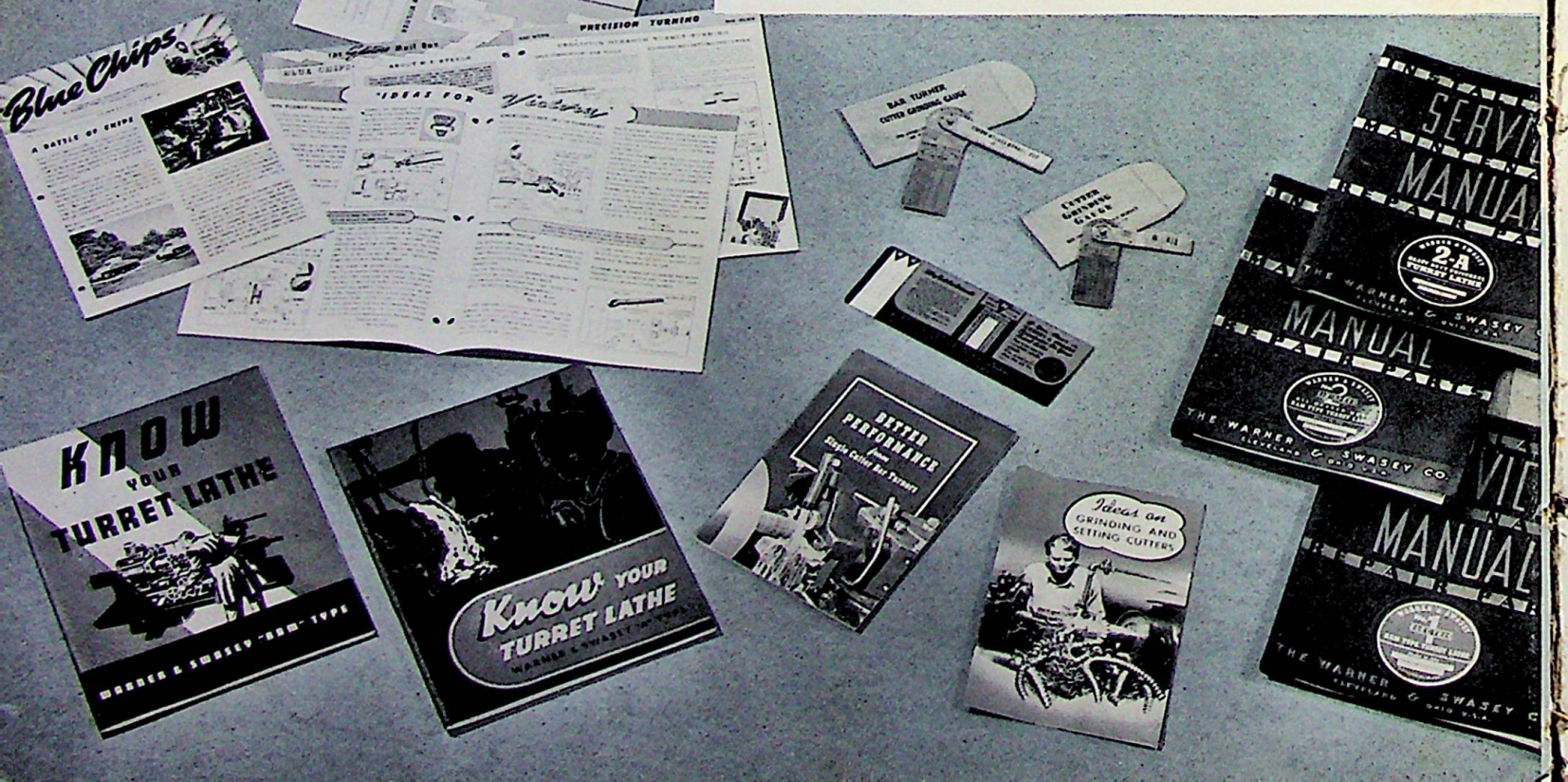
The Turret Lathe Tool Catalog completely describes all bar and chucking tools and shows how they are used.

Blue Chips is an operator's newspaper. It contains practical ideas and suggestions and is mailed directly to the operator's home. Blue Chips discusses everyday problems encountered in turret lathe work and illustrates unusual methods for setting up jobs.

"Know Your Turret Lathes" are books on the care and maintenance of Ram and Saddle type turret lathes.

Cutter Grinding Gauges to help the operator get the correct rake and clearance angles on cutters. They suggest proper angles for cutting different metals.

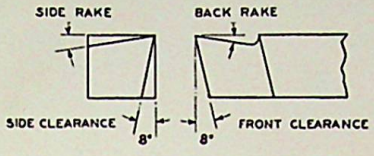
The Cutting Speed and Feed Calculator helps the operator figure the correct spindle r.p.m. for the job.



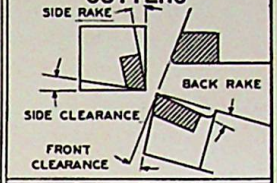
For Correct Cutter Grinds--for Combined Feed Tapers--for Setting Speeds and Feeds

SUGGESTED RAKES AND CLEARANCES FOR CUTTERS

FOR HIGH SPEED STEEL CUTTERS



FOR CARBIDE TIPPED CUTTERS

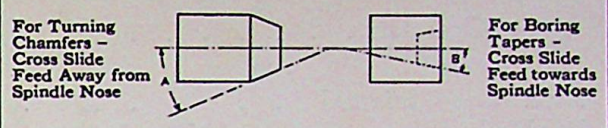


MATERIAL	Back Rake	Side Rake	Side Clearance	Front Clearance	Back Rake *	Side Rake
Cast Iron	3°	3°	4°-6°	4°-6°	0°	0°-2°
Brass	2°	2°	6°	6°	0°	4°
Bronze	6°	5°	6°	6°	0°	4°
Copper	10°	25°	8°-10°	8°-10°	4°	20°
Aluminum	8°	18°	8°-10°	8°-10°	25°	15°
Steel (Annealed Stock)						
Screw Stock (SAE X-1112 X-1315)	15°	20°	6°	6°	0°	3°
Plain Carbon Steel (SAE 1020-1035)	15°	15°	6°	6°	0°	3°
High Carbon Steel (SAE 1095)	5°	10°	6°	6°	0°	3°
Nickel Alloy Steel (SAE 2315-2335)	15°	15°	6°	6°	0°	3°
Nickel Chrom. Alloy (SAE 3140-3250)	8°-10°	12°	6°	6°	0°	3°
Chrome Molybdenum (SAE 4140)	10°	12°	6°	6°	0°	3°
Nickel Molybdenum (SAE 4615)	15°	15°	6°	6°	0°	3°
Chrome Vanadium (SAE 6145)	8°	12°	6°	6°	0°	3°

The above Angles for High Speed Steel Cutters are for General Work. For unusual jobs the resourceful operator alters them slightly to suit the material.

*Keep Back Rake Angle on Carbide Tipped Cutters as small as possible for greatest strength. Use Negative Rakes for older machines.

Angles that can be cut by combining Cross Feeds and Hexagon Turret Longitudinal Feeds with 1-A M-470 and 2-A M-510 Warner & Swasey Turret Lathes



Angle "A"	Cross Feed	Long. Feed	Angle "B"	Cross Feed	Long. Feed
4°	.0022	.037	3°	.0022	.037
5°	.0029	.037	4°	.0022	.027
7°	.0039	.037	6°	.0022	.020
9°	.0029	.020	8°	.0039	.027
13°	.0029	.015	11°	.0039	.020
17°	.0073	.027	15°	.0054	.020
22°	.0022	.006	20°	.0054	.015
29°	.0054	.011	26°	.0039	.008
37°	.0054	.008	33°	.013	.020
45°	.0073	.008	41°	.010	.011
54°	.0073	.006	50°	.0073	.006
62°	.013	.008	58°	.013	.008
68°	.013	.006	65°	.013	.006
74°	.018	.006	71°	.013	.004
78°	.018	.004	76°	.018	.004

The above Table covers only the Angles that can be cut by combining feeds on current Model 1A and 2A Turret Lathes. Similar tables are available for different sizes and models of Warner & Swasey machines. Write to the Operator's Service Bureau at The Warner & Swasey Co., Cleveland 3, Ohio for an angle chart for your turret lathe. Be sure to send in the serial number of your machine to get the correct chart.

CUTTING SPEED AND FEED CHART

The following speeds and feeds are for broad general use, and are subject to change with variables occurring in tools and material. Hard and fast rules cannot be set without exact information as to the type of machine used, condition of machine, type of cutting tool used, including brand of steel, method of mounting tool, lubricant used for cutting, if any, and a complete analysis of the material being cut and method of holding.

Material	SURFACE FEET PER MINUTE						FEEDS			
	H. S. S.‡		Stellite J		Carbide		Ram Type Machine		Saddle Type Machine	
	Rough	Finish	Rough	Finish	Rough	Finish	Rough	Finish	Rough	Finish
Cast Iron	50-60	80-100	90-120	130-160	180-200	350-400	.016-.025	.016-.025	.032-.060	.032-.125
Semi-Steel Hard	40-50	65-90	75-100	100-130	140-160	250-300	.016-.025	.016-.025	.032-.060	.032-.125
Malleable Iron*	80-100	110-130	120-140	150-200	250-300	400-500	.016-.025	.016-.025	.032-.060	.032-.060
Steel Casting (.35 Carbon)*	45-60	70-90	70-80	90-130	150-180	200-250	.010-.020	.012-.020	.018-.030	.018-.045
Brass (Commercial (85-5-5)	200-300	200-300			600-1000	600-1000	Maximum Feed of Machine			
Bronze (80-10-10)*	110-150	150-180			600	1000	.016-.030	.010-.016	.016-.050	.010-.030
Aluminum**	400	700			800	1000	Fine Feeds To Produce Good Finish			
SAE 1020* (Coarse Feed)	60-80	60-80			300	300	.020-.030	.020-.030	.024-.044	.024-.044
(Fine Feed)	100-120	100-120			450	450	.007-.020	.007-.020	.010-.030	.010-.030
SAE 1035*	75-90	90-120			250	250	.020-.030	.020-.030	.024-.044	.024-.044
SAE-X-1315*	175-200	175-200			400-500	400-500	.010-.015	.010-.015	.010-.015	.010-.015
SAE 1050*	60-80	100			200	200	.012-.020	.012-.020	.025-.090	.015-.045
SAE 2315*	90-110	90-110			300	300	.012-.020	.012-.020	.025-.090	.015-.045
SAE 3150*	50-60	70-90			200	200	.012-.020	.012-.020	.025-.090	.015-.045
SAE 4150*	60-80	80-100			200	200	.012-.020	.012-.020	.025-.090	.015-.045
Stainless Steel* (Selenium Content)	100-120	100-120			240-300	240-300	.010-.015	.010-.015	.010-.015	.010-.015

*Water Soluble Oil Lubricant. **Kerosene Lubricant. ‡Cobalt 18-4-1.

Index